

<div><div>पी डी आई एल PDIL</div></div>	PROJECTS & DEVELOPMENT INDIA LTD.	PC0288/E/001/P-II/ SEC-1.0		P1	<div><div>भारतीय वोल्टीज एल BHEL</div></div>
		Document No.		Rev	
		Sheet 1 OF 6			

## PART - II: TECHNICAL (2)



### SECTION 1.0

#### PROJECT DESCRIPTION

**PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT**

**PROJECT: COAL TO AMMONIUM NITRATE COMPLEX, AT LAKHANPUR, ODISHA (INDIA)**

P1	15/03/2024	15/03/2024	Issued for Client's approval	SR	SK	MN
P	05/03/2024	05/03/2024	Issued for Client's comment	SR	SK	MN
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD



	<u><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></u>	PC0288/E/001/P-II/ SEC-1.0	P1	
	<u><b>Bharat Coal Gasification and Chemicals Limited</b></u>	Document No.	Rev	
	<u><b>PROJECT DESCRIPTION</b></u>	Sheet 2 OF 6		

## **CONTENTS**

SL. NO.	DESCRIPTION	SHEET NUMBER
1.0	Introduction	3
2.0	Plot Area	3

## **LIST OF ATTACHMENT**

SL. NO.	DESCRIPTION	NUMBER OF SHEETS

<div> पी डी आई एल <b>PDIL</b></div>	<div><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></div>	PC0288/E/001/P-II/ SEC-1.0	P1	<div> बी एच ई लि <b>BHEL</b></div>
	<div><b><u>Bharat Coal Gasification and Chemicals Limited</u></b></div>	Document No.	Rev	
	<div><b><u>PROJECT DESCRIPTION</u></b></div>	Sheet 3 OF 6		

## 1.0 INTRODUCTION

**Bharat Coal Gasification and Chemicals Limited (BCGCL)**, *hereinafter also referred to as "OWNER"* a joint venture company has decided to build a world class Coal based Chemical complex. The Chemical complex is to be built at **Lakhanpur area of Mahanadi coalfields Limited (MCL) Odisha (India)** and will consist of Coal Gasification Plant, Synthesis gas purification Plant, Ammonia Plant, Nitric Acid Plant and Ammonium Nitrate Plant, along with Offsite and Utility Plants. Bharat Coal Gasification and Chemicals Limited (BCGCL), intend to invite quotations from eligible contractors on LSTK basis for Synthesis gas purification Plant to purify syngas received from BHEL Gasification technology for production of Ammonia Synthesis Gas ( $3H_2+N_2$ ) and Carbon-Di-oxide Gas.

**1.1 Projects & Development India Ltd. (PDIL)** has been retained by **Bharat Coal Gasification and Chemicals Limited (BCGCL)** as Pre-award Consultant for selection of a suitable LSTK Contractor for execution of the project on a Lump-Sum Turnkey basis with Single point responsibility.

**1.2 LSTK CONTRACTOR** is advised to visit and examine the site conditions and obtain for itself on its own responsibility all information that may be necessary for preparing the bid and entering into the Contract. Claims of any kind due to variation or ignorance of site conditions and environmental conditions will not be eligible in any circumstances.

## 2.0 PLOT AREA:



Coal Gasification Plant shall be built in the earmarked area as given in the overall site plan for Coal to AN Project (Refer: Enclosed Attachment-II, PC0288-0000-0001 Rev-0). LSTK CONTRACTOR should ensure that the available area should be used in the most optimum way.

### 2.1 Plant Site:

A brief status of infrastructure at Plant Site is furnished below:

- The proposed project will be located in Lakhanpur area of Mahanadi coalfields Limited (MCL) Odisha.
- The total land area of the site is -350- acres
- The area is falling under coal bearing zone and not proposed for coal extraction presently .However soil investigation study will be required in the area selected for the project.
- Plant site is located at Lakhanpur in Jharsuguda district of Odisha on the National Highway NH-49. NH-49 is passing at about 10 km from the site. The nearest railway station Belpahar is 10 km from the site. Nearest air port, Veer Surenda Sai Airport, 38 km, approx 1.5 hours journey by road/ rail. Nearest sea port Paradip is 450 km by rail/road from the site. Plant is situated at 21°46'0"N Latitude and 83°46'0"E Longitude.

### 2.2 Process Technology: Coal Gasification

<div></div>	<div><div><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></div><div><u>Bharat Coal Gasification and Chemicals Limited</u></div><div><u>PROJECT DESCRIPTION</u></div></div>	PC0288/E/001/P-II/ SEC-1.0	P1	<div></div>
		Document No.	Rev	
	Sheet 4 OF 6			

The process for coal gasification shall be based on Technology to be supplied by “Bharat Heavy Electricals Limited” (hereinafter referred to as “BHEL”). LSTK contractor shall procure license & basic engineering package and assistance during construction, commissioning & operation for the proposed plant.

#### **Process units:**

Purification plant shall be capable of handling raw synthesis gas received upstream Coal Gasification Plant by BHEL and produce ammonia syngas of desired specification (mentioned in Section-4.0 of, Part-II Technical) for production of Ammonia in downstream.

List of probable process units for the purification plant of proposed Chemical Complex along with their capacities:

S.N.	Process Unit	Capacity	Designer/Licensors
1	CO Sour Shift, Methanol wash, Liquid Nitrogen Wash, NH <sub>3</sub> Synthesis Gas Generation,		LSTK CONTRACTOR Based on Basic Engineering / Design from respective reputed technology suppliers (with assistance of coal gasification licensors, if required).
2	Sulphur Recovery Unit		

### **2.3 Utility & Other Facilities:**

Major facilities are described as under:

#### **2.3.1 Demineralised water system**

LSTK Contractor shall arrange its own DM water requirement till mechanical completion. After that, Owner shall supply required DM water at Purification Plant B.L. to LSTK Contractor from its DM water plant.

#### **2.3.2 Drinking and Service water system**

Treated water from the raw water treatment system is used as make-up to the drinking and service water systems. The service water system takes treated raw water for supply to hose stations, etc. by dedicated service water pumps and a distribution pipe network. Water for gardening is also supplied from this system. During construction till mechanical completion, LSTK contractor has to arrange its own construction and drinking water requirement. After that owner shall supply required Drinking Water and Service Water to LSTK Contractor at Purification Plant B.L.



#### **2.3.3 Cooling water system**

There will be common Cooling tower for Gasification Plant (Separate LSTK Contractor's Scope i.e. LSTK-1), Purification Plant and offsite facilities. If any further treatment is required for usage as cooling water, the same shall be in the scope of LSTK contractor. LSTK Contractor shall furnish cooling water requirement for Purification Plant.

#### **2.3.4 Condensate Polishing Unit**

Condensate generated, if any in LSTK B/L shall be sent to Owner's Condensate Polishing Unit in chemical complex for further treatment and reuse.



<div></div>	<div><div><div><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></div><div><u>Bharat Coal Gasification and Chemicals Limited</u></div><div><u>PROJECT DESCRIPTION</u></div></div></div>	PC0288/E/001/P-II/ SEC-1.0	P1	<div></div>
		Document No.	Rev	
	Sheet 5 OF 6			

#### 2.3.5 Steam and Power

**Power:** It is envisaged that entire power for LSTK B/L will be met from Grid being set up within the complex by separate LSTK Contractor.

Construction Power required for Purification Plant till mechanical completion shall be arranged by LSTK Contractor himself.

Power required for Plant start-up & operation for Purification Plant shall be supplied by Owner at a single point at substation located at LSTK B/L.

**Steam:** H.P steam requirement for Process use shall be generated in Steam Generation Plant (Separate LSTK Contractor's Scope). Start-up steam required shall be provided by Owner. LSTK contractor to indicate the quality, flow rate & duration for same, if any.

LSTK Contractor to maximise the use of generated steam inside their B.L. However, available surplus steam may be exported outside B.L. if it matches with the main steam header parameters indicated in Section-2.0 of Part-II Technical. No steam credit shall be given to the LSTK Contractor.

#### 2.3.6 Plant and Instrument air system

Plant air and Instrument air will be provided to the LSTK Contractor by owner at the **Purification Plant B.L** at one place. Proper instrument air storage and Plant air & Instrument air distribution network shall be envisaged for the Purification Plant to be taken care by the LSTK Contractor. Please refer Section-2.0 of Part-II Technical for plant and instrument air specification.

#### 2.3.7 Nitrogen system

Nitrogen requirement for the plant shall be supplied by Air Separation Unit (**Separate LSTK Contractor's Scope**). LSTK Contractor shall provide Process and utility Nitrogen requirement with desired parameters for Purification Plant. Nitrogen requirement for emergency, if any shall be indicated by the LSTK Contractor to keep provision in ASU unit.

#### 2.3.8 Sulphur Recovery Unit (SRU) & Sulphur Storage



Recovery of Sulphur from H<sub>2</sub>S generated in Acid Gas Removal Unit and transportation of liquid Sulphur to storage shall be in LSTK Contractor's scope. LSTK Contractor shall construct the sulphur storage area. Liquid Sulphur gets solidified during storing and same shall be dispatched through trucks by owner.

#### 2.3.9 Deleted.

#### 2.3.10 Solid Waste Disposal

LSTK Contractor shall provide the disposal procedure for hazardous solid waste generated in their B/L. and shall also provide enabling infrastructure to dispose off the solid waste.

#### 2.3.11 Other facilities available in Chemical Complex (LSTK Contractor may review for possible utilisation (if any) and interact with Owner regarding any clarifications if required.)

<div></div>	<div><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div><u>PROJECT DESCRIPTION</u></div>	PC0288/E/001/P-II/ SEC-1.0	P1	<div></div>
		Document No.	Rev	
	Sheet 6 OF 6			

- Mechanical Work Shop with heavy equipment section including all shop floor facilities (optional)
- Electrical Workshop with shop floor facilities & Electrical testing laboratory (optional)
- Instrumentation Workshop including testing laboratory (optional)
- Quality Control Laboratory with all facilities
- Ambient Air monitoring system
- Fire Stations including all fire fighting facilities
- Warehouses including catalyst, Chemical Stores
- Administrative Building
- Occupational Health Centre
- Canteens
- Training Centre
- Security Watch Towers
- Any other enabling facility deemed fit by Owner

 पी डी आई एल <b>PDIL</b>	<b>PROJECTS &amp; DEVELOPMENT INDIA LTD.</b>	PC0288/E/001/P-II/ SEC-2.0	0	
		Document No.	Rev	
		Sheet 1 OF 10		

## PART II: TECHNICAL (2)



### SECTION – 2.0

#### RAW MATERIAL, PRODUCT AND UTILITY SPECIFICATIONS

**PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT**

**PROJECT: COAL TO AMMONIUM NITRATE COMPLEX, AT LAKHANPUR, ODISHA (INDIA)**

0	20/05/2024	20/05/2024	Issued for Tender Purpose	SR	SK	MN
P2	21/03/2024	21/03/2024	Issued for Client's approval	SR	SK	MN
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P	01/03/2024	01/03/2024	Issued for Client's comment	SR	SK	MN
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD



	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>Bharat Coal Gasification and Chemicals Limited</b> <b>RAW MATERIAL, PRODUCT AND UTILITY SPECIFICATIONS</b>	PC0288/E/001/P-II/ SEC-2.0	0	
		Document No.	Rev	
		Sheet 2 OF 10		

## CONTENTS

Section number	Description	Sheet Number
1.0	Raw Syngas	3
2.0	Utilities	4
3.0	Specification of Product	9

## LIST OF ATTACHMENT

Attachment number	Description	Number of Sheets

 <div>पी डी आई एल PDIL</div>	<div><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div><u>RAW MATERIAL, PRODUCT AND UTILITY SPECIFICATIONS</u></div>	PC0288/E/001/P-II/ SEC-2.0	0	
		Document No.	Rev	
		Sheet 3 OF 10		

## 1.0 RAW SYNGAS

Specification of Raw Syngas fed to Purification Plant for production of Ammonia Synthesis Gas is as follows:



Parameter	Unit	Value at 100%	Value at 50%
Hydrogen (H <sub>2</sub> )	Vol %	24.5	23.7
Carbon monoxide(CO)	Vol %	30.7	33.1
Carbon di oxide (CO <sub>2</sub> )	Vol %	18.2	17.1
H <sub>2</sub> O	Vol %	23.8	23.6
Methane(CH <sub>4</sub> )	Vol %	1.9	1.8
Nitrogen (N <sub>2</sub> )	Vol %	≤ 0.5	≤ 0.5
Ar	Vol %	≤ 0.08	≤ 0.08
Hydrogen sulphide (H <sub>2</sub> S)	Vol %	≤ 0.1	≤ 0.1
NH <sub>3</sub>	Vol %	≤ 0.6	≤ 0.6
HCN	Vol %	≤ 0.05	≤ 0.05
COS	Vol %	≤ 0.04	≤ 0.04
HCl	Vol %	≤ 0.0	≤ 0.0
Syngas Particulate content	Mg/Nm <sup>3</sup>	<10	<10
Pressure	Kg/Cm <sup>2</sup> abs	27±0.5	27±0.5
Temperature	°C	325±25	325±25

Traces Contaminants:-

Parameter	Unit	Value
Ca	Ppm wt	0.5-10
Mg	Ppm wt	0.5-10
Na + K	Ppm wt	0.5-10
Pb	Ppm wt	0.01-0.5
V	Ppm wt	0.01-0.5
Hg	Ppm wt	0.05-0.3
As	Ppm wt	0.05-0.3
Ni Fe Carbonyls	Ppm wt	1-10

**NOTE: It may please be noted that these details are indicative and based on the coal details as available (as per PFR). In case of any change in coal characteristics, the aforementioned inputs would be updated.**



Synthesis Gas Purification Unit should be able to respond to the operational interruption in Ammonia plant without jeopardising the plant safety.

 पी डी आई एल <b>PDIL</b>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>  <b><u>Bharat Coal Gasification and Chemicals Limited</u></b> <b><u>RAW MATERIAL, PRODUCT AND UTILITY SPECIFICATIONS</u></b>	PC0288/E/001/P-II/ SEC-2.0	0	
		Document No.	Rev	
		Sheet 4 OF 10		



## UTILITIES (indicative specification)

### 2.0

2.1	H.P Steam		
			Design
	Pressure, kg/cm <sup>2</sup> g (Min/ Nor/ Max)	105/107/110	As per Design guidelines (Section.-5.1)
	Temperature, °C (Min/ Nor/ Max)	510/515/520	
	Silica as SiO <sub>2</sub> , ppm	< 0.02	
	pH	9-9.5	
	Conductivity, μS/cm	< 0.2	
2.2	M.P Steam		
		Normal	Design
	Pressure, kg/cm <sup>2</sup> g	-/40/-	As per Design guidelines (Section.-5.1)
	Temperature, °C	-/380± 5/-	
2.3	L.P Steam		
		Normal	Design
	Pressure, kg/cm <sup>2</sup> g (Min/Nor/Max)	3.5/4.0/4.5	As per Design guidelines (Section.-5.1)
	Temperature, °C (Normal)	-/180/-	
2.4	Cooling Water (Added with suitable chemicals)		
	Supply Header Pressure, kg/cm <sup>2</sup> g (Min/ Nor/ Max)	LSTK contractor to decide	
	Return Header Pressure, kg/cm <sup>2</sup> g (Min/ Nor/ Max)	LSTK contractor to decide	
	Mechanical Design Pressure, kg/cm <sup>2</sup> g	10	
	Supply Header Temperature, °C	36	
	Return Header Temperature, °C	By LSTK Contractor	
	Mechanical Design Temperature, °C	60	
	ΔT	10 °C max.	
	Relative Humidity at Lakhanpur.	100% (max.)	
	COC	5	
	Analysis of Cooling Water (indicative)		
	pH	7- 8.5	
	Chlorides, mg/l	100	
	Sulphates, mg/l	-	
	Silica, mg/l	25	


 पी डी आई एल <b>PDIL</b>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>  <b><u>Bharat Coal Gasification and Chemicals Limited</u></b> <b><u>RAW MATERIAL, PRODUCT AND UTILITY SPECIFICATIONS</u></b>	PC0288/E/001/P-II/ SEC-2.0	0	
		Document No.	Rev	
		Sheet 5 OF 10		

	Iron, mg/l	1		
	Manganese, mg/l	-		
	Total Suspended Solids, mg/l	25		
	Total Dissolved Solids, mg/l	500		
	Oil & Grease, mg/l	Traces		
	Ammonia, mg/l	Traces		
	Alkanity, mg/l as CaCO <sub>3</sub>	340		
	Calcium Hardness, mg/l as CaCO <sub>3</sub>	500		
	Total Hardness, mg/l as CaCO <sub>3</sub>	750		
	LSTK contractor shall limit the pressure drop of 1.5 kg/cm <sup>2</sup> g (Max) between supply and return cooling water header within his battery limit.			
2.5	Nitrogen (Utility/Process)			
	Nitrogen	Utility	Process	
	Pressure, kg/cm <sup>2</sup> g (Min/Nor/Design)	6.0/8.0/9.0	35	
	Temperature	Ambient	≤100	
	N <sub>2</sub> , Vol %, min	99.99%	99.99%	
	O <sub>2</sub> , Vol ppm	< 10	<10	
2.6	Instrument Air	Min.	Nor.	Max.
	Pressure, kg/cm <sup>2</sup> g	6.0	8.0	10.0
	Supply Temperature, °C	Ambient	Ambient	50
	Mech. Design Pressure, kg/cm <sup>2</sup> g	10.5		
	Mech. Design Temperature, °C	65		
	Dew point	-40 ° C at 8 kg/cm <sup>2</sup> g		
	Quality	Free of dust, water drops & oil		
	Storage Capacity (Storage Tank Under LSTK Contractor's Scope)	To be filled by LSTK Contractor If required		
2.7	Demineralised Water			
	Pressure @ B/L, kg/cm <sup>2</sup> g (Min/ Nor/ Max)	4.0/ 5.5/ 6.0		
	Temperature, °C (Normal)	Ambient/40 (max)		
	Mech. Design Pressure, kg/cm <sup>2</sup> g	10		
	Mech. Design Temperature, °C	70		
	pH	6.5-8.5		
	Total Hardness, ppm wt.	Zero		
	Total Dissolved Solids, ppm wt (max.)	0.1		
	Conductivity at 20 deg C, micro mho/cm (max.)	<0.2		
	M Alkanity as CaCO <sub>3</sub> , ppm wt.	Nil		
	Chlorides, ppm wt.	Nil		

 पी डी आई एल <b>PDIL</b>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>  <b><u>Bharat Coal Gasification and Chemicals Limited</u></b> <b><u>RAW MATERIAL, PRODUCT AND UTILITY SPECIFICATIONS</u></b>	PC0288/E/001/P-II/ SEC-2.0	0	
		Document No.	Rev	
		Sheet 6 OF 10		



	Iron as Fe, ppm wt. (max.)	0.01
	Silica as SiO <sub>2</sub> , ppm wt. (max.)	0.02
	Oil, ppm wt.	Nil
	Sodium as Na, ppm wt. (max.)	< 0.1
<b>2.8</b>	<b>Boiler Feed Water</b>	
	Total Hardness as CaCO <sub>3</sub> , ppm	Nil
	O <sub>2</sub> , ppm	<0.005
	CO <sub>2</sub> , ppm	< 1
	Silica as SiO <sub>2</sub> , ppm	< 0.02
	pH at 25°C	9-9.5
	Conductivity, µS/cm	0.2
	Oil, ppm	< 0.1
	Permanganate, ppm	< 5
<b>2.9</b>	<b>Boiler Blow Down (Boiler CBD)</b>	
	pH	9.0-10.0
	Silica as SiO <sub>2</sub> , ppm	< 0.5
	Conductivity, µS/cm	< 50
	Phosphate, ppm	2-5
<b>2.10</b>	<b>Service Water</b>	
	Colour	< 5.0
	Smell	Agreeable
	pH	7.0-8.5
	Taste & Odour	Unobjectionable
	TDS, mg/l	< 150
	Turbidity, NTU	< 1.0
	Total Hardness, mg/l	< 85
	Chloride (as Cl), mg/l	< 15
	Sulphate (as SO <sub>4</sub> ), mg/l	< 60
	Total Iron (Fe), mg/l	< 0.01
	Dissolved Silica, mg/l	< 4
	Supply Pressure, kg/cm <sup>2</sup> g (Min/ Nor/ Max)	4.0/6.0/8.0
	Supply Temperature, deg C	Ambient
	Mechanical Design Pressure, kg/cm <sup>2</sup> g	10.5
	Mechanical Design Temperature, deg C	65
<b>2.11</b>	<b>Process Water/ Raw water (after treatment) (Tentative)</b>	





	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>		PC0288/E/001/P-II/ SEC-2.0	0
			Document No.	Rev
	<b>Bharat Coal Gasification and Chemicals Limited</b> <b>RAW MATERIAL, PRODUCT AND UTILITY SPECIFICATIONS</b>		Sheet 7 OF 10	



	pH	7 – 8.5
	Chlorides, mg/l	20
	Sulphates, mg/l	-
	Silica, mg/l	5
	Iron, mg/l	0.2
	Manganese, mg/l	-
	Total Suspended Solids, mg/l	5
	Total Dissolved Solids, mg/l	100
	Oil & Grease, mg/l	Traces
	Ammonia, mg/l	Traces
	Alkanity, mg/l as CaCO <sub>3</sub>	68
	Calcium Hardness, mg/l as CaCO <sub>3</sub>	100
	Total Hardness, mg/l as CaCO <sub>3</sub>	150
	Supply Pressure, kg/cm <sup>2</sup> g (Min/ Nor/ Max)	4/ 6/ 8
	Supply Temperature, deg C	Ambient
	Mechanical Design Pressure, kg/cm <sup>2</sup> g	10.5
	Mechanical Design Temperature, deg C	65
<b>2.12</b>	<b>Drinking Water</b>	
	Colour	< 5.0
	Smell	Agreeable
	pH	7.0-7.5
	Taste & Odour	Unobjectionable
	TDS, mg/l	< 150
	Turbidity, NTU	< 1.0
	Total Hardness, mg/l	< 85
	Chloride (as Cl), mg/l	< 15
	Sulphate (as SO <sub>4</sub> ), mg/l	< 60
	Total Iron (Fe), mg/l	< 0.01
	Dissolved Silica, mg/l	< 4
	Supply Pressure, kg/cm <sup>2</sup> g (Min/ Nor/ Max)	4/ 5.5/ 6.0
	Supply Temperature, deg C	Ambient
	Mechanical Design Pressure, kg/cm <sup>2</sup> g	10.0
	Mechanical Design Temperature, deg C	65
	Note: Drinking water of quality conforming to IS: 10500-1991 shall be provided by the Owner to LSTK Contractor at the Battery Limit.	
<b>2.13</b>	<b>Pre-Treated Condensate</b>	
	pH	8.5 - 9.5
	Conductivity, µS/cm	0.2

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>Bharat Coal Gasification and Chemicals Limited</b> <b>RAW MATERIAL, PRODUCT AND UTILITY SPECIFICATIONS</b>	PC0288/E/001/P-II/ SEC-2.0	0	
		Document No.	Rev	
		Sheet 8 OF 10		

	Total Dissolved Solids (TDS), PPM (Max.)	0.5
	Silica (SiO <sub>2</sub> ), PPM (Max.)	0.02
	Iron (Fe), PPM (Max.)	0.02
	Copper (Cu), PPM (Max.)	0.003
	Sulphate (SO <sub>4</sub> <sup>2-</sup> ), PPM (Max.)	0.02
	Chloride (Cl <sup>-</sup> ), PPM (Max.)	0.1
	Quantity, M <sup>3</sup> /hr	(To be specified by LSTK CONTRACTOR)
<b>2.14</b>	<b>Plant Air</b>	
	Moisture	Saturated
	Oil Content	Nil
	Supply Pressure, kg/cm <sup>2</sup> g (Min/ Nor/ Max)	4.0/7.0/8.0
	Supply Temperature, deg C (Min/ Nor/ Max)	40/40/50
	Mechanical Design Pressure, kg/cm <sup>2</sup> g	10.5
	Mechanical Design Temperature, deg C	65
<b>2.15</b>	<b>Fire Water **</b>	
	Pressure kg/cm <sup>2</sup> g	Min. 7 (As per NFPA/TAC)
	Temp. deg C	Ambient
	<b>** Fire water header of LSTK area shall be connected to Fire water ring main header of the complex.</b>	
<b>2.16</b>	<b>Fuel (If required)</b>	
	Quality	Latest revision
	Pressure kg/cm <sup>2</sup> g	Atm.
	Temp. deg C	Ambient
<b>2.17</b>	<b>Power (Indicative Only) {Refer Section-5.4 Design Philosophy Electrical for detailed distribution} 11 KV GENERATION</b>	
	Power for electric drives and lighting shall be: <ol style="list-style-type: none"> <li>11000 V ± 10%, 3 phase 50 Hz ± 5% Resistance grounded for drives of 1000 KW and above.</li> <li>3300 V ± 10%, 3 phase 50 Hz ± 5% Resistance grounded for drives above 160 KW &amp; below 1000 KW.</li> <li>415 V ± 10%, 3 Phase, 50 Hz ± 5% for drives from 0.37 KW up to 160 KW, Neutral is solidly earthed.</li> <li>For motors up to 0.37 kW: 230 V ± 10%</li> <li>For instruments and lighting the voltage shall be 240V ± 10%, 50Hz ± 5%, single phase AC, grounded</li> <li>UPS system shall be 240V AC, for Telecommunication, IT, Security System, CCTV system equipment.</li> <li>UPS system shall be 110V AC (for Instrumentation)</li> </ol>	
	NOTE: Design Philosophy (Electrical)" to be followed if any discrepancy found with "Design Basis.	

 पी डी आई एल <b>PDIL</b>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>  <b><u>Bharat Coal Gasification and Chemicals Limited</u></b> <b><u>RAW MATERIAL, PRODUCT AND UTILITY SPECIFICATIONS</u></b>	PC0288/E/001/P-II/ SEC-2.0	0	
		Document No.	Rev	
		Sheet 9 OF 10		

### 3.0 SPECIFICATION OF PRODUCT

#### 3.1 AMMONIA SYNTHESIS GAS

The product Ammonia Synthesis Gas quality, which shall be (Feed stock for the production of Liquid Ammonia) shall be produced in the Purification Plant.

##### Typical Analysis of Ammonia Synthesis Gas:



Sl. No	Components	Composition
1.0	Hydrogen (H <sub>2</sub> ), Vol % (min.),	~75
2.0	Nitrogen (N <sub>2</sub> ), Vol % (min)	~25
3.0	Argon (Ar), PPV(max)	30
4.0	Mercury (Hg), PPMv (max.)	Nil
5.0	CO + CO <sub>2</sub> + other Oxygen bearing components, PPM by Vol	5 (Max.)
6.0	Pressure @ B.L of Purification Plant, kg/cm <sup>2</sup> a (Min)	18 (hold)
7.0	Temperature, °C (Max.)	30 (hold)

#### 3.2 CARBON DI-OXIDE

This will be used in LSTK 1 package for conveying of feed coal and purging purpose. Following specification will be required at LSTK1 battery limit.

##### Typical Analysis of Carbon dioxide:

Sl. No.	Components	Composition	
1.0	Carbon dioxide (CO <sub>2</sub> ), Vol % (min).	98.5 (min., dry)	
2.0	Hydrogen (H <sub>2</sub> ), Vol % (max)	0.1 (dry)	
3.0	Nitrogen (N <sub>2</sub> ), Vol % (max)	1.0 (dry)	
4.0	Argon (Ar) Vol % (max)	0.01 (dry)	
5.0	Carbon Mono-Oxide (CO) Vol % (max)	0.15 (dry)	
6.0	Moisture Vol %	Saturated	
7.0	HCN PPM by Vol	1	
8.0	Methanol PPM by Vol	100 (max, dry)	
9.0	Sulphur (COS+H <sub>2</sub> S) PPM by Vol	5 (max)	
10.0	Pressure @ B.L of Coal Gasification Plant, kg/cm <sup>2</sup> g (Min.)	32	57
11.0	Temperature, °C	<100	270



 पी डी आई एल <b>PDIL</b>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>  <b><u>Bharat Coal Gasification and Chemicals Limited</u></b> <b><u>RAW MATERIAL, PRODUCT AND UTILITY SPECIFICATIONS</u></b>	PC0288/E/001/P-II/ SEC-2.0	0	
		Document No.	Rev	
		Sheet 10 OF 10		

### 3.3 ELEMENTAL SULPHUR

Elemental Sulphur is a co-product from the Purification plant and shall be sold in market.

**The product Elemental Sulphur will meet the following specification after degassing:**

State	:	Solid
H <sub>2</sub> S content	:	10 ppm weight max.,dry
Ash	:	200 ppm weight max, dry.
Purity	:	Min. 99.9% wt% on dry basis
Colours	:	Bright yellow
Pressure	:	Not Relevant
Temperature	:	Ambient

<div> पी डी आई एल <b>PDIL</b></div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>Bharat Coal Gasification and Chemicals Limited</u></b>		PC0288/E/001/P-II/ SEC-3.0	0	<div> बी एच ई एल</div>
	<b>CONTRACTOR'S SCOPE OF WORK</b>		Document No.	Rev	
			Sheet 1 OF 71		

## PART - II: TECHNICAL (2)



### SECTION - 3.0

#### CONTRACTOR'S SCOPE OF WORK

**PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT**

**PROJECT: COAL TO AMMONIUM NITRATE COMPLEX,  
AT LAKHANPUR, ODISHA (INDIA)**

0	20/05/2024	20/05/2024	Issued for Tender Purpose	SR	SK	MN
P3	26/03/2024	26/03/2024	Issued for Client's approval	SR	SK	MN
P2	15/03/2024	15/03/2024	Issued for Client's approval	SR	SK	MN
P1	15/03/2024	15/03/2024	Issued for Client's approval	SR	SK	MN
P	05/03/2024	05/03/2024	Issued for Client's comment	SR	SK	MN
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD



 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 2 OF 71	

## **CONTENTS**

SL. NO.	DESCRIPTION	SHEET NUMBER
1.0	General	3
2.0	Other requirements	5
3.0	Major facts about Operation & Maintenance	7
4.0	Scope of work	8
5.0	Role of Technology Licensor	9
6.0	Scope of Basic Engineering Services	10
7.0	Scope of Detailed Engineering Services	31
8.0	Procurement	50
9.0	Inspection & Expediting	51
10.0	Project Planning, Scheduling & Monitoring	55

## **LIST OF ATTACHMENT**

SL. NO.	DESCRIPTION	NUMBER OF SHEETS
1.	Attachment-1	1

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 3 OF 71	

## 1.0 GENERAL



LSTK CONTRACTOR shall supply & install a Syngas Purification Unit for Coal Gasification Plant on a site owned by Bharat Coal Gasification and Chemicals Limited (**BCGCL**), Lakhanpur, District- Jharsuguda, Odisha (India) as per the requirements and specifications.

**1.1** Scope of work of the LSTK Contractor shall include Supply of License/s, Basic Design and Detailed Engineering, Procurement, Supply, Fabrication, Inspection by Third Party Inspection Agency (TPI) as applicable, Expediting, Route survey for Over Dimensional Consignments (ODCs), Insurance, Transportation of all equipment / materials to work site, Storage, construction and erection of all civil, mechanical, electrical and instrumentation works, assembly and Installation, obtaining all necessary statutory approvals, Testing, Mechanical Completion, Pre-Commissioning, Commissioning, Sustained Load Test Run, Operator Training, Performance Guarantee Test Run (PGTR) including Total Project Management and handing over of the plants and facilities under contractor's scope of work duly completed on single point responsibility basis.

**1.2** The following plants and facilities shall be under the scope of the LSTK Contractor for Syngas Purification Unit:

- a) Receiving of Syngas (automatic system shall be considered) - (1 train)
- b) Carrier CO<sub>2</sub> System-(1 train) for other consumer (LSTK -1) as per the required quality
- c) Gas purification unit to produce Ammonia Syn. Gas (N<sub>2</sub> + 3H<sub>2</sub>).-(1 train).
- d) Sulphur Recovery Unit (SRU) (1 trains) and Storage.
- e) Cooling Water requirement to be furnished. It is proposed that, cooling water requirement to be merged along with Gasification Island.
- f) Electrical Sub-station.
- g) Control System shall be supplied by LSTK-2 contractor. However Panels shall be installed in LSTK-1 Control Room. LSTK-2 Contractor to provide the following details to LSTK-1 contractor (Erection & commissioning shall be in LSTK-2 contractor only, shall be provided alongwith bid):
  - a. 1) No. & Size of the panels to be placed in control room,
  - b. HMI BOQ,
  - c. UPS panel size & Battery size
  - d. Heat dissipation requirement along with the suggestive layout
- h) Chemical laboratory instruments & laboratory chemicals.
- i) Procedure for safe disposal of hazardous solid waste, if any.
- j) Pre-Treatment of effluent generated within LSTK-2 B/L, as applicable..
- k) First fill of all catalyst, chemicals & consumables and requirement during Pre-Commissioning, Commissioning, Sustained Load Test Run and Guarantee Test Run (GTR).
- l) After GTR, 120 calendar month assisted supervisory operation.
- m) Supply of chemicals and consumables required for a period of 120 calendar months from completion of Guarantee Test Run.
- n) Fire fighting & safety system for LSTK's scope of work as per requirement of NFPA.
- o) Instrument Air requirement to be furnished.
- p) Sewage transfer within LSTK B/L, at common point.

**1.3** The following Offsite & Utility plants shall be EXCLUDED from the scope of LSTK contractor of Syngas Purification Unit:

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>	Sheet 4 OF 71		

- a) Solid Sulphur dispatch.
- b) Hazardous solid waste disposal.
- c) Raw water storage & pumping.
- d) Water pre-treatment plant.
- e) DM & condensate polishing unit.
- f) Cooling tower, CW pumps, Pump house
- g) Common Effluent Treatment Plant based on ZLD concept.
- h) Instrument and Plant Air system.
- i) Steam Generation Plant.
- j) Switchyard.
- k) Non Plant Buildings
- l) Mechanical work shop building with machineries.
- m) Electrical work shop building along with instruments & machineries.
- n) Instrument work shop building along with instruments & machineries.
- o) Railway Siding.
- p) Yard Piping for facilities outside LSTK contractor scope.
- q) Control room Building
- r) Chemical Lab Building

**1.4** Following raw material & utilities shall be made available to the LSTK contractor at one point Syngas Purification Unit Plant Battery Limit after mechanical completion of the unit.

- a) Process water
- b) DM water
- c) Fire water
- d) Instrument Air
- e) Electrical Power
- f) Cooling Water
- g) Nitrogen
- h) Plant Air
- i) Steam
- j) Boiler Feed Water.



**1.5** Following major streams shall be made available by the LSTK contractor at one point Syngas Purification Unit Plant Battery Limit (details to be provided along with the BID)

- b) Ammonia Syn. Gas.
- c) CO<sub>2</sub> gas (carrier & purge)
- d) Elemental sulphur
- e) Effluent and emission
- f) Steam (if applicable)
- g) Condensate
- h) Any other

**Note: 1** Some of the utilities like Instrument Air, DM Water, make-up water for cooling Tower (separate LSTK Contractor's scope), Electricity to be supplied by Owner after Pre-Commissioning at Syngas purification Unit B.L.

**Note: 2.** LSTK Contractor shall provide Ammonia Syn. Gas (N<sub>2</sub>+3H<sub>2</sub>) 1,05,000 NM<sup>3</sup>/hr & CO<sub>2</sub> 24000 NM<sup>3</sup>/hr @32Kg/CM<sup>2</sup>(g) & 2550 NM<sup>3</sup>/hr @57Kg/CM<sup>2</sup>(g) on 100% Plant Capacity.



 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 5 OF 71	

Note: 3. Gas Purification System containing CO shift, H<sub>2</sub>S removal, CO<sub>2</sub> removal, LN<sub>2</sub>W, SRU etc. shall be designed for full design capacity.



Note: 4. Construction Power required for Coal Gasification Plant till mechanical completion shall be arranged by LSTK Contractor himself.

Power required for Plant start-up & operation for Syngas purification Unit shall be supplied by Owner at a single point at substation located at LSTK B/L.

Note: 5. Detailed Engineering for various sections of Syngas purification Unit is to be carried out by experienced Detail Engineering Contractor who has carried out Detailed Engineering of complete or respective sections of Syngas purification Unit in the past.

## 2.0 OTHER REQUIREMENTS



- 2.1 Tie-up/ hook-up with designated tie-up points for hooking up to other systems executed by other agencies. Perform construction management and supervision of all equipments, material and works.
- 2.2 Provide and perform comprehensive quality assurance, quality control and inspection of all equipments, materials works - both in manufacturing shop and at work site.
- 2.3 Provide all manpower, materials, consumables, construction equipment / machines, tools, instruments, storage, fabrication, facility and all other services and inputs etc. necessary to perform the work and complete the plant.
- 2.4 Comply with all Central, State & Local Govt. regulations, laws and requirements applicable to the work and seek & obtain approvals/ clearances from such statutory bodies/ agencies, as required. **Bharat Coal Gasification and Chemicals Limited** (BCGCL) in this regard will be only to provide authorization in favor of LSTK CONTRACTOR for which all the necessary paper work will be done by LSTK CONTRACTOR.
- 2.5 Provide necessary temporary construction facilities like fabrication, storage, illumination etc. and removal of temporary arrangement to make the space reusable.
- 2.6 Comply with all safety practices for and during work as per applicable standards.
- 2.7 Strictly comply with applicable codes and standards of Engineering, Fabrication, Inspection, Construction etc.
- 2.8 Arrange services of Manufacturer's installation/ commissioning Engineer(s) at Site during Mechanical Completion/ Pre-commissioning/ Commissioning/ GTR of all the major equipment and systems.
- 2.9 Provide all the temporary connections/ supplies required for testing/ pre-commissioning activities and also to provide all instrument metering systems required for measurements of various parameters/ testing during test runs.
- 2.10 Arrange spare parts for start-up/ pre-commissioning / commissioning/ Sustain Load Test Run/ GTR/ 120 calendar month supervisory operation of plants. All such spares are to be available at site prior to commissioning/ start up of the plant including various test runs.

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 6 OF 71	

- 2.11 Perform testing, flushing, cleaning and pre-commissioning, start-up/ commissioning.
- 2.12 Submission of final drawings and documents shall be as per Section No 9.0 (Drawings and Documents) of Part-II Technical.
- 2.13 Project Management and planning, scheduling and monitoring/comprehensive reporting services, periodic reviews, meeting notes with **Bharat Coal Gasification and Chemicals Limited (BCGCL) / PMC**.
- 2.14 The scope of work as described above shall be supplementary to the scope of work mentioned under various parts of Tender Document. In case of any contradiction between the two, the stipulations mentioned under various disciplines shall be governing. In this regard, **Bharat Coal Gasification and Chemicals Limited (BCGCL)** interpretation shall be final and binding to LSTK CONTRACTOR.
- 2.15 Transportation of all the materials supplied by **Bharat Coal Gasification and Chemicals Limited (BCGCL)**, if any, from their store to LSTK CONTRACTOR's Store/ work site including loading/ unloading.
- 2.16 Total painting including special paints, color coding, insulations, refractory, CS / S.S. name plates etc. as per applicable standards.
- 2.17 Any other work not specifically mentioned above but required for completeness of the plant shall be undertaken by the LSTK Contractor.
- 2.18 LSTK CONTRACTOR shall implement the recommendations if any, of HAZOP / HAZAN/ SIL Study, without any additional cost / time schedule implication to **Bharat Coal Gasification and Chemicals Limited (BCGCL) / PMC**.
- 2.19 LSTK CONTRACTOR shall adhere to Design Control exactly as per provisions of ISO 9001:2015. LSTK CONTRACTOR shall submit required records as evidence for review by **Bharat Coal Gasification and Chemicals Limited (BCGCL) / PMC** as and when required, and shall carry out changes based on **Bharat Coal Gasification and Chemicals Limited (BCGCL) / PMC** review.
- 2.20 LSTK contractor shall supply the spares, lubricants, chemicals and other consumables in the LSTK price for the 120 calendar months after Guarantee Test Run in addition to the Pre-commissioning/ Commissioning/ Sustain Load Test Run spares and consumables. Quantity of spare, lubricant, chemicals & consumables shall be based on 100% plant operation. For subsequent two year requirement, LSTK contractor to provide the list along with price of recommended spares and consumables. However, price is not to be included in the lump sum price.
- 2.21 Owner desires 120 calendar months (after GTR) O&M assistance with designated selected manpower defined by Owner in below table.

Manpower required for O&M assistance

Sr. No.	Discipline	Designation	Qualification	Experience
1.	Chemical	Overall Manager	B.Tech, Chemical Engg.	Min. 10 year
2.	DCS Operator	Super-Wiser	Diploma/ B.Sc	Min. 10 year
3.	Electrical	Super-Wiser	Diploma/ B.Sc	Min. 10 year
4.	Instrument	Super-Wiser	Diploma/ B.Sc	Min. 10 year

 <div>पी डी आई एल PDIL</div>	<div><u><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></u></div> <div><u><b>Bharat Coal Gasification and Chemicals Limited</b></u></div> <div><u><b>CONTRACTOR'S SCOPE OF WORK</b></u></div>	PC0288/E/001/P-II/ SEC-3.0	0	
		Document No.	Rev	
		Sheet 7 OF 71		

5.	Mechanical	Super-Wiser	Diploma/ B.Sc	Min. 10 year
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Note-1 The manpower mentioned in Sr. 1, 2 & 4 must have the experience of Gas cleaning & Purification.

Note-2 Instrument discipline personal must have the experience of DCS, field & other instruments.

2.22 LSTK contractor shall arrange complete manpower including Licensor's manpower mutually agreed by Owner, Licensor & LSTK Contractor for Pre-Commissioning/ Commissioning/ Sustain Load Test Run/ GTR and Operation & Maintenance.

2.23 LSTK contractor shall follow the Licensor's advice to depute the Licensor's manpower with respect to numbers, discipline & experience for Safe and trouble free Pre-Commissioning/ commissioning/ Sustain Load Test Run/ GTR of plant.

2.24 Procurement of Laboratory Equipments, Installations, Pre-Commissioning, Commissioning is in the Scope of LSTK Contractor.

2.25 LSTK Contractor shall furnish the list of Laboratory Equipments to be procured based on licensor's list with bid. Laboratory Equipment's manufacturers will be based on licensor recommended list. For non license area, LSTK contractor shall furnish the laboratory equipment list along with details.

2.26 Chemicals, consumable, calibration gases required for Pre-Commissioning/ Commissioning of Laboratory shall be in LSTK Contractor scope.

2.27 120 calendar months Chemical, Consumables, Calibration Gases, and any other Consumable for Laboratory shall be in LSTK Contractor Scope. 120 calendar months Operation Assistance shall be in LSTK Contractor Scope.



### 3.0 MAJOR FACTS ABOUT OPERATION AND MAINTENANCE:

LSTK contractor shall consider 120 calendar months comprehensive operation & maintenance contract (to be renewed every year) for the complete plants and facilities under their scope of work and this shall form part of evaluation. 120 calendar months operation & Maintenance shall be started from the date of preliminary acceptance of Purification Plant. However, In case there is delay, for reasons not attributable to owner, in preliminary acceptance of plants, the contractor shall render his services to cover the above said period on the same T&C including Monthly Charges.

The O&M price shall be fixed and no escalation is applicable. During the contract period of O&M, Contractor shall maintain quality, quantity of Products and by-product as defined in the tender document and ensure trouble free operation of units individually and plant as a whole at all capacities above turn down ratio to design capacity, without any unplanned shutdown.

Contractor will depute adequate skilled and experienced staff capable for operation and maintenance of the plants covered under this contract.

This shall include experienced staff under a plant in charge. Bidders to provide details of O&M carried out by them for Purification plant including CV's of key personnel who are intended to be deployed for operation of the plants. Details of O&M carried out shall be provided with the technical un-priced bid. CV's shall be submitted for Owner approval before deputing the staff at site.

 पी डी आई एल <b>PDIL</b>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>	Sheet 8 OF 71		

All Spares, Consumables, Lube Oil to be in Bidder Scope. They have to maintain minimum spares as per list provided in Section-10.0 and to replenish the same after use. The minimum items specified in the Annexure to be handed over to the client at the end O&M contract.



Preventive maintenance of all equipments as directed by Engineer-in-charge will be carried out by the contractor and records of same will be maintained by the contractor. Same will be got checked from engineer-in-charge and submitted to Engineer-in-charge every month.

All tools and tackles required for the safe and satisfactory operation and maintenance including preventive and break down maintenance of the substation and related equipment shall be provided by the contractor. The careful maintenance and management of these tools will be the responsibility of the contractor.

#### 4.0 Scope of Work

**The scope of work of the LSTK Contractor for the plants shall include but not limited to the following:**

1. Grant of Licence and Transfer of Know How.
2. Basic Design.
3. Detailed Engineering.
4. Review, vetting and Analysis of Detailed Engineering by Process Licensor.
5. HAZOP/HAZAN/SIL Study and implementation of its recommendations.
6. Drawings and Documents with necessary software and hardware.
7. Procurement and supply of all equipment & materials.
8. Government / Statutory clearances.
9. Network Schedule.
10. Spares and Special Maintenance Tools.
11. Construction Tools.
12. Shipment, Transportation and Storing of equipment at site. Insurance during Transit, storage and construction.
13. Construction & Erection of all civil & structural items, mechanical, electrical, & instrumentation works.
14. Inspection & Expediting.
15. Project Planning, Scheduling & Monitoring
16. Quality Assurance & Quality Control
17. Safety and Plant Security.

 <div>पी डी आई एल PDIL</div>	<div><u><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></u></div> <div><u><b>Bharat Coal Gasification and Chemicals Limited</b></u></div> <div><u><b>CONTRACTOR'S SCOPE OF WORK</b></u></div>	PC0288/E/001/P-II/ SEC-3.0	0	
		Document No.	Rev	
		Sheet 9 OF 71		

18. Pre-Commissioning.
19. Mechanical Completion.
20. Start Up and Commissioning.
21. Performance Guarantee.
22. Laws and Regulations compliance.
23. Progress Monitoring and Reporting.
24. Submission of Technical Information.
25. Supervision of work of LSTK's Sub-contractors.
26. Training of Owner's Personnel.
27. Co-ordination with all organisations concerned with implementation of the project.
28. Payment of all applicable Taxes and Duties etc.
29. List & specifications of mechanical/Electrical/instrument work shop items necessary for proper maintenance of all equipments of Ammonia Plant for subsequent procurement of the same by owner.

LSTK contractor shall provide split of work between Licensor, detail engineering contractor and LSTK contractor in the form of matrix.

## **5.0 ROLE OF TECHNOLOGY LICENSOR:**



### **5.1 Supply of Licence and Know-how:**

LSTK Contractor shall arrange to grant licence to Owner for operation of plants from respective supplier's of Process Technology for the following:

- i. Ammonia Synthesis Unit
- ii. Others, if any

### **5.2 Process Design & Basic Engineering:**

Preparation of Process Design and Basic Engineering Package for the plant shall include all the details that may be necessary and sufficient to permit a competent Engineering and Construction Company to prepare the detailed mechanical design/drawings for construction and operation of the plant. Such technical information and the process design and basic engineering package shall be established in the English language and submitted to owner /PMC for approval.

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 10 OF 71	

### 5.3 **Review of Detailed engineering documents:**

Review of Detailed engineering documents for process compliance (list of such mandatory review documents shall be provided by Licensor).

### 5.4 **Review of P&I Diagram:**

Review of P & I Diagram after HAZOP/ HAZAN/ SIL Study.

### 5.5 **Assistance:**

Assistance during Detailed Engineering, Procurement, Construction, Pre-commissioning, Commissioning and Performance Guarantee Test Run (PGTR).

### 5.6 **Final checking:**

Final Checking of the plants after Mechanical completion before start of Commissioning.

### 5.7 **Training:**

Training of Owner's Operating and Maintenance Personnel.

### 5.8 **Support:**

Support during advanced process control system implementation if necessary.



## 6.0 **SCOPE OF BASIC ENGINEERING SERVICES:**

### **ENGINEERING DESIGN SPECIFICATIONS:**

The Engineering Design Specifications shall comprise of technical data and information required for the Detailed Design and Engineering, Procurement/supply of Equipment and Material, Construction, Pre-Commissioning, Start-up and Operation of the Ammonia Synthesis, Ammonia storage & associated Utilities. Such information shall be prepared for each Process Unit separately and independent of other Process & Utilities Unit. It shall include, but not limited to the following:

### 6.1 **General:**

- a) Basis of Design.

 <div>पी डी आई एल PDIL</div>	<div><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></div> <div><b><u>Bharat Coal Gasification and Chemicals Limited</u></b></div> <div><b><u>CONTRACTOR'S SCOPE OF WORK</u></b></div>	PC0288/E/001/P-II/ SEC-3.0	0	
		Document No.	Rev	
		Sheet 11 OF 71		



- b) Optimized Heat and Material Balance.
- c) Detailed Process Description.
- d) Piping and Instrumentation Diagrams (P & IDs).
- e) Basic control schemes and interlocking requirements to have safe and efficient operations.
- f) Specifications and properties of Feed, Intermediate products, By-products and Products for each individual Process & Utilities Unit.
- g) Specifications, Quantities and Points of emissions and effluent and respective procedures for safe treatment of emissions and disposal of effluent streams economically. Similar details for solid waste and its management shall also be furnished
- h) Physical and Chemical properties of major flow streams.
- i) Battery Limit definitions and conditions for various streams coming to and leaving of each individual Process & Utilities Unit.
- j) Design calculation results with respect to the Equipment, Piping and hydraulic design of each individual Process & Utilities Unit.
- k) Material specifications including corrosion allowance for effluent collection system(s).
- l) Specifications of the required utilities with allowable tolerances, giving minimum, normal and peak consumption figures with duration for individual Process & Utilities Unit.
- m) Specifications, Properties and Consumption figures of all Catalysts, Adsorbents, Solvent, Chemicals and Consumables including three proposed names and addresses of the main and permanent suppliers for each item.
- n) Specifications, Quantities and Qualities of the Utilities which are generated in Process & Utilities Unit.

## 6.2 **Basis of design:**

For each Process & Utilities Unit, the Basis of Design shall include the following:

- a) Introduction, Function and scope of the Process & Utilities Unit, Site location and existing facilities.
- b) Definition and Description of Process Design Case.
- c) Process Design Criteria and Contingencies.



 पी डी आई एल <b>PDIL</b>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	 भारत कोयला <b>BHEL</b>
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 12 OF 71	

- d) Mechanical Design Criteria and Contingencies.
- e) Feed Specifications including Tests Methods.
- f) Utilities Specifications.
- g) Products – Specifications (SOR & EOR) including Test Methods.
- h) Products – Expected Yields (SOR & EOR).
- i) Reactor's Yields (SOR & EOR) and BTP (Bed Temperature Profile) data (if applicable)
- j) Battery Limit Conditions.
- k) Chemistry of all reactions involved in the each Process Unit.
- l) Safety aspects and requirements of the Process & Utilities Unit.
- m) Specifications, Quantities, Properties and Locations of gaseous, liquid and solid wastes of the Process & Utilities Unit and proposed procedures for safe disposal of wastes (Environmental requirements).
- n) Codes and Standards.
- o) Numbering System
- p) Units of Measurement
- q) Spare Philosophy
- r) Brief Instrumentation/Control Philosophy



### **6.3 Flow Diagrams and Process Description:**

Required flow diagrams including necessary and sufficient information, data and detailed description, shall be provided individually for all sections of the Process & Utilities Unit included in the plants. LSTK Contractor may follow/ provide the drawings/documents as per Process Licensor's practice. However LSTK Contractor shall ensure the following minimum information in each of the drawing/documents as indicated below.

#### **6.3.1 Process Flow Diagrams and Process Description:**

Detailed process description (based on Process and Utility Flow Diagrams) shall be provided giving technical information which would determine optimum operating conditions and all



 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 13 OF 71	



expected alternative operations like Start-of-run, End-of-run cases with different feed compositions, if applicable etc. Detailed process description shall be submitted together with first issue of the process flow diagrams.

The process flow diagram shall contain at least the following information:

- All Process Equipment shall be shown diagrammatically marked with equipment numbers and titles.
- Duties of the Equipment.
- Operating temperature, Pressure, Total flow rates, Composition, Vapour and liquid flow rates' content and composition.
- Process lines (marked with stream numbers) showing direction of flow and all interconnections between the Process & Utilities Unit.
- Process controls with all active control loops.
- All lines essential for understanding the mass balance around each piece of equipment shall be shown.
- All figures should be given in SI metric system, (or) traditional units of measurement.
- Reflux flow rate.
- Feed tray locations, number of trays type of packing and side draw-off locations.
- Type of the heat exchangers and indication of shell and tube side.
- Streams essential towards an understanding of the mass balance shall be numbered and a table on the same diagram provided including the Componential molar flows, Mass flows, Mole percent, Molecular weight, Pressure, Temperature, Enthalpy, Density or Specific gravity, Specific heat and Viscosity and other thermodynamic data which will be used in the process design of the Process & Utilities Unit for each numbered stream at actual flowing condition. Operating Temperatures and Pressures shall additionally be provided for equipment. Reflux rates shall also be shown.

### 6.3.2 Block Flow Diagram:

Overall schematic diagram of each Process & Utilities Unit showing process sections and major Equipment necessary for defining inter Process & Utilities Unit connection.

 <div>पी डी आई एल PDIL</div>	<div><u><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></u></div> <div><u><b>Bharat Coal Gasification and Chemicals Limited</b></u></div> <div><u><b>CONTRACTOR'S SCOPE OF WORK</b></u></div>	PC0288/E/001/P-II/ SEC-3.0	0	
		Document No.	Rev	
		Sheet 14 OF 71		

For each of the Process & Utilities Unit terminal material balances shall also be shown individually as a table on the same diagram.

#### 6.4 **Material and Heat Balance Sheets:**

For each stream number shown on the Process Flow Diagrams, the material and heat balance shall be specified indicating the stream properties Flow rate, Composition, Phase, Temperature, Pressure, Operating and Standard specific gravity or density, Enthalpy, Specific heat, Viscosity, Molecular weight for gases and vapours and all other thermodynamic information and data as are used and applied in the Basic Design of each Process & Utilities Unit.

#### 6.5 **Catalysts, Chemicals, Adsorbents, Resins And Solvents:**



- Consumption figures.
- Physical, Chemical and Qualitative properties including all thermodynamic data as required for design and operation.
- Material safety datasheet and disposal procedures for hazardous materials.
- Loading, unloading and make-up procedures.
- Detailed regeneration procedures, if applicable.
- Shelf life.
- Any specific warehousing requirement.
- Three (3) proposed permanent suppliers for each item (based on availability).

#### 6.6 **Utility Data, Summary and Diagrams:**

Utility data, Summary and Diagrams including all necessary and sufficient information, Data and Specification and Detailed description, shall be provided individually for each and all of the Process & Utilities Unit.

##### 6.6.1 **Utility Data and Summary List:**

Utility data and summary list shall include Fuel for flares, Electrical power, Steam, Condensate, Boiler feed water, Cooling water, DM water, Nitrogen, Plant air, Instrument air, Fire water, Refrigerants, and so on, shall give schedule of estimated quantities for individual

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 15 OF 71	

producers/users, totalling up to the maximum estimated utility quantities for each Process Unit.

This overall maximum shall be for one consistent case for each utility, where the estimated maximum utility quantity for a particular item of equipment is not part of this consistent case, this maximum shall be stated separately.

Emergency utilities requirement (type, duration, condition and flow rate) shall be indicated with identification of producer/user. Minimum, average and peak consumption figures for utilities shall be indicated as well.



#### **6.6.2 Utility Flow Diagrams:**

Simplified schematic diagrams showing the Process Equipment, Utility producers/ Users mass flow, Operating Temperature and Pressure within the Process & Utilities Unit and major instrumentation for operation of the system. This shall include the following:

- a) Process water distribution.
- b) DM water distribution.
- c) Cooling water distribution.
- d) Fire water requirement & distribution.
- e) Refrigeration and Chilling Distribution System, if any.
- f) Boilers' feed water and steam distribution, condensate recovery, gathering and return system.
- g) Nitrogen distribution.
- h) Fuel gas distribution.
- i) Effluent gathering system.
- j) Chemical feed distribution.
- k) Plant air and instrument air distribution.
- l) Battery Limit/ Yard piping arrangement.

#### **6.7 Piping And Instrumentation Diagrams (P&IDs):**

These drawings shall show all Process Equipment and Piping, Instruments and control systems, for all anticipated operating conditions (Start-up, Normal operation, Shutdown and Emergency conditions etc). Number and sizes shall be indicated for Valves, Check valves and Safety valves. The extent of steam and/or electrical tracing and the extent and type of insulation shall also be shown. Such details as Steam-out and purge connections, Process equipment vents and lines for alternative operations and start-up/shutdown shall be shown



 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 16 OF 71	

(elevations for process equipment and lines shall be given). Utilities shall be shown entering or leaving each Process & Utilities Unit including distribution of each utility to all utility users/producers together with utility control systems specific to that user/producer.

Definitions of Piping and Instrument Diagram symbols and abbreviations used shall be provided on legend sheets of P&IDs.

Piping and instrumentation diagram shall include:



1. All Process Equipment including installed stand-by equipment.
2. Line size and line identification including material specifications for all lines. For inlet and outlet lines of safety valves only preliminary sizes will be given and final sizes will be shown in Detailed Engineering P&IDs.
3. Insulation requirements of lines (Heat conservation, Process stabilization or "not insulated") shall be shown on the P&IDs.
4. Tower and Vertical Drum Elevations from ground and tangent line elevations.
5. Horizontal Drum minimum elevations and slope.
6. Relative elevations of all equipment and piping where gravity or 2-phase flow is taking place, e.g. Re-boilers, Condensers, Seal pots.
7. Equipment characteristic parameters dimension plus Design Temperature, Pressure and Material of Construction (MOC) shall be given at the bottom of the P&ID.
8. Equipment title and number.
9. All nozzles on columns, heat exchangers, vessels and tanks and all relevant trays (numbered) in columns and all internals in vessels shall be shown.
10. Required line slope, relative location of equipment or special conditions such as required vertical loop dimensions, gravity lines with or without pockets, etc.
11. Vents and drains required for process or operating reasons (not hydraulic testing).
12. Steam, hot water or solvent tracing of lines and instruments.
13. Gas or liquid purging or flushing of control valves, instruments or relief valves, including their inlet and outlet isolating valves.
14. All start-up, by-pass, shutdown and emergency lines and lines for anticipated alternative operations.

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 17 OF 71	

15. All instruments required for proper operation of the Process & Utilities Unit.
16. Instrumentation control loops including interlocks, sequence and emergency shutdown.
17. Control valves response on air failure (fail safe philosophy shall be adopted in design).
18. Instrument tag numbers.
19. All details shall be consistent with the appropriate process flow diagram and other process documents.
20. Process specific installation position of piping components (if applicable).
21. Kind and item number of special components.
22. Battery limits of each Process & Utilities Unit.
23. Measuring and control signals transmission.
24. Flow direction of signals when combining several measuring and control circuits
25. Electrical consumers other than motors, such as electrical heat tracings and heating systems.
26. Kind of signal or specific representation of signalling lines, such as pneumatic, electric, hydraulic, function line, capillary tubing.
27. Principal separateable connections (e.g.Flanges, Spectacle blinds).
28. Sample connections.
29. Size and set pressure of safety valves and their inlet and outlet isolating valves and rupture disks.
30. Updating of P&I diagrams after design review and HAZOP/ HAZAN/ SIL study.

## 6.8 **Plot Plan:**

This shall be a plot plan based on LSTK Contractor's Know-how, Requirements of Normal and Emergency operation, Safety and Maintenance requirements including heavy crane movements. It shall include Preliminary layout of control room, Analyzer room, Substation, Laboratory (if applicable), Equipment layout and location. LSTK Contractor shall suggest the areas required for storage of Chemicals, Intermediate Streams and Products and so on in addition to general storage.

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 18 OF 71	

The Process / Off-sites & Utilities Unit plot plan shall be prepared with due consideration to the overall plot plan layout of the Plants and interrelations of the Process / Off-sites & Utilities Unit. LSTK Contractor shall use all of the available know-how and techniques and shall do his best to proposed Plants and Process & Utilities Unit plot plan which is optimized from every respect.

#### 6.9 **Equipment List:**

- This list shall show the equipment title, duty, size, tag number, type and quantity of each equipment.
- Operating temperature and pressures, Design temperatures and pressures.
- Equipment characteristics, parameters or dimensions and material of construction.



#### 6.10 **Equipment Data Sheets:**

Specification sheets giving all Process and Mechanical design data required for designing the equipment, including turn down ratio. Further specific design information shall be as follows:

##### 6.10.1 **Reactors:**

Specification sheets containing all data required with relevant sketches and drawings including all other information and data which are used and applied in the Basic Design and are necessary for operation of the Process & Utilities Unit. The Information/Item which is marked by an asterisk (\*), shall be supplied elsewhere in Engineering Design Specification or Operating Manual.



- Capacity.
- \*Space velocity (Normal and Design conditions).
- \*Conversion per pass (Normal and Design conditions).
- Operating temperature and pressures, Design Temperature and Pressure.
- \*Recycling ratio (Normal and Design conditions).
- \*Reactor Pressure Drop (SOR & EOR).
- Reactor catalyst bed life.

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 19 OF 71	

- h) Catalyst, adsorbent and resins and its characteristics (as required for design).
- i) Reactor inlet and outlet operating conditions.
- j) \*Reactor bed temperature profile (if applicable).
- k) Reactor lining data (e.g. thickness, material, number of layers etc).
- l) Corrosion allowances.
- m) \*Process fluid physical and thermodynamic properties (normal and design conditions at inlet and outlet).
- n) Stress relieving and insulation requirements.
- o) Materials of construction.
- p) All dimensions (length, diameter, nozzle size and elevations).
- q) Dimensions tolerances (if any).
- r) Reactor internal details.
- s) Emergencies (upset conditions) temperatures and pressures.
- t) Catalyst and adsorbent bed(s) height.
- u) \*Basic recommendation for spares for commissioning and 120 calendar months operation and capital spares.

#### **6.10.1.1 Compressors and Blowers:**

- a) Materials of construction.
- b) Corrosion allowance.
- c) Minimum, normal and maximum flow rates required considering all defined modes of operations.
- d) Special mechanical features required.
- e) Operating and Design Temperatures and Pressures, Physical and Thermodynamic Properties at Inlet and Outlet.



 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 20 OF 71	

- f) Control requirements and Safety device.
- g) Suction and discharge conditions (Normal and Design).
- h) Specific Design and Fabrication requirements.
- i) \*Basic recommendation for Spares (Commissioning, 120 calendar months operation and capital spares).
- j) Estimated Efficiency and Hydraulic Power.
- k) Sealing Requirements.
- l) Type of Compressors.
- m) Type of Driver.
- n) Estimated Power Consumption.
- o) Recommended RPM.
- p) Noise protection requirements.

#### **6.10.2 Pumps:**

- a) Fluid Physical Properties.
- b) Alternative Specifications if necessary for specific service.
- c) Minimum, Normal and Maximum flow rates.
- d) Sealing Requirements.
- e) Suction and Discharge conditions.
- f) Specific Design and Fabrication requirements.
- g) Operating and Design Temperature and Pressure, Physical and Thermodynamic Properties.
- h) Estimated Efficiency and Hydraulic Power.
- i) Flushing requirements.
- j) NPSH required.
- k) Materials of Construction (MOC).





 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 21 OF 71	

- l) Corrosion allowance.
- m) Type and special features required.
- n) Type of Driver.
- o) Recommended RPM.
- p) Pump performance curve
- q) Principal requirement for Operation Control (Minimum from spill back).
- r) Estimated Shut-off Pressure.
- s) Estimated Power Consumption.
- t) \*Basic recommendation for Spares for Commissioning and 120 calendar months operation and capital spares.

#### **6.10.3 Vessels, Columns and Internals:**

Data sheet including standard process sketch and tray/packing specification shall be provided showing:

- a) Process vapour/liquid loading.
- b) Maximum Operating Temperature and Pressure.
- c) Mechanical Design Temperature and Pressure.
- d) Pressure drop.
- e) Materials of Construction (MOC) and corrosion allowance.
- f) Foaming characteristics (if any).
- g) Diameter and height or length.
- h) Number, type and spacing of beds for columns.
- i) Packing material, if required.
- j) Number, size, rating and location of nozzles (Location of nozzles with respect to special height requirements).
- k) High and low liquid levels.



 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 22 OF 71	

- l) Jacketing, if any.
- m) Fluid Physical and Thermodynamic Properties (Density, K value, Enthalpy, Critical properties, Viscosity, Liquid Surface Tensions, and etc).
- n) Any Special surface finish requirement.
- o) Stress Relieving.
- p) Insulation Requirements.
- q) Type, Number and Efficiency of trays.
- r) Details for Columns, including tray layout and tray pressure drop.  
(to be confirmed by Vendor)
  - Heating coil, if any
  - Fatigue analysis requirement (Operating cycles)
  - Hot spot indication requirement
  - Shutdown conditions (if applicable)
  - Vacuum condition (Pressure and Temperature).
  - Internal details.
  - Tray and packed beds process loading data.
  - Tray/ packed bed loading profile (if required for detail design).
- s) Skirt height.
- t) Details of special internals such as Pans, Distributors, etc.
- u) Mist eliminators, Supports, Mesh or Packing, etc.
- v) \*Basic recommendation for spares for Commissioning and 120 calendar months operation.
- w) Instrumentation requirements.



#### **6.10.4 Heat Exchangers (all types):**

Data sheets giving all Process and Thermal Design of all heat exchangers with relevant sketches and drawings including but not limited to the following:

- a) Operating and Design Pressures and Temperatures (Inlet and Outlet).

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 23 OF 71	

- b) Surface areas.
- c) Heat load and Fouling factors.
- d) Limiting transfer rates where applicable
- e) Limiting Viscosities and Pour points.
- f) Vaporization and Condensation curves.
- g) Restrictions on combining air fin services.
- h) Specific Design and Fabrication requirements.
- i) Tube and Baffle arrangement (if applicable).
- j) Permissible Pressure drop.
- k) Material of Construction (MOC).
- l) Corrosion allowances.
- m) Fluid properties such as Specific heat, Boiling Temperature, Thermal Conductivity, Density, Surface tension, Vapour and Liquid enthalpy, Critical properties and etc.
- n) Any specific foundation requirement.
- o) Nozzle location (if applicable) and Gasket material.
- p) The Exchanger type and Configuration to be specified via relevant standard data sheet.
- q) Mean Metal Temperature of tube side component of the Shell & Tube heat exchanger (if applicable).
- r) For Tubular Exchangers, Vibration analysis to be indicated by LSTK Contractor.
- s) Instrumentation requirement.
- t) Alternative specifications for specific services.
- u) Where Kettle type exchangers are used, the specifications shall also include a sketch, vapour space and surge volume required.
- v) For Air coolers, estimated power consumption, number of bays, fan speed control, louver control and type of fan (induced or forced draft) shall also be included.
- w) Different Thermal operating conditions for Fixed tube sheet exchangers.

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 24 OF 71	

- x) \*Basic recommendation for spares for Commissioning and 120 calendar months operation and capital spares.

#### **6.10.5 Steam Turbines:**

- Item
- Type

##### **For Steam Turbines:**



- Capacity and Steam Rate including on Heat and Material balance taking into account Power production and Turbines Estimated Efficiency
- Steam condition at Inlet and Outlet of each stage (Temperature, Pressure, Enthalpy and all other required Physical and Thermodynamic properties, for Operation and Design.)
- Estimated Efficiency.
- Special control requirements.
- Estimated number of stages of turbine.
- Material of Construction (MOC).
- Safety devices and controlling system.
- Governor type.
- \*Basic Recommendation for Spares for Commissioning and 120 calendar months Operation and Capital spares.

#### **6.10.6 Miscellaneous Equipment:**

For all loading and unloading equipment, package units, dryers and filters, ejectors, mixers etc, complete duty specifications and technical information shall be provided which would include all process and mechanical design data as required for the equipment design and operation in different mode.

#### **6.11 Instrumentation:**

The following documents shall be compiled in Engineering Design Specification:

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 25 OF 71	

**6.11.1** Control philosophy description and drawing: explaining and showing the concept of DCS/PLC/ESDS, FGD, local panels and packages control system regarding design basis and monitoring/control, remote/local, master/slave, dedicated/shared systems aspects, start-up location, systems location and interconnection.

**6.11.2** Advanced control is not required.

**6.11.3** Specification for DCS/PLC/ESDS.

**6.11.4** Specification for Instrumentation.

- a) Cause and effect diagrams showing electrical and instrument interlocking and trip requirement.
- b) Sequence and interlock (normal and safety) description as well as simplified logic diagram/flowcharts according to IEC 6 1131.3.

**6.11.5** Preliminary Alarm and Trip set points.

**6.11.6** List and Specification for Special Systems/Instruments and requirements.

**6.11.7** Concept of Gas monitoring system.

**6.11.8** Electrical Power and Air Consumption for Instrumentation.

**6.11.9** Control room general information regarding HVAC, Fire Alarm, Fire Fighting Systems, etc.

**6.11.10** Preliminary control room layout.



**6.11.11** Preliminary console front arrangement. Basis requirements for DCS Configuration: including Special displays, Grouping for displays, reports etc.

**6.11.12** Instrument index including Tag no's, Service, Process conditions, Type, Size, Range, Alarm/trip set points, P&IDs No., reference to other documents etc.

**6.11.13** DCS/PLC/ESDS I/O summary.

**6.11.14** Instrument data sheets providing the following information:

- a) Tag number

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	 <div>भारत भारती BHEL</div>
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 26 OF 71	

- b) Name
- c) Service
- d) Equipment or Line number
- e) P&IDs Number
- f) All data which is necessary for sizing, selection and specifying the instrument such as:

- ❖ Stream data in Minimum, Normal and Maximum or other Specific operating conditions (to ensure proper rangeability, reading and control).
- ❖ Vaporization across Valves, Sealing, Purging or Flushing requirements including any special process design considerations such as pour point.
- ❖ Consideration and recommendation regarding Explosion, Corrosion/Erosion effect, Toxicity and Suspended particles of process medium.
- ❖ Response time.
- ❖ Leakage class.
- ❖ Accuracy (according to process requirements).



- g) Type of Instrument (Principle of Measurement code).
- h) Preliminary Size and Range.
- i) Material of Construction (MOC).
- j) Impulse line and Instrument Casing Heating/Insulation requirement.

Relief valve, Rupture disk, Breather valve summary. A summary shall be provided of the loads from each relief device for each emergency condition under which the relief valve opens, e.g., fire, power failure (and other utility), blocked-in condition etc. Relief and flow data summary sheets shall be provided.



## 6.12 **Electrical:**

General Electrical specifications will provide sufficient information for Detailed Engineering and shall include the following:

1. Specifications of Normal and Emergency Power supply and Electrical installation.

 पी डी आई एल PDIL	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>  <b><u>Bharat Coal Gasification and Chemicals Limited</u></b>  <b><u>CONTRACTOR'S SCOPE OF WORK</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
		Document No.	Rev	
		Sheet 27 OF 71		

2. Single Line Diagram (SLD) to be used as the basis for Detail Engineering.
3. Requirement of information for:
  - a) Interlocking method with Instrumentation system.
  - b) Plant Telecommunication system.
  - c) Fire alarm system.
  - d) Lighting system.
  - e) Electrical consumers with indication of Estimated Power Consumption except illumination.
  - f) Consumers requiring Emergency Power Supply and duration of it.
4. Classification of hazardous areas:
  - a) Electrical area classification drawing showing the extent of hazardous areas (elevation and plan).
  - b) List of Inflammable and flammable materials to be handled along with their properties such as Ignition temperature, Applicable gas group, etc.
  - c) Equipment selection criteria for areas having Flammable and/or Inflammable materials
5. Energy requirement of Process / Off-sites & Utilities Unit in Kilowatt hours per ton of product and the total expected power (kW) requirement with details of high/medium voltage and low voltage loads.
6. Implications of power failure and recommended Plant's emergency supply scheme for all types of electrical loads which require emergency power.
7. List of drives requiring emergency power feed along with their power consumption. Any specific requirement for lightning protection, where applicable.
8. Main specifications of critical drives/variable speed drives and their controls (to be added in equipment data sheets).
9. If there is any requirement of uninterrupted power supply system (UPS) the following details shall be provided:
  - ❖ Total load.
  - ❖ Reacted voltage and permissible variation. Duration for which UPS system shall be designed.
  - ❖ Step load/permissible voltage dip.
  - ❖ In-rush current in worst case.
  - ❖ Load power factor.

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 28 OF 71	

❖ Redundancy, if needed.

10. Any specific requirement of type/material of conductor to be used for grounding, (if applicable).
11. Details of the preventive measures or means to be furnished for type of cables and their insulation cover, (if applicable).
12. List of derived requiring acceleration features to ensure faster start-up and/or to minimize Plants shutdown time in case of process disturbances due to momentary voltage dip or brief interruption (5-10 sec.) in normal power supply.

#### **6.13 Piping:**



1. Piping lay-out plans shall be provided indicating the critical areas of piping including general arrangement of piping in plan view.
2. General specification for piping material including pipe classifications according to process requirement for Process, Utility and Service lines included in entire Plants.
3. Typical Piping specifications (for each classification).
4. Special Insulation requirements for critical piping.

#### **6.14 Pipe Class Summary (Basic Piping Specification):**

A summary of piping class for all the process, utility and service lines for entire Plants shall be provided. A standard process, utility and service lines summary shall include:

- 1) Piping material specifications and ratings.
- 2) Flange material and ratings.
- 3) Design pressure and temperature.
- 4) Gasket types and bolting.
- 5) Corrosion allowances.
- 6) Valve types, size, material and rating.
- 7) Type of fluid.
- 8) Fittings.
- 9) Strainers.
- 10) Expansion joints.
- 11) Check valves.



 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 29 OF 71	

#### 6.15 **Line List:**

Line index keyed to line numbers on piping and instrument diagrams showing Line numbers, Line size, Class, Design and Operating data, Type of insulation, Flowing phase, Alternating condition (if any), test pressure, test fluid, insulation thickness etc. to be provided.

#### 6.16 **Design Calculations:**

For the Process Units, LSTK Contractor shall provide to Owners' engineers on a piecemeal basis, the input and output sheets of simulation for the following calculations:

- Design calculations for estimating chemicals requirements.
- Calculation sheets for items such as vessels, columns, pump and vessel, control valves and relief valve loads sizing.
- Hydraulic design tabulations sheets including back-up data and calculation shall be provided for each individual loop. For this reason the design philosophy for line sizing shall be submitted as well.
- Design data developed for design of each item of equipment.



#### 6.17 **Insulation List and Specifications:**

LSTK Contractor shall indicate the insulation requirements in each Process & Utilities Unit with its Engineering Specifications.

#### 6.18 **Other Required Information:**

- Any other documents or data which are reasonable necessary to perform the detailed design, Procurement and construction, Pre-commissioning, Commissioning, Start-up and Operation of the plants.
- Estimated Manpower requirement with number and qualification for start-up and normal operation of the Process & Utilities Unit to be submitted.

#### 6.19 **LSTK Contractor's Engineering Design Specifications and Drawings:**

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>	Sheet 30 OF 71		



Any specific Standard Specifications, Instructions and Procedures which LSTK Contractor deems necessary to be taken into account for Detailed engineering, Procurement, Design and Manufacturing of the equipment, Transportation and Erection, Pre-Commissioning, Commissioning, Start-up and Operation of the Plants shall be pointed out and to be included in the Engineering Design Specifications.

## 6.20 **Effluent Treatment:**

LSTK Contractor shall provide Basic design Input/ Output data and information for treatment of Process & Utilities Unit effluents with due regard to type, quantity and composition of the effluents and waste disposal (which is to be prepared and included in the respective Engineering Design Specification) considering specific requirements of Central & Orissa State Pollution Control Authority, and as are necessary for Design and operation of effluents and waste disposal system.

## 6.21 **Safety:**

- LSTK Contractor shall perform the Hazard Analysis (HAZAN), Hazard and Operability studies (HAZOP) using PFD and P&ID together with Plot Plan and Equipment data sheets and Safety-related equipment checklist. During HAZOP meetings, LSTK Contractor shall report any accidents (if any) in the process licensor's plant and the necessary precaution that the licensor has adopted for rectifying the same.
- Recommendation for Fire fighting facilities required for the Process & Utilities Unit and Rate of water/foam required, cooling or deluge system (sprinkler system) and identification of the areas which require it.
- Recommendation for fire fighting facilities for control room. Recommendation for fire fighting for all buildings and facilities which need fire fighting facilities.
- Recommendations for Handling/Storage of various Chemicals, Catalysts, Adsorbents, Resins and etc.
- Proposed methods of Fire fighting for different types of fires and for different areas.

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 31 OF 71	

- f) Whether or not shutdown of specific Process / Off-sites & Utilities Unit or Plants is necessary in case of any type of fire.

Any other Specific safety requirements.

#### **6.22 Hot Flare System:**

The LSTK Contractor shall prepare Design and Engineering as per API-521 guidelines, of whole flare system (one for Ammonia Plant, one for common for both Ammonia storage tank including flare design loads (for each emergency condition, e.g. Power failure, Steam failure, Fire and other utility failure and Blocked in condition), separate Flare headers, separate Knock out drums up to LSTK battery limit. LSTK CONTRACTOR to consider Flare Knock-out Drums for Ammonia Plant within the battery limit of their unit.

#### **6.23 HAZOP Study Report:**

LSTK Contractor shall carry out HAZOP study through an independent agency specialised in this field and implement its recommendations during following stages and submit HAZOP Report for the approval of the Owner/PMC.

- Basic Design and Detailed Engineering.
- Construction, Erection and Mechanical Completion.
- Plant Start-up and Commissioning.



### **7.0 SCOPE OF DETAILED ENGINEERING SERVICES:**

#### **7.1 Introduction:**

The minimum requirements for Detailed Design and Engineering of the Plants shall be according to Standards, Specifications and Procedures. LSTK Contractor shall prepare/provide all the drawings and documents for approval as detailed below.

Coordination shall be done through Owner/PMC for the Plants to ensure uniformity and standardization of Engineering, Designs and Specifications of all major Equipment, Piping, Mechanical parts, Instrumentation, Electrical items, Insulation, Painting and other bulk materials. This would minimize spare parts and facilitate operation and maintenance of the Plants.

#### **7.2 Drawings and Documentation:**

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 32 OF 71	

### 7.2.1 General:

LSTK Contractor shall prepare/provide all such Drawings and Documentation which shall be necessary for performing the procurement of Equipment and Materials, Construction, Pre-commissioning, Commissioning and Operation of the Plants.

The above drawings and documentation shall include, but is not limited to the following:

#### a) Plot Plan:

- 1) LSTK Contractor shall prepare detailed layouts and plot plans for Process & Utilities Unit included in the Plants based on overall plot plan of the Complex. Overall Plot Plan of the Plants shall be prepared by LSTK Contractor and shall show Location of all buildings, Battery limits of Process & Utilities Unit, Routing of roads and Configuration of pipe racks. The plot plan shall be prepared with due consideration to the Process & Utilities Unit plot plan proposed by LSTK Contractor.



#### 2) Process & Utilities Unit Detailed Plot Plan:

Based on overall Plot Plan of the Complex, LSTK Contractor shall prepare/provide detailed plot plan for Process & Utilities Unit included in the Plants. Detailed plot plan shall be on scale and shall show exact location of each equipment with their Tag number, Interconnections between the equipment, Configuration of pipe racks, Access ways, Sewerage and Trenches inside the Process & Utilities Unit, Package unit detailed layout (through vendor), battery limit connections all of the Process and Utility lines (Incoming and outgoing) etc. The Detailed Process & Utilities Unit plot plan shall be prepared taking into account easy operation and maintenance of each individual equipment and accessories and parts included in the Process & Utilities Unit.

#### b) Unit Limit Drawings:

LSTK Contractor shall prepare the Process & Utilities Unit limits' drawings showing details of all over ground and underground interconnections at Battery limit (Process and Utility Incoming and Outgoing lines) for the Process & Utilities Unit.



#### c) Piping & Instrumentation Diagrams:

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 33 OF 71	

These drawings shall show all Process Equipment and Piping, Instruments and Control systems, for all anticipated operating conditions (Start-up, Normal operation, Shutdown and Emergency conditions and etc). Sizes shall be indicated for Valves, Check valves and Number and Size for safety valves. The extent of Steam and/or Electrical tracing and the extent and type of insulation shall be shown. Such details as Steam out and Purge connections, Process equipment vents and lines for alternative operations and Start-up/Shut-down shall be shown (important elevations for Process Equipment and lines shall be given). Utilities shall be shown entering and leaving the Process & Utilities Unit including distribution of each utility to all utility users and/or producers together with utility control systems specific to that user and/or producer. Definitions of Piping and Instrumentation symbols used shall be provided on a cover sheet for Process & Utilities Unit P&I Diagrams.



Piping and Instrumentation Diagrams shall include:

1. All Process Equipment including installed stand-by equipment (when warehouse standby is available, a note shall be laid down for that specific equipment).
2. Line size and Line identification for all lines.
3. Insulation requirements of lines (Heat conservation, Personnel protection, Process stabilization).
4. Tower and Vertical Drum tangent line elevations.
5. Horizontal Drum minimum elevations and slope.
6. Relative elevations of all Equipment and Piping where gravity or 2-phase flow is taking place e.g. Re-boilers, Condensers, and Seal pots.
7. Equipment characteristic parameters or Dimensions plus Design Temperature and Pressure and Material of Construction (MOC).
8. Equipment Title and Number.
9. All nozzles on Columns, Vessels, Heat exchangers and Tanks and all trays in columns and all internals in vessels shall be shown.
10. Required line slope, Relative location of equipment or special conditions such as required vertical loop dimensions, Gravity lines with or without pockets, etc.
11. Vents and Drains required for process or operating reasons (not hydraulic testing).



 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 34 OF 71	

12. Steam, Hot water or Solvent tracing of lines and instruments.
13. Gas or liquid purging or flushing of control valves, Instruments or relief valves.
14. All Start-up, By-pass, Shutdown and Emergency lines.
15. All Instruments required for proper operation of Process / Off-sites & Utilities Unit.
16. Instrumentation control loops including Interlocks, Sequence and Emergency shutdown.
17. Control valves response on air failure.
18. Instrument tag numbers.
19. All details shall be consistent with the appropriate Process Flow Diagram and other process documents.
20. Process specific installation position of piping components.
21. Kind and Item number of special components.
22. Battery Limits and Limits of Process / Off-sites & Utilities Unit.
23. Measuring and Transmission of control signals.
24. Flow direction of signals when combining several measuring and control circuits.
25. Electrical consumers other than motors, such as heating systems.
26. Kind of signal for specific representation of Signalling lines, such as Pneumatic, Electric, Hydraulic, Function line, Capillary tubing.
27. Principal separable connections.
28. Start-up, Normal and Emergency shutdown, Catalyst regeneration, Catalyst/Chemical/Resin loading, unloading and Emergency provisions which shall be necessary for safe operation of the Plants.
29. Alternative operations (all expected modes of operations) which shall be necessary for continuous operation of a Process / Off-sites & Utilities Unit/Plants, when other Process Units are having shutdown.
30. Sample points and details of sampling.
31. Details of Pump flushing, cooling water, Drains, Vents, etc.

### 7.2.2 Equipment:

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 35 OF 71	

- a. Engineering drawings and/or Specifications for each individual Equipment, Materials, etc.
- b. Equipment drawings and/or specifications for Towers, Reactors, Drums, Heat exchangers (all types), Tanks and Non-code vessels and Machinery such as Compressors, Pumps, Turbines etc, containing sufficient information to enable equipment manufacturers to prepare detailed drawings for manufacturing of equipment.
- c. Equipment arrangement drawings.
- d. Detailed drawings and documents of equipment required for Proper erection, Pre-commissioning, Commissioning, Operation and Maintenance.
- e. Material requisitions containing all required Process and Engineering information and data and all necessary Standard Drawings and Specifications to permit the purchase of equipment. Material requisitions shall be up to date with all relevant and required information and data to enable any vendor to prepare and submit a proper quotation before final issuance for inviting bids.
- f. Stress analysis due to piping on equipment considering Temperature, Pressure and all other expected loads.
- g. Calculation result sheets of Vessel design (through manufacturer) and Calculation result of Thermal Stress of Piping, Structural design and so on.
- h. Equipment "Sketches and Data sheet" for Towers, Reactors, Drums, Heat exchangers (all types), Tanks and Non-coded Vessels and Machinery such as Compressors, Pumps, Turbines and etc. Such drawings shall contain sufficient information and data to enable equipment manufacturers to prepare shop fabrication drawings.
- i. Detail procedure for preservation of equipment during Short time and Long time of Non operation.
- j. Equipment List, containing at least the following information:
  1. Item number (Tag number).
  2. Item descriptions including Duty, Design and Normal conditions.
  3. Overall dimensions of Equipment.
  4. Erection Weight of Equipment.
  5. Type of equipment (e.g. Centrifugal or Reciprocating pump; Tubular or Air Fin Exchanger etc) and Material of Construction (MOC).
  6. Tangent to Tangent length (for Vessels).

 <div>पी डी आई एल PDIL</div>	<div><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></div> <div><b><u>Bharat Coal Gasification and Chemicals Limited</u></b></div> <div><b><u>CONTRACTOR'S SCOPE OF WORK</u></b></div>	PC0288/E/001/P-II/ SEC-3.0	0	
		Document No.	Rev	
		Sheet 36 OF 71		

7. Absorption and Rate of Power Consumption (Steam or Electric).

8. Type (s) of Driver(s).

k. Performance curves for Pumps and Compressors.

l. Project Engineering specifications for each Individual Equipment and/or Components including but not limited to Piping material and drawings, Electrical, Instrumentation, Insulation and Painting specifications incorporating of all requirements of Owner's and LSTK Contractor's standard drawings and specifications.

### 7.2.3 Civil work, Structural work and Buildings work:



#### a) Site preparation activities:

1. Preparation of general Site grading design drawings including specifications and procedures to perform all Site preparation activities including land development and to make Site ready for next steps (e.g. foundation works). Any engineering required to remove the existing facilities from the Site as necessary to build the Plants are included in Owner Scope. Owner will specify the interfacing and tie-in as required.
2. LSTK Contractor shall Design and prepare construction drawings & specifications for all civil & steel structural works required to complete Ammonia Synthesis Unit, Ammonia storage and associated RCC Cooling Towers as given in scope of works.
3. LSTK Contractor shall Design and prepare construction drawings, specifications including procedures for construction of Pipe racks, Culverts and Retaining walls.
4. LSTK Contractor shall Design and prepare road layouts and all other necessary drawings, specifications including procedure to build all roads within the Plants.

#### b) Sewers, Drains and Underground Lines and Piping:

1. Preparation of schematic Sewer Layouts.
2. Preparation of Sewer Flow Rate Diagram.
3. Preparation of Detailed Underground layout drawings, Specifications including procedures required for construction. It shall show all Sewers, Manholes, Catch basins, Cable trenches, Electric cable road crossings and Underground normal and pressure piping etc, within the Plants.





 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 37 OF 71	

4. Preparation of Storm Water Drain Layout.
5. Preparation of Detailed drawings for layout of Storm Water Drain.

c) Foundations, Concrete Structures and Paving:

1. LSTK Contractor shall prepare Soil Improvement Schemes and Drawings.
2. LSTK Contractor shall establish loading data for foundation and equipment supporting structures.
3. Piling specification design, Drawings and Construction procedures wherever required within the Plants shall be performed by LSTK Contractor.
4. All required Drawings for foundations of all Equipment and Machinery, Structures, Pipe racks, Buildings, Compressor shelters etc and all foundation drawings, specifications and procedures required for proper and efficient construction shall be prepared by LSTK Contractor.
5. Loading data and Calculation results of foundation designs to be specified and submitted to Owner.
6. LSTK Contractor shall prepare Construction drawings specifications and procedures to build all reinforced concrete structures. Where supply of equipment requires the provision of items of civil engineering nature e.g. concrete sumps, LSTK Contractor shall undertake the design in accordance with vendor requirements.
7. Preparation of Anchor bolt detail schedules, and specification.
8. Construction drawings, specifications and procedures for all other civil work e.g. Paving, Culverts and Trenches.
9. Bills of quantities and specifications of materials for civil works (e.g. Reinforcing bars, Cements, Anchor bolts etc)
10. Bar bending schedules.
11. All detailed drawings, Specifications and Procedures required to perform all civil works of the Plants.

d) Plant Buildings:

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 38 OF 71	



LSTK Contractor shall prepare and submit at least the following Documents/Drawings for construction of all plant buildings like sub-stations and control room.

1. Building sketches, Layouts and Design drawings, Specifications and Procedures for construction of buildings.
2. Project engineering specifications for construction of buildings.
3. Detailed Architectural, Mechanical and Electrical drawings, required for construction of the buildings.
4. Plan drawings for buildings, indicating skeleton with major dimensions.
5. Design Structural, Mechanical and Electrical calculation results for all buildings.
6. Bills of quantities and specifications for all required Materials for Construction of buildings.
7. Requirements of the buildings for Air Conditioning.
8. Requirements of the buildings for Fire fighting and Fire protection.
9. Requirements of the buildings for Fire alarm system.

e) **Structures:**

LSTK Contractor shall prepare and submit at least following documents / drawings on structure works.

1. Complete arrangement drawings for Steel structures with all member sizes, Plan and framing elevation, Typical sections, and Details for preparation of shop detailed drawings and Fabrication work.
2. Loading diagrams and calculation results for all structures.
3. Steel structure drawings for Equipment supports, Racks, Platforms, Ladders and stairways, etc with sufficient details required for preparation of shop detailed drawings and fabrication work.
4. Steel structure project engineering specifications and standard details for Hand rails, Equipment supports, Racks, Stairs, Cat ladders, Platforms, Fire proofing, etc.
5. Material requisition for steel structures.
6. Developing and designing special members of structural steel which may become necessary for handling or supporting of special equipment and items during manufacturing, transportation and construction of the Plants.
7. Preparation of all required specification including Procedures, Standard and Specification for manufacturing and construction of structures.



 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 39 OF 71	

## 8. Preparation of shop fabrication drawings.

### 7.2.4 Piping:

LSTK Contractor shall prepare at least the following documents / drawings for piping:

1. Piping design, Fabrication, Erection, Testing and Flushing specifications.
2. Piping materials classification and specifications for Process and various services in the Plants and LSTK Contractors' requirement considering Corrosion, Erosion, High Temperature and High Pressure, all expected special conditions and etc.
3. Piping arrangement for all pipes on the pipe racks included in the Plants.
4. Cross-sectional drawings of all piping entering and leaving Process & Utilities Unit Battery limits.
5. Layout drawings.
6. Isometric drawings, (except for long runs shown on plan drawings) of all Carbon steel, Alloy and Stainless steel, indicating all fittings and materials and referring to Sand blasting, Pre fabrication, Fabrication, Erection, Surface preparation, Painting and Insulation in accordance with the specifications and procedures. Test pressure and it's media shall also be specified.
7. Piping arrangement drawings for all underground piping included in the Plants.
8. Detail drawings and specifications for under ground piping and its protection device.
9. Detail Piping arrangement drawings or Isometrics for Process, Utility, Instrument air and all other various services and Steam/Electric tracing in the Plants. These shall cover requirements for Pre fabrication, Fabrication, Erection, Pre-commissioning, Commissioning, Operation and Maintenance in accordance with the Approved for Construction P&ID's.
10. Detail drawings or catalogue drawings and specifications of Valves, Fittings, Traps, Safety valves, Control valves and all other piping components included in the Plants.
11. Piping drawings for match lines (interconnections) at Battery Limit.
12. Detail piping drawings for Vent and Drains required for process and operating reasons in the Plants including hydraulic testing.
13. Piping Drawings indicating location of required Supports, Anchors and guides, for all piping within the Plants.
14. Steam tracing detail drawings and specifications. Such drawings shall contain all information, data and procedures required for Construction/Erection, Operation and Maintenance.



 <div>पी डी आई एल PDIL</div>	<div><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></div> <div><b><u>Bharat Coal Gasification and Chemicals Limited</u></b></div> <div><b><u>CONTRACTOR'S SCOPE OF WORK</u></b></div>	PC0288/E/001/P-II/ SEC-3.0	0	
		Document No.	Rev	
		Sheet 40 OF 71		

15. Flexibility calculations and Stress analysis results for all piping systems as set out under Project Specifications including piping supports, especially for those systems subject to High Temperatures/Pressures and other loadings.
16. Vessel trims and special support design.
17. Colour coding of painting for piping suitable from safety and operation point of view.
18. Initial, Intermediate and Final material take-off for all Piping materials, Components and items included in the Plants. These take-offs shall cover all required Piping materials, Components and items of the Plants, otherwise supplementary take-offs shall be performed up to complete fulfilment of the requirements.
19. Material requisitions for all Piping materials, Components.
20. Line lists showing complete line identification (Line size, Service, Unit No, P&ID No, Pipe class, Operating and Design Temperatures and Pressures, Type of Insulation and etc), Line extremities, Maximum Pressure, Maximum Temperature, Material flowing and it's condition (Vapour, Liquid, Mixture), Quantity, Alternate operating conditions (if any), test pressures, test fluids, insulation thickness etc.
21. All Design calculations result, information and data in respect of preliminary hydraulic design of the piping system and final or adjusted hydraulic design calculations, data, information and configurations of the Plants.



#### **7.2.5 Instrumentation:**

LSTK Contractor shall prepare, but not limited to, the following drawings and documents:

1. Instrument index containing Tag no's, Service, Process conditions, Type, Size, Range, Alarm/trip set points, Manufacturer, Model No etc., P & ID No, reference to other documents etc.
2. Systems Architecture (Hardware configurations) drawings.
3. General specifications for Instruments, Control systems and accessories in respect of Engineering, Procurement, Manufacturing, Inspection, Construction and Operation. (One document for instrumentation overall practice and individual documents for further attachment to material requisitions).
4. Sizing calculations.
5. Instrument data sheets (for further attachment to material requisitions).
6. Cause and Effect diagrams.
7. Interlock and Sequence (ESDS and non ESDS) description and Logic diagrams / flow charts according to IEC – 61131.3.

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 41 OF 71	

8. Alarm / trip set points.
9. Loop sketches.
10. Loop diagrams.
11. Instrument hook-up drawings with material requirements.
12. Instrument mounting drawings with material requirements.
13. Instrument Heat tracing drawings with material requirements.
14. Instrument Cable tray / Ladder / Trench layout.
15. Instrument location drawings (layouts) showing positions of Instruments, Junction boxes, Local panels, Cable routing, and Instrument air header take off valves and cables on trays / ladders and/or in trenches.
16. Control/Auxiliary/Analyser room layout, showing all necessary details including locations, cable entry and route, tray/trench details etc.
17. Front view drawings of Control panels/Consoles with dimensions.
18. Earthing layout for instrumentation system.
19. Data required for Instruments/System Configuration such as I/O summary, Host Connection, Diagrams, Flow charts, Mathematics, Graphics, Layouts, Grouping lists, Ranges, Scales, Parameters, Set points, Colour codes etc.
20. Instrument cable lists and schedules.
21. Material take off (MTO) lists.
22. Material requisitions, Bid evaluations and Purchase orders for Instruments/Systems and bulk materials.
23. Instrument JB Diagram/Connection.
24. Vendors technical drawings, Catalogues and Documents including Installation, Operation, Calibration, Configuration, Programming and Maintenance manuals for Instruments/Systems with illustrated parts lists.
25. Instruments/Systems configuration documents including Device Description/ Capability files, Software details, Source and application programs etc.
26. Panels/Consoles/Cabinets' internal layout.
27. Panels/Consoles/Cabinets Interconnection block diagram with cable nos.
28. Power supply distribution drawings.
29. Interfacing diagrams/Philosophy between control systems and MCC.



 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 42 OF 71	

30. Termination and Wiring diagrams as well as hardware configuration for construction and trouble shooting purposes.
31. Spare parts lists and filled SPIR forms.
32. Tests, inspections and QC certificates and reports.
33. UPS Power consumption for Instruments.
34. Connection between Auxiliary and HMI Interface.

#### 7.2.6 Electrical:



LSTK Contractor shall prepare/provide, but is not limited to the following documents for electrical works:

1. Area classification drawings.
2. Schematic One-Line Diagrams of Power wiring and Instrument power supply.
3. Load summary and analysis.
4. System design including Voltage profile, Reacceleration.
5. Relay Setting Schedule.
6. Grounding System layout.
7. Communication and paging system and their respective specifications.
8. Lightning protection system design, layout and general specifications indicating any special requirement in the entire Plant.
9. Telephone system design layout and general specifications.
10. Emergency supply including Uninterrupted Power Supply system design and specifications.
11. Battery charger specifications and Storage battery capacity requirements.
12. Complete Fire alarm system design, Layout, Details and Specifications.
13. Cathodic protection system layout and detail including design specification and calculations.
14. Schematic Wiring diagrams for all Circuit breakers and Electrical items having internal wiring or relays.
15. Cable schedules and Routing showing the Service, Type, Size and Number of cores.

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>	Sheet 43 OF 71		

16. Complete list of Starters with sufficient Capacity and specifications for each.
17. Complete list of Switchgear with sufficient capacity and specifications for each and all categories.
18. Layout of Switchgear rooms.
19. All Lighting, Earthing, Control station and other miscellaneous equipment fixing and mounting details including specifications.
20. Initial and final Material take-offs for all Electrical equipment, Accessories and materials.
21. Material requisitions for all Electrical accessories, Equipment and Materials including heat tracing material, if any.
22. Design, Drawings and Specifications for materials required for electric heat tracing (if any).
23. Detail drawings and documents of Transformers required for Erection, Operation and Maintenance.
24. Complete One Line Diagram covering all circuits from incoming lines to major equipment indicating Metering, Relaying and Main Interlocking Systems.
25. Specifications of all electrical equipment and all electrical component and accessories showing Connection diagram, External view with Physical dimensions, Specifications of apparatuses and accessories and instruction manual in sufficient detail.
26. Motor schedule showing Service, Number (Normal Operation and Stand by), Number of poles, Output capacity, Type, Classification and remarks indicating any special requirement.
27. Impedance map and calculations results of fault current on every feeder bus bar.
28. Calculation analysis and results sheets, Start-up detail (taking into account power consumption and requirements for start-up of motors) for large capacity motors, Line failure, Instant load transferring in case of important line failure and so on.
29. Protection co-ordination curves in the whole electrical system, including protection in main substation.
30. Block diagrams, Connection diagrams, Design philosophy and Instruction manuals for interlocking systems, Alarm system and other complicated Power and Control systems.
31. Plot plan showing the location of major Equipment, Battery charger room and Classification of hazardous locations.



 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 44 OF 71	

32. Physical location of Lighting fixtures, Receptacles and wiring as well as their installation details, as per area classification.
33. Physical location of Electrical Equipment and Wiring installed and installation details.
34. Physical location of Grounding electrodes, equipment to be grounded and wiring layouts as well as their installation details.
35. Engineering, Manufacturing, Inspection requirements, Construction/Erection, Pre-commissioning and Commissioning specification and procedures for all electrical components, Equipment, Accessories and Materials.
36. Symbols
37. Cable cutting schedule
38. Cable orientation on Trays and/or Trenches
39. Cable room tray orientation.

#### **7.2.7 Insulation:**

LSTK Contractor shall prepare the following detailed documents as minimum requirements on insulations.



1. Insulation specification and schedule for each vessel, tower, drum, heat exchanger, pipelines and so on indicating operating and design temperatures, type of insulation, service, thickness of insulation and insulation specifications including type and number of tracers all required drawings and procedures for construction/erection of insulation and all other related material to be provided.
2. Wrapping requirements and specifications shall be provided in detail.
3. Initial and final material take-off and requisitions, for pipe lines and equipment insulation material including wrapping and all other required material for insulation.
4. Design calculations result in respect of insulation of piping and equipment.

#### **7.2.8 Painting:**

LSTK Contractor shall prepare the following documents as minimum requirements on painting:

1. Painting schedule with references to the applicable Painting Specifications and Codes.
2. Initial material take-offs.



 <b>पी डी आई एल</b> <b>PDIL</b>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	 <b>बी एच ई एल</b> <b>BHEL</b>
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>	Sheet 45 OF 71		

3. Methods and procedures of Surface preparation in detail.
4. Methods and procedures of painting of Equipment and Material in the manufacturer workshop and at Site in detail.



#### **7.2.9 Miscellaneous Equipment and Materials:**

1. Specifications for Design and Fabrication, for other Equipment and Materials, Electric motors, Valves and all package units. These shall also include Catalyst, Adsorbent, Resin, Chemicals and Solid handling, Loading and Unloading equipment and Accessories, Chemical feed system fillers and etc.
2. Specifications and Procedures for Construction/Erection, Pre-commissioning, Commissioning and Operation (all expected modes) for all of the Equipment, Machinery and Materials named and specified in item 1 above in detail.
3. Data sheets including all required information and data for all of the Equipment, Machinery and Materials named and specified in item 1 above in detail.
4. Standard drawings for all of the Equipment, Machinery and Materials named and specified in item 1 above in detail (if applicable).
5. Any other drawings which are necessary to prepare shop fabrication by manufacturer and assembly drawings for all of the Equipment, Machinery and Materials named and specified in item 1 above in detail.

#### **7.2.10 Vendor Drawings & Documents:**

LSTK Contractor shall provide at least the following vendor documents:

1. Certified drawings for all equipment to be approved by LSTK Contractor. Vendor drawings shall include Foundation loading plans, General arrangement and detailed drawings.
2. Construction Installation and operation instructions to be issued at least eight weeks prior to shipping of respective items, equipment, etc.
3. Equipment dossier for Pressure Vessels, Columns, Drums, Silos and Heat exchangers, including Design Calculations, Welding procedures, Welding qualifications, Material Test Certificates, Inspection certificates, etc.
4. Recommended spare parts list for Pre-Commissioning, Commissioning and 120 calendar months operation.

 पी डी आई एल PDIL	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	 भारत BHEL
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 46 OF 71	



5. Performance test certificates for all rotating equipment for tests carried out at the manufacturer's shop. All inspection reports with necessary and sufficient information for all of the Equipment, Machinery and Materials to be submitted to Owner at right time to be reviewed and commented or Approved (wherever applicable) by Owner.
6. Special measures to protect the Bearings, Shafts, Gears and other parts of rotating machines during Transportation, Storage at Site and against emergency (partial or total) shutdowns of the Plants, or as a result of a cut-off of steam or electric power, due to lack of oil or cooling water.
7. Electrical and Instrument diagrams, wherever applicable.

### 7.3 Heat Transfer Equipment Data:

The thermal and mechanical design information to be provided by LSTK Contractor shall at least include but is not limited to the following:

#### 7.3.1 Shell and Tube Exchangers including Double Pipe Exchangers (Process Information to be provided for each shell)

1. Exchanger type and its Duty in design condition and different modes of operations including Shell and Tube side Inlet and Outlet Temperatures.
2. Total Gross and Effective Heat Transfer Surfaces.
3. Out side diameter, Wall thickness, Pitch type, Configuration and Length of tubes.
4. Number of tubes and passes.
5. Shell and tube side flow rates (design and in different modes of operations) and required physical and thermodynamic data for the fluids flowing in both sides.
6. Shell pass configuration, inside diameter and length of the shell.
7. Type of shell side baffling, number of shell side baffles, baffle cut and baffle orientation.
8. Number, location and size of nozzle connections, tube sheet thickness, number and size of bolts.
9. Calculated and allowable pressure drops (shell side and tube side).
10. Heat transfer coefficients in shell and tube side as well as overall heat transfer coefficient.
11. Calculation result sheets for all and any individual exchangers.
12. Specific requirement, if any.

 <b>पी डी आई एल</b> <b>PDIL</b>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>  <b><u>Bharat Coal Gasification and Chemicals Limited</u></b>  <b><u>CONTRACTOR'S SCOPE OF WORK</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
		Document No.	Rev	
		Sheet 47 OF 71		

13. Fouling factor, on both sides.



### 7.3.2 Shell and Tube Exchangers:

Mechanical Design Information, Overall dimensions, diameters and elevations of exchanger and its supports and connections, scanting thickness of all pressure parts and major non-pressure parts with following details.

1. Tube sheet layout and general arrangement drawings with sufficient details. Design and operating pressure and temperatures.
2. Nozzle diameters and flange ratings.
3. Weight of equipment empty and filled with water.
4. Materials of construction of shell, tubes, tube sheet and other parts including corrosion allowances, shell wall thickness, tube sheet thickness, number and size of bolts.
5. The weight of removable tube bundles.
6. Insulation requirements, thickness, type and materials as well as painting materials and surface preparation.
7. Any special requirements (e.g. seal welding).
8. Any special manufacturing procedures to be followed by vendor.

### 7.3.3 Air Cooled Heat Exchangers (If applicable):

1. Surface area and bundle arrangement. Air cooler duty in design condition and different modes of operations (if applicable). Process inlet and outlet temperatures and air side temperature increase models.
2. Tube length, diameter and number (1), type of fining, tube wall thickness, fan diameter and type requirements for variable speed control and fan pitch.
3. Absorbed and installed motor horsepower (1), header type, nozzle sizes and rating, type of driver, louver requirement, heat transfer rates, (tube side, air side and overall), flow rate (design and in different modes of operations if applicable) in tube side and its condition at inlet and outlet process side pressure drop and air side pressure drop, plot area and unit weight and material specifications.
4. Noise limit specification.
5. Insulation requirements, thickness and type.
6. Material of insulation and painting including surface preparation.

 पी डी आई एल PDIL	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>  <b><u>Bharat Coal Gasification and Chemicals Limited</u></b>  <b><u>CONTRACTOR'S SCOPE OF WORK</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
		Document No.	Rev	
		Sheet 48 OF 71		

**Note:** (1) To be provided by vendor.

#### **7.3.4 Plate Type Heat Exchangers:**

1. Exchanger process specifications e.g. flow rate, pressure drop, etc
2. Exchanger duty/heat transfer coefficient
3. Adopted fouling factor/excess surface area (1)
4. Type, area and number of flow plates (1)
5. Plate thickness (1)
6. Dimensional outline drawing (1)
7. Mechanical calculation results
8. Inspection reports including material certificates
9. Maintenance instructions

**Note:** (1) To be provided by Vendor.

#### **7.4 Drawings And Documents Issued For Construction:**



LSTK Contractor shall provide, construction drawing/document stamped as "Approved for Construction" and shall be signed by a responsible person to confirm that the drawings/documents are certified in all respects and in all details. Drawings and documents issued by LSTK Contractor for construction purposes shall be sufficient from all respects and shall be so detailed in order to perform and execute all activities satisfactorily for construction/erection, pre-commissioning, commissioning and all modes of operations of the Plants, Machinery and Materials included in the Plants.

LSTK Contractor shall also provide complete set of technical procedures and specifications for satisfactory performance of the installation/construction/erection, pre-commissioning, commissioning and all modes of operations of all of the Equipment, Machinery and Materials included in the Plants.

#### **7.5 Selection of Equipment and Materials:**

##### **7.5.1 General Design:**

LSTK Contractor shall carry out design and select Equipment and Materials (in accordance to the procedures specified in the Contract) which reflect up-to-date proven and established technology. Prototype designs shall not be acceptable.

 <div>पी डी आई एल PDIL</div>	<div><u><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></u></div> <div><u><b>Bharat Coal Gasification and Chemicals Limited</b></u></div> <div><u><b>CONTRACTOR'S SCOPE OF WORK</b></u></div>	PC0288/E/001/P-II/ SEC-3.0	0	
		Document No.	Rev	
		Sheet 49 OF 71		

### 7.5.2 Standardization:

LSTK Contractor shall give close consideration to the need for standardization to restrict and minimize the number of types and sizes of the similar equipment, machinery, materials, parts, components and items in the Plants such as electric motors, machinery, control valves and/or some of their parts, accessories and components such as mechanical seals and so on, in order to simplify maintenance and reduce spares requirements for the inventory at site.

## 7.6 Welding Procedures:

### 7.6.1 Classification:

1. Class A Weldments are defined as follows:

- a. All alloy steel weldments
- b. All alloy clad weldments.
- c. All dissimilar metals weldments.
- d. All non-ferrous metal weldments.
- e. All weldments for operating temperatures below 0 °C.
- f. All air fin exchanger header weldments.
- g. Carbon steel weldments over 30 mm thickness.
- h. Field fabricated tank weldments over 12 mm thickness.
- i. Exchanger tube to tube sheet welds.
- j. All main seam weldments on field fabricated vessels.

2. Class B weldments are defined as follows:



- a. All field or shop fabricated piping.
- b. Welding of pressure parts.
- c. Welding non-pressure parts to pressure parts.
- d. Other standard weldments governed by a code of practice which calls for qualification of welding procedure and welders.

### 7.6.2 Documentation:

All welding Basic and procedures, specifications and welder qualifications data shall be properly and fully documented.

## 7.7 Lubricants, Chemicals, Catalysts, Adsorbent, Resins, Etc.:

LSTK Contractor shall prepare and furnish to Owner/ PMC lists of lubricants required for initial fill and 120 calendar months operation, with consumption for all equipment which need

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 50 OF 71	

lubricants, based on information from Vendors and approved Vendor list. LSTK Contractor shall also indicate equivalent lubricant brands available in India which can be used alternatively. Initial requirement of all lubricants, chemicals, catalysts, adsorbents resins etc are in LSTK scope.

**LSTK Contractor shall prepare and furnish to Owner / PMC lists of chemicals, resins, catalysts, adsorbents, solvents, refrigerants chemicals and other consumables necessary and required for efficient operations and all similar requirements for initial fill (if applicable) and 120 calendar months operation, consumptions (wherever applicable) together with all necessary information and data, and three names of permanent suppliers (if possible) for any respective items as stated above.**

## 7.8 Operation Manual



LSTK Contractor shall supply detailed Operation, Safety and Laboratory manual for all plants. The operation manual shall include detailed description of Pre-Commissioning; Commissioning, initial startup, Normal Operation, Shut Down and Emergency & Safety procedures. It shall also include suggested Log Sheets for recording plant operation and analytical data.

The Laboratory Manual shall include detailed description of analytical procedures, collection of samples, frequency of analysis etc. along with quality control for raw materials, intermediate and finished product. The manual shall include list of laboratory instruments/equipments and list of chemicals with their specifications.

## 8.0 PROCUREMENT:

Contractor's scope includes ordering, all import formalities, fabrication/purchase of equipment and materials, port clearance, packaging and transportation to site, stores management which includes preservation and storage of equipment and materials, uncovered storage, air-conditioned storage and open storage. Items requiring covered storage and air-conditioning storage is to be highlighted along with the bid. Items contemplated for fabrication at site to be submitted along with the bid although both these aspects would be covered under the Contractor's responsibility.

Vendor manuals relating to installation, operation and maintenance and test certificates should be necessarily sent along with equipment. Please also refer Final Documentation Submission requirement spelt out in this Tender Document, in this regard.

 <div>पी डी आई एल PDIL</div>	<div><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></div> <div><b><u>Bharat Coal Gasification and Chemicals Limited</u></b></div> <div><b><u>CONTRACTOR'S SCOPE OF WORK</u></b></div>	PC0288/E/001/P-II/ SEC-3.0	0	
		Document No.	Rev	
		Sheet 51 OF 71		

Before ordering, clearances for technical portion would be taken from Owner/ PMC in respect of the critical equipments (special equipments) comprising of mechanical static and rotary equipments, electrical and instrumentation items. For instrumentation items, other equipment and materials can be ordered without referring to PMC as long as ordering is in accordance with datasheets, drawings, standards, specifications. Any ordered items which do not confirm to the contractual requirement identified at any stage of the project shall be rejected. Replacement/modification time/cost implication arising out of this shall be to the LSTK Contractor's account.

Whenever clearances are to be taken, it would be necessary to submit details of technically acceptable offer. Supply of adsorbents as required. Assistance for Procurement of spares for **120 calendar months** operation as per spare part philosophy detailed in the scope of supply, Pre-commissioning-Commissioning spares and Insurance spares are in the Contractor's scope.



Coding system for stores management to be given by Owner/PMC after the award of the contract is to be adhered to by Contractor; suitable procedure based on the same shall be developed by the Contractor for execution.

## 9.0 INSPECTION & EXPEDITING:

The Contractor is required to organise a proper inspection and expediting system so as to ensure timely delivery of all the items/equipment meeting the specified quality criteria. This function has to be carried out by appropriate deployment of qualified personnel who have wide experience in their respective fields. Inspection of all items supplied under this contract shall be carried out by independent third party inspection agencies like Llyods/ BV/ TUV/ PDIL. The cost of third party inspection shall be borne by the LSTK Contractor. Expediting is one of the vital activities of successful and efficient procurement system which enables timely execution on the project. Such expediting has to be carried out by deployment of expediting coordinator located at Contractor's Head Office who would be assisted by expeditors located in various regional offices. To enable this function to be very effective and fruitful, following functions are to be carried out as a minimum.

### 9.1 Expediting Coordinator:

Expediting Coordinator located at the Contractor's HO will liaison with various departments such as purchase, projects, engineering, transportation etc. on one hand and regional

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	 <div>भारत भारती BHEL</div>
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 52 OF 71	



inspection/expediting offices and vendors on the other. The basic functions of such expediting coordinator would be:

- ❖ Maintain effective communication link between various departments of the Contractor including his regional offices and vendors on whom the orders are placed.
- ❖ Status maintenance of all the orders.
- ❖ Analyzing the order status in detail after identifying the critical order and initiation of suitable remedial measures.
- ❖ Acting as an effective instrument in final delivery of the item within contractual delivery date (CDD).
- ❖ Preparation of order closes out reports of each order.
- ❖ Expediting coordinator shall be a person who is highly communicative and has sound technical knowledge; he must be highly analytical, alert, quick in gathering up-to-date information of the various orders.

#### **9.1.1 Responsibility of Expediting Coordinator:**

- ❖ Attending periodical review meetings with Contractor's project department and Owner/PMC.
- ❖ Distribution of Fax of Intent/Letter of Intent and status maintenance.
- ❖ Liaison with regional offices to obtain order generate acknowledgement of Fax of Intent/Letter of Intent.
- ❖ Intimate Owner/PMC of reservations (if any) from the vendor in purchase order acceptance.
- ❖ Distribution of POs / PRs to vendors and regions.
- ❖ Expediting of vendor's drawings and other related documents.
- ❖ Expediting of approval of drawing by respective engineering department and timely return of the same to the vendor.
- ❖ Ensure receipt of periodical expediting reports and preparation of monthly status report against each order as per the requirement of Owner/PMC.
- ❖ Identification of critical orders/issues and initiate of remedial action.
- ❖ Expediting of decision on deviation sought by the vendor.



 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	 <div>भारत भारती BHEL</div>
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 53 OF 71	



- ❖ Follow up actions with various concerned departments regarding all the issues discussed in the review meetings.
- ❖ Prompt despatch of material after inspection with the assistance of transportation department.
- ❖ Follow up of despatch particulars after despatch.
- ❖ Ensure preparation of order close out report for each order giving complete details of the order including ordered quality, contractual delivery date (CDD).
- ❖ Date of completion, delay, if any and reasons for delay, status of final documents etc.
- ❖ Ensure receipt/distribution of vendor documents including final documents as per PR.
- ❖ Preparation of final procurement closing report. The order close out reports shall be accompanied with two sets of complete documents in respect of each order bound/put together in a folder comprising of: purchase order, purchase requisition, change orders (if any), inspection certificates, material test certificates, final vendor drawings (if applicable), operation/maintenance manuals, any other document as specified in PR.

## 9.2 **Expeditor:**

Expeditor's responsibility commences from the time he receives the intimation of placement of TOI/LOI/order on vendor located in his region till the time he furnishes the despatch particulars of the item under a particular PO. During this process expeditor shall monitor and maintain all activities of the vendors such as:

- ❖ Vendor's understanding of the order.
- ❖ Submission of design drawing documents for approval.
- ❖ Sub-ordering, planning and scheduling.
- ❖ Manufacturing testing and despatch.
- ❖ Delays, power cuts, strike lock out etc.
- ❖ Submission of final documents as per PR.

Above functions may be possible only by frequent visits to vendor's office and shops including their sub-vendor's establishments as the case may be. Expeditor shall be able to visualise the problems in advance and suggest timely corrective measure. In nutshell, expeditor is not a mere progress reporter but a vital catalyst for successful completion of the job.

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 54 OF 71	

### 9.2.1 Responsibility of the Expeditor:



- ❖ Ensure order acknowledgement from the vendor.
- ❖ Communicate the person concerned the reason for vendor's inability to accept the order (if so).
- ❖ Progress reporting of various orders located in the region.
- ❖ Communication with the vendors whenever he finds lack of efforts on their part.
- ❖ Raise alarm report at an appropriate time on possible serious delay or vendor's inability in meeting with scheduled date of delivery and also to suggest action plan.
- ❖ Liaise with inspection department for timely inspection, including third party inspection/statutory inspection as specified/required.
- ❖ Liaise with engineering department for approval of drawing, acceptance of deviation etc. through the expediting coordinator.
- ❖ Liaise with transportation department for sound and quick despatch of material.

### 9.3 Inspection Quality Assurance System:

The objective of the quality assurance scheme of the Contractor shall be to ensure the conformity of equipment, material, site construction (if any) to various standards, specifications, drawings and technical requirements that are being mutually agreed between the Contractor and Owner/PMC. Quality Assurance System should clearly indicate the organisational approach for quality control and quality assurance of the various equipment/construction activities (if any) and also provide a verifiable evidence of the Contractor having carried out all the activities laid down in the bid document and the procedure. Such conformity to quality level shall be ensured by controlling the quality level of purchased items at vendor's/sub-vendor's shop/site and shall cover from source surveillance to final inspection. The Contractor to submit a detailed inspection and testing plan for various shop/site activities as a part of his Procurement Manual which shall be duly approved by Owner/PMC. The Procurement Manual shall as a minimum include:

#### In house Inspection Programs:

- ❖ Inspection procedures consistent with mandatory codes.
- ❖ Procedures for material identification and transportation.
- ❖ Certification of non-destructive testing.

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	 <div>भारत भारती BHEL</div>
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 55 OF 71	

Inspection responsibility shall include but not be limited to the following:

- ❖ Single or multiple visits to the vendor's shop/site as per the requirement.
- ❖ Pre-inspection liaison meeting with the vendor for vendor's correct understanding of the inspection requirements.
- ❖ Approval of quality assurance/quality control plan procedure clearly indicating stages of inspection with specific reference to witness and review.
- ❖ Ensure submission of quality control procedure and approval of the same for critical sub-orders.
- ❖ Inspection of various equipment/items as per relevant codes, specifications/drawings including witnessing of final acceptance test at vendors works/site.
- ❖ Maintenance of inspection reports periodically highlighting hold, deviation etc.



As indicated for expediting coordinator, LSTK Contractor should nominate an inspection coordinator with similar responsibility who will liaise various inspection offices/vendors for proper coordination.

#### **9.4 Inspection through an Approved Third Party Inspection Agency:**

Inspection requirements shall be fulfilled through Owner/PMC approved Third Party Inspection Agency. The payments to be made to the Third Party Inspection Agency shall be the responsibility of the LSTK Contractor. Further, the responsibility for inspection/testing as per specification approved documents and agreed Quality Assurance procedure and plans shall be that of the LSTK Contractor. Inspection activities of the Third Party Inspection Agency shall be coordinated by the Inspection Coordinator of Contractor.

### **10.0 PROJECT PLANNING, SCHEDULING & MONITORING:**

The Contractor is required to institute and maintain a proper planning, scheduling and monitoring system and employ professionally qualified and experienced planning engineers for the project. The system shall have latest state of the art technique. To this effect, Contractor shall implement this system through the Prima Vera Project Planner. The system developed should be capable to support and enforce proper control mechanism in the project. It should be based on hierarchical breakdown of works with elaborate level of detailing and control. The levels of controls should be such that it supports and foster controls at activity

 <div>पी डी आई एल PDIL</div>	<div><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></div> <div><b><u>Bharat Coal Gasification and Chemicals Limited</u></b></div> <div><b><u>CONTRACTOR'S SCOPE OF WORK</u></b></div>	PC0288/E/001/P-II/ SEC-3.0	0	
		Document No.	Rev	
		Sheet 56 OF 71		

level, function level and management level with greater emphasis on target, scope and commitment at various stages of contract for accountability and action planning. Such multi-level/ multi-tier system of planning, scheduling and monitoring, supports, effective information generation, assimilation, summarisation and reporting in proper and adequate manner. The system shall be predictive type and should constitute pre-warning mechanism to diagnose and anticipate the problem well in advance and provide preventive features/measures. It is required that work breakdown structure should consist of details of systems, work packages, functions, work items and activities from monitoring point of view at micro level and summarisation at higher levels. It is expected that the work breakdown structure coding system or methodology to be followed shall be informed/discussed with the successful LSTK Contractor during the kick-off meeting.



Following schedules, documents, reports shall be prepared and submitted by the Contractor for Owner's/PMC's review/approval at various stages of the project:

#### 10.1 **Kick-Off Meeting:**

On award of job, the Contractor is required to submit the following documents which will be discussed during the kick-off meeting to establish planning requirements, inputs and outputs for overall schedule, monitoring and progress reporting.

- List of work package/areas.
- List of critical drawings.
- Breakdown of work packages to work items level.
- Input requirements of each work item/activity.
- Schedule start and finish dates of all milestone/activities in line with overall schedule of the project.
- Overall system-wise, discipline-wise weightage for each item/activity.
- Three month front-end schedule within a week of award.

In this kick-off meeting, it will be endeavoured to reach complete understanding with Contractor on activities, inputs and logic to establish planning documents for monitoring.

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 57 OF 71	

Venue of the kick-off meeting to be held between the successful LSTK Contractor, PMC and the Owner, shall be either at PMC Office or Owner Office.

## 10.2 **Early Planning Document/Look Ahead Schedule:**

Immediately after the award of contract and pending finalisation of overall project schedule, detailed activity chart/network, functional schedules etc., the Contractor in consultation with PMC shall prepare a look ahead schedule as a guideline for the activities to be performed during the relevant periods.

## 10.3 **Overall Project Schedule:**

The Contractor shall submit within 30 days of Fax of Intent, the work breakdown structure showing project work load, that is, preparation of tenders, material requisitions, construction drawings equipments etc. Along with a sufficiently detailed overall project schedule in the activity network form, clearly indicating the major milestones, inter relationship/interdependencies between various activities such as process, engineering, procurement tendering, manufacture, delivery, construction etc. together with computer analysis of critical path and floats as well as quantum of work for major activities.



The schedule will be reviewed and approved by Owner/PMC and the comments if any shall be incorporated in the network issued for implementation within two weeks from receipt of comments. The network thus finalised shall form part of the Contract and will become the basis for developing further detailed activity network. This schedule shall not be revised without the prior permission from the Owner/PMC during the entire period of contract. The changes made during revision of the contract shall be approved by Owner/PMC.

## 10.4 **Detailed Activity Network:**

The Contractor should develop detailed activity networks for various systems/plant/ unit of the project, based on approved overall project schedule within two months of Fax of Intent. Such networks would be computerised for further monitoring and reporting.

## 10.5 **Functional Schedules:**

The Contractor should prepare resource-based detailed functional schedules in line with detailed activity networks for functional monitoring, scheduling and control. This should clearly reflect strategies and philosophy of execution. Owner/PMC reserves the right to check the functional schedule and status of activities at anytime and at any location of

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	 <div>भारत भारती BHEL</div>
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 58 OF 71	

performance/execution. Further, the functional schedules shall be submitted by the Contractor on demand by the Owner/PMC.

#### **10.6 Progress Measurement Methodology:**

The Contractor is required to submit during the kick-off meeting, the detail methodology of progress measurement of engineering, procurement, manufacturing, delivery, computation of total service/physical progress at the unit-wise level and on the overall basis. The progress basis shall be physical realisation of work such as in terms of deliverables and construction quantity/volume accomplished. The amalgamation of such output across the project to compute overall progress shall be suitably established with proper rational and norms and maintained throughout the project. Owner/PMC reserves the right to modify the methodology in part or in full.

#### **10.7 Vendor Scheduling and Monitoring:**



The Contractor shall establish schedules for pre-ordering and post ordering for follow up. The vendor monitoring preferably should be on logical networks and commitments at least on critical items in order to monitor them on regular basis for effective control. Owner/PMC may demand such follow up procedure and logical networks for various critical equipment at any time during the course of order execution. The manufacturing schedule shall be established and agreed with the vendors and acceptance shall be brought to the notice of Owner/PMC in time.

#### **10.8 Construction Network:**

The Contractor shall prepare and submit a detailed construction network with full consideration of logistics, construction studies and method for Owner/PMC approval. The Contractor shall describe the resources required and special construction equipments, Tools and tackles to be mobilized. The network shall be developed subsequent of substantial progress of engineering and ordering with fairly known construction workload and quantities.

#### **10.9 Construction Worksheets:**

The Contractor shall further detail out the construction network into area-wise details in terms of work, quantity and schedule, to firm up basis for area control. The construction schedule should be worked out based on work front generation criteria which will call for availability of input like drawings, materials and access for each/group of activity to be performed. It may be

 पी डी आई एल PDIL	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	 भारत भारती BHEL
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 59 OF 71	

in the form of resource loaded bar chart with 'S' curve. Owner/PMC reserves the right to access the same.

#### **10.10 Construction Contractor Schedule:**

The Contractor shall agree upon the construction schedules with sub-contractors for proper mobilisation, monitoring and control. Owner/PMC reserves the right to ask for such programme and status of any time as may be required.

#### **10.11 Computerisation:**

Contractor should follow proper computerised control for the following project modules:



- Activity network
- Engineering (Residual)
- Purchasing, delivery and expediting
- Tendering
- Construction planning and control
- Materials control at head office.
- Material allocation and control at field office
- Proper warehousing control
- Project documents and construction drawings

The above distinct but integrated components of project should be monitored as deliverable and quantum level. To perform such elaborate level of input-output control at each deliverable, the packages used should forecast resources based on recovery plan in dynamic manner for adequate control.

As indicated earlier, project schedules as above shall be developed/evolved using the latest version of the Prima Vera Project Planner Software Package.

#### **10.12 Project Review Meetings:**

Contractor shall present programme and status at various review meetings as required.

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 60 OF 71	

#### 7.12.1 Monthly Review Meeting:

Level of participation	:	Project and planning of PMC and Contractor
Agenda	:	Monthly programme v/s progress status/statistics Major hold ups/slippage Completion outlook Assistance required Areas of concern and critical issue Recovery action plan
Venue	:	Owner/PMC office

#### 7.12.2 Weekly Review Meeting:

Level of participation	:	Contractor/PMC's site in-charge and job engineers
Agenda	:	Weekly programme v/s actual achieved in week Programme for next week Purchase requisition status report Recovery actions and hold up analysis
Venue	:	Site office

#### 10.13 Progress Reporting:



The Contractor shall submit the following progress reports on a regular basis for Owner/PMC information/review.

##### 10.13.1 Monthly Progress Report

This report shall be submitted on a monthly basis within seven calendar days from cut-off date, or as agreed upon, covering overall scenario of the project. The report shall include, but not limited, to the following:

- Executive summary or summary of major events/activities.
- Schedule v/s actual percentage progress and progress curves for engineering, ordering, manufacturing, delivery, contracting, construction, commissioning, overall.
- Areas of concern/problem/hold-ups, impact; recovery action plans/catch-up plans.
- Activities executed achievements during months and targets for the following month.



 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 61 OF 71	

- Analysis of critical activities and impact on overall completion.
- Chronological achievements of key events indicating schedules and actual date.
- Annexure giving status summary for drawings material requisitions, equipment and materials delivery, contracting and construction.
- Resource requirement deployment status.
- Change order status.
- Invoice status.
- Construction photographs.

#### 10.13.2 Weekly Reports:

This report will be prepared for Head Office and construction site in summarized fashion and submitted on every Tuesday taking status as of Sunday by the Contractor on weekly basis and will cover following items:



- Activities completed (engineering, procurement, contracting, construction. etc.)
- Programme for subsequent week.
- Resource deployed – man and machine.
- Quantities and productivity achieved in key areas of work.
- Progress on procurement activities including material requisition status reports.
- Constraints, if any.

The report/information may be transmitted preferably through fax to Owner/PMC HO.

#### 10.13.3 Daily Reports:

- Important activities for the day at site.
- Material/equipments receipts for the day.
- Labour deployment report.

#### Requirement of Copies for Submission of Schedule & Reports

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>	Sheet 62 OF 71		

SN	Name of Document	Number of Copies		
		Owner	PMC	
			HO	Site
1	Overall project schedule	4	2	2
2	Detailed activity network	4	2	-
3	Functional schedule	-	2	2
4	Construction network	4	2	2
5	Monthly progress report	4	2	2
6	Weekly progress report	2	2	2
7	Daily report	1	-	2



Copies shall be forwarded through PMC. Above requirement is indicative and shall be reconfirmed during kick-off meeting.

#### 10.14 **Material Control:**

It is essential that the Contractor follow an integrated material control system for the project. In the system, material identification in the drawing office, procurement and allocation, are all channelized and controlled in an orderly manner. The Contractor should follow a system for material identification like system-wise or area-wise/zone-wise, and should give construction orientation to material control. The Contractor, right from the beginning, at the drawing office stage will start identifying materials system-wise or area-wise. The system will be based upon backing of material from the material take off stage through material requisitioning, placement of purchase order, manufacturing at vendor's shop upto receipt at site for making the material available for performing planned and sequential construction work.

At the construction site, the Contractor will develop and implement a system of inspection, receipt and effective utilisation of materials received by re-examining the work front availability and priority between and amongst various systems and areas.

In the case of multiple agencies carrying out construction at site, the Contractor must adopt methodology of allocation and de-allocation and timely issue of the materials thereby preventing possible idle storage of items at the Contractor's level. Contractor must follow proper warehousing procedure at project store to maintain various planned and unplanned issues and dynamic stock status records. Through periodic reviews, the Contractor will have a

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	 <div>भारत भारती BHEL</div>
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 63 OF 71	

system of generating hold up reports well in advance to identify exception on material availability and to track such material by the expeditious through a systematic follow up procedure from the vendors.

Owner/PMC may introduce checkpoints at procurement, allocation and construction stages to know the development, status and behaviour of the system and the Contractor shall submit the following reports on monthly basis: bulk material status report, and material hold up/shortage report.

#### **10.15 Project Time Control Methodology:**

**10.15.1** The time for completion of the complete scope of work shall be strictly as per the time schedule given in the tender document.



**10.15.2** The LSTK Contractor shall furnish the following documents along with the bid:

- (a) An overall schedule in the form of network, clearly indicating all important milestones in design, engineering, fabrication, procurement construction, testing, commissioning, etc. for the plant commensurate with the overall time schedule.
- (b) Resource deployment schedule indicating mobilisation of all critical resources including manpower and machinery for the smooth execution of the job at engineering offices, fabrication shops and construction site. The resource schedule shall also contain various construction aids envisaged to be deployed for execution.
- (c) Organisation structure for effective project management and control, clearly indicating the responsibility centre as well as bio-data of the key personnel, who are permanent employees of the Contractor.

**10.15.3** Within 30 days of issue of fax/letter of intent, the Contractor shall finalise the following as detailed earlier:

##### **(a) Overall Project Schedule**

Overall project schedule in line with the agreed milestone and detailed to adequate work breakdown structure level covering all phases of the work such as detailed engineering, procurement, manufacturing, shipment, tendering and field erection. This schedule shall also include the interface activities to be provided by the Owner/Engineer-in-Charge and the dates by which such facilities are needed. Contractor shall get the scheduled

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>	Sheet 64 OF 71		

submitted and reviewed by Owner/Engineer-in-Charge and the agreed schedule shall form part of the Contract monitoring document based on which performance would be reported and evaluated. This document shall be signed by both the parties. The Owner/Engineer-in-Charge shall also review the weightage allotted to various activities and method of reporting to be adopted by the Contractor. During the progress of the contract if in the opinion of Owner/Engineer-in-Charge, desired progress as physically/sequentially is not maintained, it would be obligatory on the Contractor to re-programme the work schedule in order to accommodate the backlog and/or provide work front to other agency, without any obligation to the Owner/PMC.

(b) Functional Schedules

- Engineering Schedule

This shall indicate list of drawings, specification and sketches to be prepared discipline wise for each plant and scheduled date of issue of each document.

- Ordering, Manufacturing & Delivery Schedule

This will be in the form of bar chart and shall indicate item-wise all the major activities regarding ordering, shop fabrication/manufacturing and delivery of materials.

- Construction Schedule



This will be in the form of a detailed bar chart showing all the construction activities (civil, structural, piping, equipment erection, electrical, instrumentation, insulation, painting, etc.) at site with their durations and workload and highlighting the inputs namely drawings, materials availability, etc., compatible with the related functional schedule. The Contractor shall provide on request key construction net work of any work module for critical review and control.

- Resource Deployment Schedule

A detailed deployment schedule indicating manpower, machinery, construction, equipment in line with the overall project schedule.

- Pre-commissioning and Commissioning Schedule

Contractor shall develop this schedule in the form of a bar chart and submit the same to PMC for review.

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 65 OF 71	

- Any other document required for monitoring.



**10.15.4** In line with the construction schedule, the Contractor shall submit a monthly programme for site activities and the target set in shall be strictly adhered to. In all matters concerning the extent of targets set out in the monthly programme and the degree of achievement, the decision of PMC shall be final and binding. The monthly programme shall be further broken into weekly programmes. At the end of each week, a report shall be submitted by the Contractor indicating the achievement during the week against the targets, reason for shortfall if any and the construction programme for the following week. Contractor shall also attend weekly/monthly review meeting conducted by PMC or by his representative to review project status.

**10.15.5** The Contractor shall regularly submit a detailed progress report in respect of:

- Release of drawings
- Sub-ordering of materials
- Manufacturing
- Delivery of equipment/material status report
- Construction
- Other features like mobilisation, safety etc.
- Report indicating the critical activities governing the timely completion of the project and actions to overcome the same to be submitted every month.

This report will be issued every month on an agreed cut off date and shall include the following brief description of the progress achieved during the month. Reason for short fall if any and action plan to make up short-fall.

- Scheduled and actual percentage progress discipline-wise/system-wise as well as overall physical progress.
- Job completion trend in the form of updated overall schedule.
- Progress photograph highlighting major achievement.

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 66 OF 71	

**10.15.6** The Contractor at any point of time of operating would be permitted to revise the accepted schedule/control documents with the Owner/Engineer-in-Charge without changing the contractual completion date.

**10.15.7** The review of the performance of work would be made at different levels of management and Contractor is expected to ensure proper participation for effective reviewing and action plan.

**10.15.8** The Contractor should ensure availability of professionally qualified planning engineer both at HO and site deemed adequate by the Owner/Engineer-in-Charge.

**10.15.9** The Contractor at his own cost should maintain a control room at site highlighting all the features, schedule and achievements of the project.

**10.15.10** Weighted percentage of each discipline/group of work shall be mutually agreed to between the Contractor and Owner/Engineer-in-Charge after the award of contract to facilitate compilation of progress.

## **11.0 QUALITY ASSURANCE & QUALITY CONTROL:**



### **11.1 Quality Assurance/Quality Control:**

All work/services to be performed by the Contractor under this contract shall be of specified/approved quality and Contractor shall have a quality assurance/quality control (QA/QC) system during the performance of various activities such as engineering, procurement, tendering, construction etc. Review/approval of activities by Owner/PMC shall not however dilute the responsibility of Contractor for maintaining quality.

#### **(a) QA/QC Procedure:**

Contractor shall submit the QA/QC procedure to be adopted for engineering procurement and construction activities of plant for review and approval to Owner/PMC. The QA/QC procedure shall cover all activities to be performed by Contractor. Some important activities and procedures to be evolved are listed below:



- **General:** Document control, coordination, non-conformance report of Sub-contractors, output identification and traceability, QA system review.

 <div>पी डी आई एल PDIL</div>	<div><u><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></u></div> <div><u><b>Bharat Coal Gasification and Chemicals Limited</b></u></div> <div><u><b>CONTRACTOR'S SCOPE OF WORK</b></u></div>	PC0288/E/001/P-II/ SEC-3.0	0	
		Document No.	Rev	
		Sheet 67 OF 71		

- Residual Basic Engineering: Residual basic engineering and detail engineering; drafting; engineering for procurement.
- Procurement/Inspection: Incoming material control, welding qualification and repair, manufacturing or fabrication process control, applicable non-destructive examination, coating/lining, preservation, post-weld heat treatment wherever applicable, packaging and despatch control, transportation, inspection/test plans for all specific and mandatory tests (as per drawings and codes) with clear indication of witness, verification and hold points.
- Construction: Pre-construction activities, job construction, welding qualification and repair, inspection/test plans for all specified tests (as per drawing and codes) with clear indication of witness, verification and hold points. Contractor shall prepare construction QA plans for review of the Owner/PMC and the same shall cover as minimum the areas as under, and shall confirm their compliance to approved codes/standards/specifications, etc.
- Site Preparation: Tie-ins buildings and structures, incorporation of all witness tests/hold points of construction work, clean-up testing, instrumentation installation and construction.

(b) As a part of Construction and Quality Assurance, the Contractor shall also comply with the following activities:

- Stage-wise inspection of quality of work as per approved QA plan and contract specifications.
- Develop welding procedures and welders qualification procedures for their work.
- Ensure compliance of various statutory rules, regulations and safety measures and to arrange and co-ordinate site inspection, testing etc. as required under local statutory rules and regulations prevalent in India.
- Take all necessary precautions to protect construction work and material from damage by climate, outside elements and construction activities.
- Ensure that materials used are in accordance with drawings/project specification.

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>		Sheet 68 OF 71	

- Review safety procedures prepared by the Contractor for compliance with applicable codes, regulations and Owner requirements.
- Prepare schemes for heavy/critical equipment's erection/lifts/rigging before and submit the same for PMC review/approval.
- Ensure alignment (hot/cold) of all critical rotary equipment/machinery and their upkeep/maintenance as per suppliers' recommendations.
- Perform housekeeping activities, which include maintaining sanitary facilities, sweeping clean up, removal of excess materials/temporary facilities, scaffolding, as necessary.
- Conduct periodic quality/technical audits for ensuring quality and conformance with the contract.
- To take immediate appropriate corrective actions as and when such discrepancy arises to fulfil quality, safety obligations.

(c) QA/QC procedure shall also include quality plans, mostly in tabular formats defining the specific quality practices and flow of every identifiable activity of a discipline. All disciplines concerned with the performance of work are to be covered. These quality plans should indicate the following:



- For Design and Engineering: Activity description; preparation, checking, review and approval requirements; code of conformance (applicable standard specification number); applicable procedure number; QA data/records produced.
- For Procurement and Construction: Activity description; procedure number, inspection and test plan number, conformance code, testing and inspection code

(d) QA/QC procedure and quality plans will be discussed during kick-off meeting. Hold, witness and verification points and Owner/PMC/Licenser review/audit requirements will be finalised between Contractor and Owner/PMC/Licenser.



(e) During the performance of the contract, the Contractor shall:

- Implement approved quality assurance programme including but not limited to:



 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>	Sheet 69 OF 71		



- (i) Performance of internal quality audits, preparation of audit reports and submission for review of PMC. Contractor shall evolve a comprehensive system of planned and documented audit to verify whether various performed activities comply with detailed procedures, specifications, guidelines etc. and to determine the effectiveness of quality system. Scope of such internal audits shall be furnished to PMC for review. Verification documents shall be generated during audit and submitted periodically to PMC for review. Throughout all stages of the scope of contract, the Contractors procedures, documents, activities, products and services and those of his Sub-contractor's shall be subject to Owner/PMC review/approval. Such surveillance and audit are optional and shall not relieve the Contractor of his contractual obligations and liabilities.
- (ii) Generation of QA records (mostly inspection and test plans) as per quality plan and submission for review by Owner/PMC. The Contractor shall submit all quality records (generated during activity execution) and audit results on well laid formats/performance for Owner/PMC review. The rights of such review are reserved by Owner/PMC. Owner/PMC may review it in full, parts or selectively. However, complete correctness of the QA records shall be the sole responsibility of the Contractor irrespective of its review by Owner/PMC.
- Facilitate Owner/PMC in the quality audit at works.
  - Certify QA Programme documents of Contractors and submit to Owner/PMC for review.
  - Carry out audits/inspection at Contractors works as per approved QA programme and submit the reports for review by Owner/PMC
  - Get similar QA system implemented at his Sub-contractor's works/office. QA records from the Contractor shall be reviewed and certified for compliance by the Contractor before submitting to Owner/PMC for information.
  - Carry out audits at Contractors' office/works and submit the report to Owner/PMC for information.
  - Ensure that all personnel shall be assigned tasks commensurate with their qualification. Specialized workmen shall be qualified and certified.

 <div>पी डी आई एल PDIL</div>	<div><u><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></u></div> <div><u><b>Bharat Coal Gasification and Chemicals Limited</b></u></div> <div><u><b>CONTRACTOR'S SCOPE OF WORK</b></u></div>	PC0288/E/001/P-II/ SEC-3.0	0	
		Document No.	Rev	
		Sheet 70 OF 71		

- Handle non-conformance brought out by internal and external sources as follows:
  - (i) Non-conformance brought out by Contractor's own review/audit shall be resolved by Contractor himself. One level higher than those responsible to carry-out the activity shall resolve the non-conformance. Such resolution shall be in full knowledge of Departmental Manager. Corrective action shall be initiated at the earliest. Report of such resolution shall be submitted to Owner/PMC for information.
  - (ii) Non-conformance brought out by Owner/PMC through any of the following shall be resolved by the Contractor. Such corrective actions shall be submitted to Owner/PMC for review. However, corrective action shall be initiated at the earliest: technical reviews, QA review and surveillance, inspection, external audit (Owner/PMC)

#### **Glossary of Terms used in the Section**

- **Hold Point:** A point designed by Owner/PMC/Licensors in the approved quality plan submitted by Contractor in the kick-off meeting which requires inspection/verification and acceptance by Owner/PMC before any further processing is permitted. The Contractor shall not process the activity/item beyond a hold point without written approval by Owner/PMC/Licensors except where prior written permission for further processing is available.
- **Witness Point:** An activity designated by Owner/PMC/Licensors which requires witnessing by Owner/PMC/Licensors as the activity is performed. After proper notification has been provided (notification modalities and period shall be finalised in kick-off meeting), the Contractor is not obliged to hold further processing if Owner/PMC/Licensors is not available to witness the activity or does not provide comments before the date notified. Basis of acceptance shall be as per relevant technical specification.
- **Verification Point:** A point where Owner/PMC/Licensors Plans to audit, monitor or witness in-process activity. The Contractor is not obliged to provide any advance written notification of these points. Basis of acceptance shall be as per relevant technical specification.

 <div>पी डी आई एल PDIL</div>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-3.0	0	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>CONTRACTOR'S SCOPE OF WORK</u></b>	Sheet 71 OF 71		

- Quality Surveillance: Monitoring or making observations to verify whether or not material/items or services conform to specified requirements. Surveillance activities may include audit, inspections, witness of testing, review of quality documentation, personnel qualifications etc.
- QA Records: Documents which demonstrate achievement of required quality and verify effective operation of quality system, viz. inspection reports, test data/Inspection and test plans, qualifications reports, validation reports, audit report, material review reports, calibration data.
- Quality Audit: A systematic examination of the acts and decisions by people with respect to quality in order to independently verify or evaluate and report degree of compliance to the operational requirement of the quality programme, or the specifications or contract requirements of the product or service.

PART - II: TECHNICAL (2)

SECTION 4.0



DESIGN BASIS

PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT

PROJECT: COAL TO AMMONIUM NITRATE COMPLEX, AT LAKHANPUR, ODISHA (INDIA)

0	20/05/2024	20/05/2024	Issued for Tender Purpose	SR	SK	MN
P	05/03/2024	05/03/2024	Issued for Client's comment	SR	SK	MN
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD



	<div><u><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></u></div> <div><u><b>Bharat Coal Gasification and Chemicals Limited</b></u></div> <div><u><b>DESIGN BASIS</b></u></div>	PC0288/E/001/P-II/ SEC-4.0	0	
		Document No.	Rev	
		Sheet 3 of 14		

## 1.0 GENERAL

This document (Design basis) indicates the requirements for design of Synthesis Gas Purification unit for Ammonia Synthesis Gas Generation facilities to be constructed by LSTK Contractor on LSTK basis.

## 2.0 REQUIREMENT PERTAINING TO PURIFICATION UNIT FOR AMMONIA SYNTHESIS GAS SUPPLY

Syngas Purification Unit is the source for producing hydrogen and nitrogen in 3:1 mole ratio for Ammonia production in the proposed Coal to Ammonium Nitrate Chemical Complex along with gaseous Carbon Di-oxide to be used as carrier gas for coal conveying and as purge CO<sub>2</sub> in Coal gasification unit. Ammonia Syngas, generated in Coal Gasification Plant (Separate LSTK scope) at required battery limit condition are sent to the downstream Ammonia Plant (Separate LSTK scope) after purification. LSTK CONTRACTOR is required to construct the Synthesis Gas Purification Unit after receiving raw syngas from upstream Coal Gasification Plant to meet requirement of specified Ammonia Syn. Gas and carrier and purge CO<sub>2</sub> Gas at a required rate, purity, composition, pressure and temperature to the Coal to Ammonium Nitrate Chemical Complex network continuously during the on-stream days of the Complex.

2.1 Deleted.

2.2 Capacity of Coal Gasification based Ammonia Synthesis Gas /Carbon Di-oxide Gas generation Facility.

The Coal Gasification Plant shall be designed to meet the following quantity requirement of Ammonia Synthesis Gas, by-product Carbon Di-oxide and Argon. LSTK CONTRACTOR shall specify the supply quantities of other products.

### 2.2.1 Ammonia Synthesis Gas (100% pure) (N<sub>2</sub> + 3H<sub>2</sub>):

Continuous Normal requirement: **105000** NM<sup>3</sup>/hr (100%)  
Maximum requirement: **115500** NM<sup>3</sup>/hr (110%)  
Minimum requirement: **52500** NM<sup>3</sup>/hr (50%)



### 2.2.2 Carbon di-oxide Gas (100% pure, dry) (i)-conveying & (ii)- purging:

Continuous Normal requirement: (i) **24000** NM<sup>3</sup>/hr (ii) **2550** Nm<sup>3</sup>/hr (100%)  
Maximum requirement: (i) **26400** NM<sup>3</sup>/hr (ii) **2805** Nm<sup>3</sup>/hr (110%)  
Minimum requirement: (i) **12000** NM<sup>3</sup>/hr (ii) **1405** Nm<sup>3</sup>/hr (50%)

### 2.2.5 By-Products from Synthesis Gas Purification Unit:

#### Sulphur:

Continuous Normal supply: -----Kg/hr (To be specified by LSTK CONTRACTOR)  
Minimum supply: -----Kg/hr (To be specified by LSTK CONTRACTOR)

	<p><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></p> <p><b><u>Bharat Coal Gasification and Chemicals Limited</u></b></p> <p><b><u>DESIGN BASIS</u></b></p>	PC0288/E/001/P-II/ SEC-4.0	0	
		Document No.	Rev	
		Sheet 4 of 14		

### 2.2.7 Plant Configuration:

Gas Purification System with all associated sub systems containing CO sour shift, Methanol wash process for H<sub>2</sub>S and CO<sub>2</sub> removal, Liquid Nitrogen Wash, Sulphur Recovery Unit etc. shall be designed for full design capacity (110% Ammonia Syngas)..

### 2.2.8 Sulphur Recovery Unit Configuration:

Sulphur recovery unit shall be based on gasifier feed coal quality and shall be installed in single train. Design of the unit should take care minimum/maximum sulphur in the feed when Gasifier is running on 100% coal. LSTK Contractor to consider recovery of Sulphur as 99.9%. No credit shall be given for sulphur recovery.

Following min. facilities may be considered:-

- Combustion air blowers can provide the discharge.
- Acid gas Knock out drum and Sour gas knock out drums can be shared after which the acid gas can be split for single train of SRU.
- Sulphur Pit for SRU can be shared for sulphur run down flow from each locks can flow into common pit.
- De-aerator for feeding BFW into steam drums and condensers can be given as common
- All utilities header such as HP steam, LP steam, BFW, condensate recovery system can be given in sharing mode with separate tap-off for each vessel/equipment.(HOLD)

**2.3** Tail Gas treating unit which can be used for recovery of H<sub>2</sub>S from tail Gases. Tail gas from final condenser of SRU will be passed through TGTU followed by Incinerator/boiler and stack. H<sub>2</sub>S gas recycled from TGTU can be sent back to common Acid gas KOD inlet.  
Quality Specification

**2.3.1** Product Ammonia Syn. Gas produced from the plant shall cater to the following minimum specification:

Kindly refer Section-2.0 of NIT, Technical

**2.3.2** Carrier CO<sub>2</sub> Gas produced from the plant shall cater to the following minimum specification at the B.L. of Coal gasification plant:



Kindly refer Section-2.0 of NIT, Technical

**2.3.3** By-product Sulphur (solid) produced from the plant shall cater to the following minimum specification:

Kindly refer Section-2.0 of NIT, Technical

### 2.4 Feed stock for Purification Plant

Synthesis Gas Purification Unit shall be designed to use following as feed stock.

	<div><div><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></div><div><b><u>Bharat Coal Gasification and Chemicals Limited</u></b></div><div><b><u>DESIGN BASIS</u></b></div></div>	PC0288/E/001/P-II/ SEC-4.0	0	
		Document No.	Rev	
		Sheet 5 of 14		

Kindly refer Section-2.0 of NIT, Technical for feed syngas quality.

Synthesis Gas Purification Unit should be able to respond to the operational interruption in upstream Gasification Plant and downstream Ammonia plant without jeopardising the plant safety.

**2.4.1 Sulphur storage:** Offsite storage facility (shaded with proper concrete dyke) shall be provided by LSTKCONTRACTOR.

- Storage Capacity = Fifteen day's production
- Storage area = ---- m<sup>2</sup> (To be specified by LSTK CONTRACTOR)
- Storage pressure = Atmospheric
- Operated/maintained by = OWNER
- Unloading facility from pipeline= by LSTK CONTRACTOR at B.L. of Storage.

Storage for solid Sulphur will be an open pit for min. 15 days storage.

The open pit shall have two compartments along with ramp provision for pay loader and truck loading arrangement. The open pit should have proper water drainage system. Flooring & dyke wall should be anti-corrosive. Dyke height will be min. 2 meter.

Transfer of liquid Sulphur from inter-mediate storage (i.e. Sulphur pit including de-gassifier) located at LSTK B.L. to above mentioned storage shall be the responsibility of LSTK CONTRACTOR. One Tank Truck lorry loading bay with covered shed for liquid sulphur to be provided by LSTK Contractor.

### 3.0 GENERAL REQUIREMENTS

#### 3.1 Plant On-stream factor:

Plant design and engineering are to be carried out for achieving a high degree of operational reliability. The plants are to be designed with high on-stream factor (not less than 330 days in a year) with minimum continuous operating cycle of 1year between turn around.

#### 3.2 Turn-Down ratio\*:

The Ammonia Syn Gas / Carbon di-oxide /Sulphur Units shall be designed to operate and demonstrate for 12 hrs. Stable operation with turn-down ratios as given below:



- Ammonia Syn Gas : 50% of plant design capacity
- Carbon di-oxide : 50% of plant design capacity
- Sulphur : LSTK Contractor to suitably design considering Gasifier operation on 100% ROM Coal

NOTE: \*- LSTK Contractor shall demonstrate that above mentioned ISBL Plants are capable of producing indicated turn down capacity for 12 continuous hours / as mutually agreed upon by LSTK Contractor/ Owner/ PMC. For details, please refer Section 8.0of Part-II Technical.

#### 3.3 Capacity Utilization:

Chemical Complex will run at its Nameplate Capacity (i.e. 100%) on and from the first year of operation since commissioning. If required, the plant may be run at 110% capacity as well as at its Turn down capacity (as specified in Cl. No. 3.2 of this section).



	<p><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></p> <p><b><u>Bharat Coal Gasification and Chemicals Limited</u></b></p> <p><b><u>DESIGN BASIS</u></b></p>	PC0288/E/001/P-II/ SEC-4.0	0	
		Document No.	Rev	
		Sheet 6 of 14		

### **Catalyst**

Plant shall be designed to achieve rated throughput at design controlling temperature and pressure conditions even at catalyst End of Run (EOR) conditions.

### **Catalyst Handling System**

The system shall have adequate flexibility to handle catalyst of different size and geometry and with suitable flexible hoses, pipe section for loading and evacuating from respective converter/ reactor of different services. A portable separator shall be provided for reuse of partially discharged catalysts.

### **3.4 Plant Availability:**

Plant availability factor for producing Ammonia Syn. Gas, Carbon Di-oxide, Sulphur, should be 100% excluding the planned shutdowns as per the OWNER's requirements.

### **3.5 FLARE**



The entire flaring requirement for the Purification Plant shall be provided by the LSTK CONTRACTOR up to the battery limit to cater the discharge of mitigated flare load from the unit. All hydrocarbon / combustible gases and vapours (sour & sweet gases) shall be relieved to the flare through separate knock out drums (sour & sweet). LSTK CONTRACTOR to consider Flare Knock-out Drums for Purification Plant within the battery limit of their unit.

### **3.6 Shift Conversion Section**

The system shall be installed in single train. Shift Conversion section shall be designed for the End of Run (EOR) condition of catalysts. Carbon Mono-oxide emission limit shall be 350 PPMv(max).

### **3.7 Methanol WASH for H<sub>2</sub>S / CO<sub>2</sub> Removal:**

LSTK Contractor shall provide H<sub>2</sub>S / CO<sub>2</sub> removal units with conventional & well proven design in single train. Selective removal of H<sub>2</sub>S and Carrier CO<sub>2</sub> gases are required for utilization in SRU and in Gasification Plant respectively. A typical design of Acid gas removal unit is as described. The system shall be optimised for low energy consumption, CO<sub>2</sub> slip not more than 5ppm volume at upstream of Liquid Nitrogen Wash (LNW) Unit and low inert or hydrogen in the CO<sub>2</sub> gas.. The system shall be designed to maximise re-use of condensate generated within the system. The design of Tower Internals shall consider high efficiency Norton or equivalent type distributors compatible with high efficiency type of tower packing. To achieve minimum carryover of solution with process gas or H<sub>2</sub>S or CO<sub>2</sub>, suitable washing arrangement at Absorber and Regenerator top shall be provided. Major circulation pumps shall be on two (2) working and one (1) standby philosophy. All pumps shall be electric motor driven. Difference of NPSH<sub>a</sub> to NPSH<sub>r</sub> should be minimum 2.0 meters. Cartridge type filters and/or activated carbon beds shall be used to maintain solution quality. Anti foam and corrosion inhibitor injection system shall be provided. Split range full capacity vents shall be provided on the Carrier CO<sub>2</sub> line as well as absorber outlet process gas line. The CO<sub>2</sub> removal system should not have positive water balance. In case vanadium penta-oxide is used in the system as corrosion inhibitor then facility for aeration

	<div><u><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></u></div> <div><u><b>Bharat Coal Gasification and Chemicals Limited</b></u></div> <div><u><b>DESIGN BASIS</b></u></div>	PC0288/E/001/P-II/ SEC-4.0	0	
		Document No.	Rev	
		Sheet 7 of 14		

of solution also should be given. Full capacity vent is to be provided on H<sub>2</sub>S product line and shall be connected to the incinerator / flare complying statutory requirements.

### 3.8 Catalyst for Synthesis Gas Purification:

The system shall be installed in single train. Catalyst shall be designed for end of run (EOR) condition of catalyst.

### 3.9.(DELETED)

### 3.10 Drives:

The selection of drives shall be preferred as follows. However LSTK Contractor may adopt any other configuration (Pump/Compressor, Turbine/Motor) as recommended by the Process Licensor for the sake of energy optimisation with proper justification.

Cooling Water Pumps* (3W+1S) (LSTK-1 to confirm)	Electric motor Driven.
Liquid Nitrogen Pump for LN <sub>2</sub> W, (1W+1S)	Motor driven with VFD

### 3.11 Plant Equipment Metallurgy:

CO <sub>2</sub> Regenerator: From Top dished head up to 100 mm below top packing bed	SS 304
Packing & Tower internals of Towers of CO <sub>2</sub> /H <sub>2</sub> S Removal Section	SS 304
CO <sub>2</sub> O/H Condensers/ CO <sub>2</sub> Cooler Re-boilers, Shift gas coolers	SS304 for Parts coming in contact with moist CO <sub>2</sub> gas or solution
Sulphur/ H <sub>2</sub> S	NACE shall be followed



### 3.12 Critical Piping

Process Gas exit catalytic reactors	Material Superior to C - ½Mo
Wet CO <sub>2</sub> gas, rich CO <sub>2</sub> loaded solution	SS 304
DM water	SS 304
Process condensate	SS 304/SS 304L
Instrument air	SS 304
Lube oil and seal oil	SS 304
High pressure steam for temperature above 460°C	2.25 Cr.-1Mo
High pressure steam for temperature above 425°C	1.25Cr 0.5Mo
Medium & Low pressure steam temperature < 425°C	A106 Gr.BSmls

In general the following may be offered for cooling water service:

- All exchangers with cooling water service shall have cooling water on tube side
- All such exchangers shall have SS 304 tubes. The tube size shall not be less than ¾".

## 4.0 Effluents from Purification Plant

 <div>पी डी आई एल PDIL</div>	<div><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div><u>DESIGN BASIS</u></div>	PC0288/E/001/P-II/ SEC-4.0	0	 <div>बी एच ई एल BHEL</div>
		Document No.	Rev	
		Sheet 8 of 14		

- Generated effluent in Syn gas Purification contractor's area will be pre-treated within LSTK contractor's B/L limit. However, effluent from all units within LSTK's B/L along with pre-treated effluent will be transferred to common ETP (Owner's scope). LSTK contractor shall also provide the safe disposal procedures and enabling infrastructure for solid waste disposal from pre-treatment section For balance of Plant in LSTK Contractor's BL, Process Waste Water, Contaminated rain water& Floor washings from plants shall be routed to OWNER's oily water sewer (OWS), Boiler Blow Down after cooling to 40 Deg C shall be routed to common effluent treatment plant for recovery & Process drains to be routed to OWS or Closed Blow-down (CBD). No effluent/ discharge shall be routed to storm water drain. OWNER has considered & provided for the following effluents from Syn gas Purification Plant in its effluent treatment design for different conditions of operation of Syngas Purification.

- Liquid Effluent from Syn gas Purification Unit** to meet below specification at their b/l.



Parameter	Unit	Value (Max.)
Odour & Colour	-	Odourless & Colourless
pH Value	-	6.5 to 8.0
Suspended solids	mg/lit	100
Oil and grease	ppm	10.0
Vanadium (as V)	ppm	0.20
Ammonical Nitrogen as "N"	mg/lit	50
Free Ammonical Nitrogen	ppm	4.0
Nitrate Nitrogen as "N"	mg/lit	10
Total Kjeldahl Nitrogen as "N"	mg/lit	100

- Oily water**

Parameter	Unit	Value
Oil	mg/lit (max)	10
Quantity	M <sup>3</sup> /Hr (max)	(To be specified by LSTK CONTRACTOR)
Frequency of discharge per year		(To be specified by LSTK CONTRACTOR)
Duration of each discharge	Hrs.	(To be specified by LSTK CONTRACTOR)

- Boiler Blow-down**

Parameter	Unit	Value
pH		9 – 11
Silica (as SiO <sub>2</sub> )	ppm	< 0.5
Conductivity	μS/cm	<50
Phosphate (PO <sub>4</sub> <sup>3-</sup> )	ppm	2 - 5

	<div><u><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></u></div> <div><u><b>Bharat Coal Gasification and Chemicals Limited</b></u></div> <div><u><b>DESIGN BASIS</b></u></div>	PC0288/E/001/P-II/ SEC-4.0	0	
		Document No.	Rev	
		Sheet 9 of 14		

Quantity	M <sup>3</sup> /Hr (max)	(To be specified by LSTK CONTRACTOR)
Frequency of discharge per year		(To be specified by LSTK CONTRACTOR)
Duration of each discharge	Hrs.	(To be specified by LSTK CONTRACTOR)

▪ **Sour water**

Parameter	Unit	Value
H <sub>2</sub> S	Wt. %	< 1
Quantity	M <sup>3</sup> /Hr (max)	(To be specified by LSTK CONTRACTOR)
Frequency of discharge per year		(To be specified by LSTK CONTRACTOR)
Duration of each discharge	Hrs.	(To be specified by LSTK CONTRACTOR)

LSTK CONTRACTOR has to confirm compliance to above specifications.

LSTK Contractor shall guarantee the liquid pollution levels as per limits and gaseous pollution levels as per requirement of Central and Odisha State Pollution Control Authority.

Note: The standards to be met shall be as per latest revision and each parameter should conform to the stipulated standard as per CPCB/OSPCB whichever is more stringent.

## 5.0 SAFETY, HEALTH & ENVIRONMENT:

### 5.1 General



LSTK CONTRACTOR& his employees shall-

1. Comply with the conditions of the EC (Environmental Clearance), NOC/ Consent to Establish, Air & Water Consents, Hazardous Waste Authorization and the standards stipulated in the Gazette Notifications for the concerned industry.
2. Follow all the relevant rules & regulations like The Factories Act, The Environment (Protection) Act etc.
3. Implement recommendations of EIA Report & Risk Analysis Report.

### 5.2 Safety

LSTK CONTRACTOR& his employees shall-

1. Observe own/ Licensor's safety rules & regulations during construction, erection pre-commissioning, commissioning-
2. Observe 'No Smoking' strictly in the LSTK premises. Any person who is found smoking or in the possession of match box or lighter or any other means of ignition in the Coal to AN Chemical Complex or in the Production plant shall be turned out of the Complex . Suitable action as decided by the OWNER's management shall also be taken.
3. Maintain good standards of housekeeping.
4. If required, Take all safety precautions and obtain permission from the fire & safety department of Coal to AN Chemical Complex before carrying out any hot job.

	<div><u><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></u></div> <div><u><b>Bharat Coal Gasification and Chemicals Limited</b></u></div> <div><u><b>DESIGN BASIS</b></u></div>	PC0288/E/001/P-II/ SEC-4.0	0	
		Document No.	Rev	
		Sheet 10 of 14		

5. Deploy a qualified safety officer to monitor the safety performance.
6. Report all accidents to the Fire & Safety Department of the Coal to AN Chemical Complex and fulfil all legal formalities.
7. Enlist all chemicals on stock with their respective MSDS.
8. Take due insurance cover for affecting neighbourhood (damage, loss & injury to people, property & environment) due to any untoward incident.

### 5.3 Traffic Safety

LSTK CONTRACTOR& his employees shall –

1. Maintain the speed limit of 25 Km/hr inside the Coal to AN Chemical Complex premises.
2. Avoid traffic congestion and abide by the traffic rules by deploying trained and licensed drivers.

### 5.4 Environment



LSTK CONTRACTOR& his employees shall –

1. Shall avoid wastage of drinking water, etc.
2. Transfer only neutralized effluent to the Effluent Treatment Plant of the OWNER as specified in cl.4.0 above
3. Install Hydrocarbon (HC) leak detectors at strategic locations in the plant area.
4. Install SO<sub>2</sub>, NO<sub>x</sub>, CO online analyzers in all the stacks for computerized monitoring as stipulated in the EC. Stack heights shall be as specified in the EIA Study conducted for the OWNER's Coal to AN Chemical Complex and stacks shall have proper sampling & monitoring facilities.

#### Stack Emission Limit

SO <sub>2</sub>	50 mg/ Nm <sup>3</sup>
NO <sub>x</sub>	250 mg/ Nm <sup>3</sup>
Particulate Matter	10 mg/ Nm <sup>3</sup>
CO	100mg/ Nm <sup>3</sup>

Carbon Mono-oxide emission limit shall be 350 PPMv (max) for Shift Conversion Section. Above values are indicative. LSTK Contractor to follow the latest norm of

	<div><div><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></div><div><b><u>Bharat Coal Gasification and Chemicals Limited</u></b></div><div><b><u>DESIGN BASIS</u></b></div></div>	PC0288/E/001/P-II/ SEC-4.0	0	
		Document No.	Rev	
		Sheet 11 of 14		

CPCB/ OSPCB. State PCB or Central PCB norms whichever is more stringent shall be complied by LSTK Contractor.

- Monitor fugitive emission of Hydrocarbon (HC)/ VOC & Benzene through Portable Monitor at periodicity as per the Gazette Notification (latest) under the heading Fugitive Emission (Standards for Equipment Leaks Pt. No.7).

#### **Limit of VOC & Benzene Concentration**

	VOC ppm*	Benzene ppm*
Pump/ Compressor	5000	2000
Valves/ Flanges	3000	1000
Other Components	3000	1000

\* Above figures are based on gazette notification-18<sup>th</sup> March'08 however LSTK Contractor have to follow the latest one. LSTK Contractor to follow the latest norm of CPCB/ OSPCB. State PCB or Central PCB norms whichever is more stringent shall be complied by LSTK Contractor.

## **6.0 UTILITIES:**

Some of Utilities as specified in the ITB shall be supplied to LSTK CONTRACTOR by the OWNER. The characteristics of utilities are provided below and in Section 4.2 of Part II Technical.

### **6.1 Cooling Water shall be arranged by OTHER LSTK CONTRACTOR for using within Purification LSTK Battery Limit:**

NOTE-Purification LSTK Contractor to review below characteristics and confirm at the time of bidding:

Treated Process Water/ Service water Characteristics (**Tentative**):

Kindly refer Section-2.0 of NIT, Technical

### **6.2 De-Mineralised Water:**

Characteristics:

NOTE-Purification LSTK Contractor to review below characteristics and confirm at the time of bidding:



Kindly refer Section-2.0 of NIT, Technical

Note: \*- Surplus Steam may be exported to LSTK B.L., if it matches with the main steam header parameters as mention in Section 2.0 of Part-II Technical. No steam credit shall be given to the LSTK Contractor.

### **6.3 Drinking water:**

Characteristics – Drinking Water Quality Limits:

Kindly refer Section-2.0 of NIT, Technical

	<div><u><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></u></div> <div><u><b>Bharat Coal Gasification and Chemicals Limited</b></u></div> <div><u><b>DESIGN BASIS</b></u></div>	PC0288/E/001/P-II/ SEC-4.0	0	
		Document No.	Rev	
		Sheet 12 of 14		

Drinking water of quality conforming to IS: 10500: 1991 during plant operation only shall be provided by the OWNER to LSTK CONTRACTOR. During construction till mechanical completion, LSTK contractor has to arrange his own construction and drinking water requirement.

#### 6.4 Steam:

##### 6.4.1 Surplus Steam export to the OWNER shall be accepted:

The quantity and quality of export steam shall adhere to the following specifications:

Description	Units	Value
Quantity	Min / Nor / Max, Kg/Hr	LSTK Contractor to specify
Pressure	Min / Nor / Max, Kg/cm <sup>2</sup> g	LSTK Contractor to specify
Temperature	Min / Nor / Max, °C	LSTK Contractor to specify
Quality	Refer Clause no. - 3.1, 3.2, 3.3 Section-2.0 of Part-II Technical	

##### 6.4.2 Start-up Steam as specified in Clause no. - 3.1, 3.2, 3.3 of Section-2.0 of Part-II Technical shall be arranged by OWNER. Quantity, duration and frequency to be furnished by LSTK Contractor.

#### 6.5 Pre-Treated Condensate:

##### 6.5.1 Pre-Treated Condensate export to the OWNER:

The quality of export Pre-Treated Condensate shall adhere to the following specifications:

Kindly refer Section-2.0 of NIT, Technical

#### 6.6 Power Supply:

Power shall be made available to LSTK CONTRACTOR by owner at their B.L. at one point as per following parameters:

Kindly refer Section-2.0 of NIT, Technical

The actual fault levels shall be arrived at on the basis of incoming power source, transformers, contribution of motors, etc. and shall be indicated in the Bid.

All switch boards of the same voltage shall be rated for identical fault level. Minimum fault level to be considered for design and selection of equipment shall be as follows:



For 11KV supply – 40KA for 3 sec.

For 3.3KV supply – 26.24KA for 3 sec.

However, fault level for 415V switchboards shall not exceed 50KA for 1 sec. 11KV/0.433KV or 3.3KV/0.433KV Transformer rating shall not be more than 2000kVA.

NOTE: Design Philosophy (Electrical)" to be followed if any discrepancy found with "Design Basis.



 <div>पी डी आई एल PDIL</div>	<div><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div><u>DESIGN BASIS</u></div>	PC0288/E/001/P-II/ SEC-4.0	0	 <div>बी एच ई लि. BHEL</div>
		Document No.	Rev	
		Sheet 13 of 14		

## 7.0 CLIMATIC DATA:

### 7.1 Wind:

Wind Load Design: as defined in IS: 875 Part 3

### 7.2 Air Temperature:

Parameters	Temperature, °C	Remarks
Dry bulb (Summer)	Max: 47.19 ° Min: 10.99 °	
Dry bulb (Winter)	Max: 37.84 ° Min: 10.17 °	
Average Temperature	26.2 °	
wet bulb	-	
Max for Mechanical / Civil / Structural	35 °C (HOLD)	
Minimum for winterization (Average)	-	

#### 7.2.1 Atmospheric Air Composition:

SO <sub>x</sub>	9.18
NO <sub>x</sub>	27.70
NH <sub>3</sub>	-
SPM <sub>10</sub>	44.15
HC (methane)	-
HC (non methane)	-
CO	-
VOC	-

NOTE: Bidder to take correction factors and worst atmospheric condition on above.

### 7.3 Relative Humidity:

Relative Humidity	RH%
Relative Humidity, Minimum	21.79%
Relative Humidity, Maximum	99.5%
Relative Humidity, Average	74%

### 7.4 Rainfall:

Rainfall	Value
Annual	1534.5 mm
Design rainfall (per hour)	-

Note: - Civil philosophy is to be referred

### 7.5 Barometric Pressure:

Barometric Pressure	Value
Average	904.45



### 7.6 Seismic Design Code:

Refer Section-5.5 (Design Philosophy – Civil & Structural Works) Part II-Technical.

### 7.7 Plant Elevation:

The final plant elevation shall be established in consultation with owner / consultant based on overall project requirement.



 पी डी आई एल <b>PDIL</b>	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>  <b><u>Bharat Coal Gasification and Chemicals Limited</u></b>  <b><u>DESIGN BASIS</u></b>	PC0288/E/001/P-II/ SEC-4.0	0	 भारत बल <b>BHEL</b>
		Document No.	Rev	
		Sheet 14 of 14		

	PROJECTS & DEVELOPMENT INDIA LIMITED	PC00288/E/001/P-II/ SEC-4.1	P	
		Document No.	Rev	
		Sheet 1 of 6		

## PART II: TECHNICAL



### SECTION – 4.1

#### BATTERY LIMIT INTERFACE

**PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT**

**PROJECT: COAL TO AMMONIUM NITRATE COMPLEX, AT LAKHANPUR, ODISHA (INDIA)**

P	06/03/2024	06/03/2024	Issued for Client's comment	SR	SK	MN
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD



	<u><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></u>	PC0288/E/001/P-II/ SEC-4.1	P	
	<u><b>Bharat Coal Gasification and Chemicals Limited</b></u>	Document No.	Rev	
	<u><b>BATTERY LIMIT INTERFACE</b></u>	Sheet 2 of 6		

## **CONTENTS**

SL. NO.	DESCRIPTION	SHEET NUMBER
1.0	Battery Limit Interface	3
2.0	Battery Limit Conditions	3

## **LIST OF ATTACHMENTS**

SL. NO.	DESCRIPTION	NUMBER OF SHEETS
1.0		

	<p><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></p> <p><b><u>Bharat Coal Gasification and Chemicals Limited</u></b></p> <p><b><u>BATTERY LIMIT INTERFACE</u></b></p>	PC0288/E/001/P-II/ SEC-4.1	P	
		Document No.	Rev	
		Sheet 3 of 6		

## 1.0 BATTERY LIMIT INTERFACE:

### 1.1 Interface Engineering:

LSTK Contractor shall carry out all interface engineering for complete compatibility with PDIL/ Bharat Coal Gasification and Chemicals Limited (**BCGCL**) design with respect to location/ specification for all incoming and outgoing pipelines from the Purification Plant.

### 1.2 Battery Limit Isolation:

LSTK Contractor shall provide double block and bleed arrangement with spectacle blind for all process and steam streams coming into and going out of the Purification Plant. For other utilities, LSTK Contractor shall provide isolation valves within their plant battery limit.

### 1.3 Metering System:

LSTK Contractor shall provide metering system for all incoming and outgoing process and utility streams as indicated in the instrument specification of the ITB.

## 2.0 BATTERY LIMIT CONDITIONS:

2.1 Feedstock supplied to **Purification Plant** shall be from upstream Coal Gasification Plant (Separate LSTK scope)

### 2.2 Ammonia Syn. Gas: (



Temperature and pressure condition of Ammonia Syn. Gas required at Purification Plant battery limit shall be as follows:

Stream / Condition	Min	Normal	Max	Mech. Design
<b>Ammonia Syn. Gas</b>				
Header pressure, (kg/cm <sup>2</sup> a)	Refer section 2	-	-	As per design guidelines.5.1
Supply temperature, (deg C)	-Refer section 2	-		As per design guidelines 5.1

### 2.3 Carbon Di-oxide☹

Temperature and pressure condition of carbon dioxide required at Purification Plant battery limit shall be as follows:

Stream / Condition	Min	Normal	Max	Mech. Design
Carbon Di-oxide Gas for conveying				
Header pressure, (kg/cm <sup>2</sup> abs)	Refer	-	-	As per design

	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-4.1	P	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>BATTERY LIMIT INTERFACE</u></b>	Sheet 4 of 6		

	section 2			guidelines.5.1
Supply temperature, (deg C)	-	-	Refer section 2	As per design guidelines 5.1
Carbon Di-oxide Gas for purging				
Header pressure, (kg/cm <sup>2</sup> abs)	69			175
Supply temperature, (deg C)			270	285

## 2.4 Nitrogen Gas⊗

Temperature and pressure condition of Nitrogen required at Purification plant battery limit shall be as follows:

Stream / Condition	Min	Normal	Max	Mech. Design
<b>Nitrogen Gas (UTILITY)</b>				
Header pressure, (kg/cm <sup>2</sup> abs)	7.0	9.0	10.0	11.5
Supply temperature, (deg C)		Ambient	-	70

Stream / Condition	Min	Normal	Max	Mech. Design
<b>Nitrogen Gas (PROCESS)</b>				
Header pressure, (kg/cm <sup>2</sup> abs)	To be filled by LSTK Contractor	To be filled by LSTK Contractor	To be filled by LSTK Contractor	To be filled by LSTK Contractor
Supply temperature, (deg C)	To be filled by LSTK Contractor	To be filled by LSTK Contractor	- To be filled by LSTK Contractor	To be filled by LSTK Contractor



## 2.5 Sulphur (Liquid):

Temperature and pressure condition of Sulphur required at Coal to AN chemical complex plant Battery limit shall be provided as follows:

Stream / Condition	Min	Normal	Max	Mech. Design
<b>Sulphur (Liquid)</b>				
Supply pressure, (kg/cm <sup>2</sup> abs)		5.5*	6.9*	8.4/FV*
Supply temperature, (deg C)		155*	165*	180*

Note: - \* - figures are indicative. However Licensor's specifications to be followed.

## 2.6 Flare: LSTK Contractor shall have to consider flaring requirement and piping up to LSTK B/L of Purification Plant.

	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC0288/E/001/P-II/ SEC-4.1	P	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b>	Document No.	Rev	
	<b><u>BATTERY LIMIT INTERFACE</u></b>	Sheet 5 of 6		

Condition		Mech. Design
High Pressure	*	*
Low Pressure	*	*

\* To be specified by LSTK Contractor

## 2.7 Cooling water (shall be arranged by Separate LSTK Contractor for use within I.S.B.L.):

Condition	Min	Normal	Max	Mech. Design
Supply pressure, kg/cm <sup>2</sup> g	*	*	*	*
Return pressure, kg/cm <sup>2</sup> g	*	*	*	*
Supply temperature, °C	*	*	*	*
Return temperature, °C	*	*	*	*

\* To be specified by LSTK Contractor

**Note:** LSTK Contractor shall limit pressure drop of 1.5 Kg/cm<sup>2</sup> (max) between supply and return CW header within its battery limit.

## 2.8 De-Mineralised Water: make-up DM water shall be provided from balance of plants by OWNER to LSTK Contractor.

Condition	Min	Normal	Max	Mech. Design
Supply pressure, kg/cm <sup>2</sup> g	4.0	5.5	6.0	10.0
Supply temperature, °C	-	Ambient		65

## 2.9 Service Water: to be provided by the Owner to the LSTK Contractor



Condition	Min	Normal	Max	Mech. Design
Supply pressure, (kg/cm <sup>2</sup> g)	4.0	6.0	8.0	10.5
Supply temperature (deg C)	Ambient	Ambient	Ambient	65

## 2.10 Drinking water: to be provided by the Owner to the LSTK Contractor

Condition	Min	Normal	Max	Mech. Design
Supply pressure, kg/cm <sup>2</sup> g		6.0	6.5	12.5
Supply temperature, (deg C)		Ambient	Ambient	65

## 2.11 Instrument Air: to be provided by the Owner to the LSTK Contractor

Condition	Min	Normal	Max	Mech. Design
Header pressure (kg/cm <sup>2</sup> g)	4.5	7.0	8.0	10.5
Supply temperature (deg C)	Ambient	40	50	65

	<u><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></u>	PC0288/E/001/P-II/ SEC-4.1	P	
	<u><b>Bharat Coal Gasification and Chemicals Limited</b></u>	Document No.	Rev	
	<u><b>BATTERY LIMIT INTERFACE</b></u>	Sheet 6 of 6		

## 2.12 Service air: to be provided by the Owner to the LSTK Contractor

Condition	Min	Normal	Max	Mech. Design
Header pressure (kg/cm <sup>2</sup> g)	4.0	7.0	8.0	10.5
Supply temperature (deg C)	40	40	50	65

## 2.13 Steam:

Steam Level	Pressure (kg/cm <sup>2</sup> g)				Temperature (deg C)			
	Normal	Max	Min	Design	Normal	Max	Min	Design
HP	107	110	105	130	515	520	510	545
MP	40	*	*	44	380 ± 5	*	*	425
LP	4.0	4.5	3.5	6.0	180	*	*	250
HP (Saturated)	107	110	105	130	315	317	314	342

\* To be specified by LSTK Contractor

## 2.14 Electric Power: to be provided by the Owner to the LSTK Contractor

Power requirement	Voltage	Phase	Frequency
	11000 V ± 10%	3	50 Hz ± 5%

## 2.15 Treated Condensate export from Purification Plant BL:

Description	Pressure (kg/cm <sup>2</sup> g)				Temperature (deg C)			
	Min	Max	Normal	Design	Min	Max	Normal	Design
Treated Condensate			8	12			45	65

## 2.16 Liquid Effluent from Purification Plant BL:

Description	Pressure (kg/cm <sup>2</sup> g)				Temperature (deg C)			
	Min	Max	Normal	Design	Min	Max	Normal	Design
Liquid Effluent			3	8			Amb.	65

Note: Purification Plant shall be designed based on Zero Liquid Discharge philosophy.

<div><div>पो डी आई एल PDIL</div></div>	PROJECTS & DEVELOPMENT INDIA LIMITED	PC0288E/001/P-II/ SEC-5.1	P	<div><div>भारतीय वोल्टीज एल BHEL</div></div>
		Document No.	Rev	
		Sheet 1 of 9		

## PART II: TECHNICAL

### SECTION – 5.1



#### DESIGN PHILOSOPHY - PROCESS

**PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT**

**PROJECT: COAL TO AMMONIUM NITRATE COMPLEX, AT LAKHANPUR, ODISHA (INDIA)**

P	06/03/2024	06/03/2024	Issued for Client's comment	SR	SK	MN
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD





	<div><div><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></div><div><b><u>Bharat Coal Gasification and Chemicals Limited</u></b></div><div><b><u>DESIGN PHILOSOPHY - PROCESS</u></b></div></div>	PC0288/E/001/P-II/ SEC-5.1	P	
		Document No.	Rev	
		Sheet 2 of 9		

## **CONTENTS**

Section Number	Description	Sheet Number
1.0	General	3
2.0	Design Pressure	4
3.0	Design Temperature	5
4.0	Corrosion Allowance	6
5.0	Hydraulic Retention Time	6
6.0	Heat Exchangers	6
7.0	Pumps	7
8.0	Compressors	7
9.0	Pressure Relief Valves	7
10.0	Columns & Vessels	8

## **LIST OF ATTACHMENTS**

Attachment Number	Description	Number of Sheets

	<div><div><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></div><div><b><u>Bharat Coal Gasification and Chemicals Limited</u></b></div><div><b><u>DESIGN PHILOSOPHY - PROCESS</u></b></div></div>	PC0288/E/001/P-II/ SEC-5.1	P	
		Document No.	Rev	
		Sheet 3 of 9		

## 1.0 GENERAL



The plants shall be designed to operate safely and satisfactorily at a capacity of 50% (turn down capacity) to 110 % (i.e. Design Capacity). Equipment and machinery shall be provided so that the plants can operate for at least two years without major overhaul or inspection. All design shall conform to the latest edition of the applicable sections of ASME, ASTM, IEEE, NFC, TEMA, AISI, NEMA, AISC, ACI, OSHA, UBE and other governing codes or standard practices. Any other equivalent and acceptable Code of Standard practice may be adopted with the approval of the Process Licensor. In addition, the following state/local Codes/laws shall supplement:

a)	Pressure Vessels/ Formed ends	ASME, Section VIII, DIV.I / Indian Standard IS 4049.
b)	Boilers	Indian Boiler Regulations Act
c)	Buildings & Structural	Relevant Indian Standard (BIS)
d)	Electricity	Indian Electricity Rules.
e)	Sanitary	Relevant Indian Standard (BIS)
f)	Safety	a) Manual of Chief Inspector of Explosives, Govt. of India. b) NFPA
g)	Water Pollution	Relevant Indian Standard (BIS) / Central Pollution Control Board/ Odisha State Pollution Control Board limits norms set by Ministry of Environment & Forest, MINAS

### 1.1 System of Measurements:

The system of measurement metric shall be as follows:

Parameter	Preferred Units	Alternative Units
Temperature	°C	
Pressure - absolute	kg/cm <sup>2</sup> abs	
Pressure - gauge	kg/cm <sup>2</sup> g	
Flow (liquid)	m <sup>3</sup> /hr	kg/hr
Flow (gas)	Nm <sup>3</sup> /hr	kg/hr
Flow (steam)	kg/hr	
Length, Level	mm	M
Time	hr	sec, min
Heat	kcal	Gcal
Power	kW	
Fouling resistance	m <sup>2</sup> hr °C / kcal	

	<p><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></p> <p><b><u>Bharat Coal Gasification and Chemicals Limited</u></b></p> <p><b><u>DESIGN PHILOSOPHY - PROCESS</u></b></p>	PC0288/E/001/P-II/ SEC-5.1	P	
		Document No.	Rev	
		Sheet 4 of 9		

Parameter	Preferred Units	Alternative Units
Pipe size / diameter	Inches (in)	Mm
Mass	kg	
Liquid relative density	sp gr T°C/15.6°C	
Liquid density	kg/m <sup>3</sup>	
Vapor flowing density	kg/m <sup>3</sup>	
Furnace draft	mm of WC	
Storage tank pressure	mm of WC	
Vacuum	mm of Hg, mm WC	
Standard vapor	Nm <sup>3</sup> /hr at 0°C & 1.033 kg/cm <sup>2</sup> a	
Standard liquid	m <sup>3</sup> /hr at 15.6°C	
Thermal conductivity	kcal/hr-m-°C	
Heat Transfer coefficient	kcal/hr-m <sup>2</sup> -°C	
Enthalpy, Entropy	kcal/kg	
Heat rate	10 <sup>6</sup> kcal/hr or MM kcal/hr	Gcal
Viscosity	cP	
Kinematic Viscosity	cSt	
Sound Pressure	dB(A)	
Sound Power	dB(A)	

## 2.0 DESIGN PRESSURE



### 2.1 General Rule:

Design pressure of Process Static Equipment shall be based on the maximum Operating Pressure. Malfunction and Equipment failure shall be taken into consideration by safety devices. Design pressure shall be selected from the list below. Alternatively LSTK Contractor shall select the design pressures as recommended by the process licensor.

- For max operating pressure below 2 kg/cm<sup>2</sup> g use 3.5 kg/cm<sup>2</sup> g
- For max operating pressure between 2 kg/cm<sup>2</sup>g and 15 kg/cm<sup>2</sup>g use Max. Operating Pressure + 1.5 kg/cm<sup>2</sup>
- For Max. Operating Pressure between 15 kg/cm<sup>2</sup> g and 100 kg/cm<sup>2</sup> g use Max. Operating pressure x 110 %
- For Max. Operating Pressure equal and above 100 kg/cm<sup>2</sup> g use the Maximum Operating Pressure + 10 kg/cm<sup>2</sup> g. Alternatively LSTK Contractor shall select the maximum operating pressure as recommended by the process licensor.

### 2.2 Equipment under Vacuum:

Equipment normally operated under vacuum is designed for full vacuum and for the highest pressure it can experience in case of vacuum failure. Equipment containing a fluid with a vapour pressure at ambient temperature lower than atmospheric pressure which can be isolated shall be

<div></div>	<div><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></div> <div><b><u>Bharat Coal Gasification and Chemicals Limited</u></b></div> <div><b><u>DESIGN PHILOSOPHY - PROCESS</u></b></div>	PC0288/E/001/P-II/ SEC-5.1	P	<div></div>
		Document No.	Rev	
		Sheet 5 of 9		

equipped with vacuum breaking device or else be designed for full vacuum. Equipment subject to vacuum due to mal-operation or failure shall be equipped with vacuum breaking devices or else be designed for full vacuum.

### 2.3 **Complete Systems:**

Several pieces of Equipment protected by the same relief valve shall have a design pressure of at least the set pressure of the relief valve.

### 2.4 **Equipment on the Discharge of a Pump:**

Equipment which may have to bear the shut-off pressure of a pump shall have a design pressure equal to or higher than the shut-off pressure. Pump shut-off pressure shall be estimated according to Clause 8.0.

### 2.5 **Reactor Loops and Similar Process Systems:**

For reactor loops and similar process systems the recommendations of API RP 521 Appendix F (latest edition) and API RP 520 Appendix B (latest edition) will be followed.

### 2.6 **Thin walled Tanks and Vessels:**



Atmospheric thin walled tanks and vessels shall have a design pressure equal to the highest pressure imposed upon discharge of the pressure relief device. The design pressure for vacuum shall be equal to the lowest pressure imposed upon suction of the vacuum relief device.

## 3.0 **DESIGN TEMPERATURE**

Design temperature for process equipment shall be whichever is higher:

- Maximum operating temperature + 15 °C
- Boiling temperature at design pressure of process medium inside, if applicable.
- Design temperature shall be rounded up to full 5°C steps.
- Design minimum temperature shall be specified only if the minimum operating temperature is below 0 °C. Design minimum temperature shall be 5 °C less than the minimum operating temperature. Special attention shall be given to low boiling liquids.
- For piping, design temperature shall be determined according to ASME B 31.3.

Alternatively LSTK Contractor shall select the design temperature as recommended by the process licensor.

	<div><div><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></div><div><b><u>Bharat Coal Gasification and Chemicals Limited</u></b></div><div><b><u>DESIGN PHILOSOPHY - PROCESS</u></b></div></div>	PC0288/E/001/P-II/ SEC-5.1	P	
		Document No.	Rev	
		Sheet 6 of 9		

#### 4.0 CORROSION ALLOWANCE

Materials of construction and corrosion allowance for all Equipment and machinery shall be for a design life of 25 years (except for heat exchanger tubes). However, minimum corrosion allowance for carbon steel (including 0.5 Mo alloy steels) shall be:

Pressure Vessels and other applicable Equipment	3 mm
Storage Tanks	1.5 mm
Piping	1.5 mm
Removable parts or internals (on each side in Contact with operating fluid)	0.75 mm
For stainless steel/titanium	0 mm
Carbon steel with epoxy resin coating	3 mm

#### 5.0 HYDRAULIC RETENTION TIME

Hydraulic retention time (Hold-up Requirements) is defined between low level (LL) and high level (LH).

Type of Service	Retention Time
Feed Surge drum	30 minutes (*)
Reflux only	5 minutes (*)
Column Feed on flow control	15 minutes (*)
On cascade level/flow control	8 minutes (*)
Re boiling by Fired Heater	8 minutes (*) on feed to heater
Re boiling by Thermo siphon	10 to 30 seconds on circulation
PRODUCTS to storage	
Without Pump	5 minutes (*)
With Pump	7 minutes (*)
Feeds and Products feeding another Unit	
On flow control	15 minutes (*)
On cascade/level flow control	8 minutes (*)
Tanks capacities	LSTK Contractor to confirm
Steam drum (LHH – empty) Min	10 minutes
Deareator Min	30 minutes (*)



In the case of pumps ensuring several services such as reflux and liquid distillate to storage, the residence time of the corresponding vessel will be whichever is greater from the above list.

(\*) To be advised by LSTK Contractor if specified values need to be enhanced.

#### 6.0 HEAT EXCHANGERS

In general heat exchangers shall be designed to 110 % of their operating duty/flow.

Columns overhead coolers shall be designed to 120 % of their operating duty/flow.

	<div><div><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></div><div><b><u>Bharat Coal Gasification and Chemicals Limited</u></b></div><div><b><u>DESIGN PHILOSOPHY - PROCESS</u></b></div></div>	PC0288/E/001/P-II/ SEC-5.1	P	
		Document No.	Rev	
		Sheet 7 of 9		

Large heat exchangers shall be split into two or more shells for easy operation and maintenance. As far as possible AES type of exchangers shall not be used.

## 7.0 PUMPS

Normally pumps shall be designed to 110 % (else as defined in individual sections) of their maximum required flow rate in worst case of operation. Pumps for fractionation column reflux, pump round and re-boiler, flow rates shall be designed to 120% of their maximum required flow rates.

The shut-off pressure shall be estimated according to the following criteria whichever is higher:

- Differential head at rated flow x 120 % + LH (level high) suction static head + max operating pressure suction side.
- Differential head of pump at rated flow + LHH (level high high) suction static head + design pressure suction side x 120 %. No over design shall be applied to the rated pressure.



BFW pumps shall be designed for 120% of their maximum required flow rate in worst case of operation. Pump drives shall be preferably electric motor driven, wherever is applicable and Steam Turbines shall be preferably of Back-Pressure type.

## 8.0 COMPRESSORS

In general, compressors shall be designed to a minimum of 110 % (else as defined in the individual sections) of their maximum required flow. However, they are subject to special considerations according to the process. All vent valves and anti-surge valve shall be of leakage Class-V.

## 9.0 PRESSURE RELIEF VALVES

Pressure relief valves shall be supplied with locked open isolating valves. Pressure relief valves for operational failure shall have installed spares. Also PRV on fire case with Hydrocarbon service shall have installed spare. LSTK Contractor shall take care of any additional requirement as per guidelines of the process licensor. The set pressure of pressure relief valves shall be equal to the design pressure of the equipment. All safety valves will have bypass with exception of safety valves which are only for fire cases and if there is more than one safety valve. All pressure relief blows out lines of process gas and ammonia syn. gas should be connected to the flare.

	<div><div><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></div><div><b><u>Bharat Coal Gasification and Chemicals Limited</u></b></div><div><b><u>DESIGN PHILOSOPHY - PROCESS</u></b></div></div>	PC0288/E/001/P-II/ SEC-5.1	P	
		Document No.	Rev	
		Sheet 8 of 9		

## 10.0 COLUMNS AND VESSELS

### 10.1 Nozzle:

- Minimum size 3/4" (for S.S shall be 1 inch).
- Nozzle rating according to once of connected piping for instrument min. Class 150 ANSI rating.

### 10.2 Manhole:

- Manhole size 24" (\*)
- Manhole installation for Tray Tower

For tray towers, manholes shall be provided at top, bottom, feed point and draw-off point of tower and after each 20 trays or after every 15 m elevation distance, whichever is lesser as minimum.

(\*) In case there is restriction for diameter, minimum 20" may be used.

### 10.3 Hand hole or Inspection hole:

- Preferable Size 8 inches
- Minimum Size 6 inches

### 10.4 Vent and Drain:

Vent and drain for vessels will normally be provided at the minimum length on overhead or bottom line in accordance with the following table:



Volume or diameter of vessel (m <sup>3</sup> or mm)	Vent diameter (inches)	Drain diameter (inches)
V < 75 or D ≤ 4,500	2	2
75 < V ≤ 220 4,500 < D ≤ 6,000	3	3
220 < V ≤ 420 or D > 6,000	4	4
V > 420	6	4

Note: Vent and drain connections are not necessarily located on vessels.

All Columns shall have high efficiency demister for removal of moisture and entrainment.

### 10.5 Steam Out:

Steam out nozzles shall be sized as follows:

	<div><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></div> <div><b><u>Bharat Coal Gasification and Chemicals Limited</u></b></div> <div><b><u>DESIGN PHILOSOPHY - PROCESS</u></b></div>	PC0288/E/001/P-II/ SEC-5.1	P	
		Document No.	Rev	
		Sheet 9 of 9		

Type of Application	Nozzle Size (inches)
Drums and heat exchangers (when applicable)	2
Column diameter (m), D	
a) $D \leq 4$	2
b) $4 < D \leq 5.5$	3
c) $D > 5.5$	4

#### 10.6 Storage (Chemical/Catalyst/Additives):

LSTK Contractor shall consider all facilities necessary for safe loading, unloading, storage, transportation of chemical/ catalyst/ additives within the plant Battery limit during Construction stage.



<div> पी डी आई एल <b>PDIL</b></div>	<b>PROJECTS &amp; DEVELOPMENT INDIA LTD.</b>	PC288/E/001/P-II/ SEC-5.2	0	<div> बी एच ई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 1 OF 113		

## PART-II: TECHNICAL



### SECTION – 5.2

#### DESIGN PHILOSOPHY - INSTRUMENTATION

**PLANT: SYNGAS PURIFICATION UNIT**




**PROJECT: COAL TO AMMONIUM NITRATE PLANT  
AT JHARSUGUDA, ODISHA (INDIA)**

0	15.03.24	15.03.24	Client comments Incorporated	KM	HK	RKR
P	21.02.24	21.02.24	Issued for Review	KM	HK	RKR
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 2 OF 113		

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.	Instrumentation And Controls
2.	Scope
3.	Control Philosophy (General)
4.	Basis Of Design
5.	Instrumentation Code And Practices
6.	Hazardous Area Classification & Electrical Execution
7.	Electrical Supply
8.	Field Instruments
9.	Primary Differential Producers
10.	Other Flow Meters
11.	Level Instruments
12.	Level Gauge Glass
13.	Pressure Instruments
14.	Temperature Instruments
15.	Control Valves
16.	Pressure Relieving Devices
17.	Switches And Solenoid Valves
18.	Control And Shutdown System
19.	Emergency Shutdown System (ESD)
20.	Control Room
21.	Package Unit Instruments
22.	Noise Immunity Of Electronic Instruments
23.	Specification For Contacts
24.	Local Control Panels
25.	Installation
26.	Fire And Gas Detection System
27.	Operator Training Simulator
28.	Factory Acceptance Test (FAT)
29.	Site Acceptance Test (SAT)
30.	CCTV
31.	Telephone Exchange
32.	Local Area Network (LAN) for CR
33.	Compressor Control System
34.	Instrument Workshop

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 3 OF 113		



### LIST OF ATTACHMENTS

ANNEXURE NUMBER	DESCRIPTION	NUMBER OF SHEETS
1	Instrument Accuracies	
2	Instrument Process Connections	
3	System Configuration	

### General Specifications

GSTD-0001 GENERAL SPECIFICATION FOR ANALYSER SHELTER  
 GSTD-0002 REQUIREMENTS FOR ANALYSER SYSTEMS  
 GSTD-0003 GENERAL SPECIFICATION FOR STACK ANALYSER  
 GSTD-0004 GENERAL SPECIFICATIONS FOR ANALYSER SYSTEM  
 GSTD-0005 PROCESS STEAM ANALYSER  
 GSTD-0006 CALIBRATION GAS REQUIREMENT & UTILITY CONSUMPTION  
 GSTD-0007 GENERAL SPECIFICATIONS FOR MASS SPECTROMETER  
 GSTD-0120 GENERAL SPECIFICATION MOTORISED ACTUATOR  
 GSTD-0201 GENERAL SPECIFICATION FOR DCS & PLC SYSTEM  
 GSTD-0202 GENERAL SPECIFICATION FOR PLC SYSTEM  
 GSTD-0210 GENERAL SPECIFICATION FOR MACHINE MONITORING SYSTEM  
 GSTD-9998 INSPECTION AND TEST REQUIREMENTS

## 1.0 INSTRUMENTATION AND CONTROLS

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 4 OF 113		

## 2.0 SCOPE



2.1 This section outlines the general requirements and specifications for Instrumentation and Control System for the project. The Instrumentation and Control System shall consist of but not limited to the following:

- a) Electronic micro-processor based Distributed Control System located in Control Room.
- b) SAFETY PLC (TMR/QMR/VMR) based Emergency Shutdown System.
- c) All Field Instruments including control valves and safety valves.
- d) Compressor Controls System (CCS)

CCS will continuously monitor and control centrifugal compressors through performance control (including energy efficiency), remote adjustment of speed set point and anti-surge protection. Moreover a CCS may be interfaced with a Machine Monitoring Systems (MMS) for machinery protective functions and with a Safety Instrumented System (SIS) for all safety and shutdown actions.

- e) Analyser Systems with Analyser shelter (SS). Minimum one Analyser Shelter for syngas purification unit plant depending on allowable transportation time and other factors. Mass-spectrometer, if recommended by Licensor can be used with its proven track record in India.
- f) CCTV system as per attached specification in tender.
- g) Operator training simulator (OTS) system (with all the hardware, software, monitors and other accessories) shall be totally independent and separate from the plant DCS/ESD system.
- h) Fire and Gas System.
- i) Suitable Clean Agent System as per NFPA 2001 shall be provided for Control Rooms.
- j) Gas Detectors
- k) EPABX system including handsets.
- l) LOCAL AREA NETWORK (LAN) for Main Control Room

Selected Instrument shall be latest & proven model with minimum one year proven track record (PTR) in an hydrocarbon industry like Fertilizer, Refinery, Petrochemical and Gas Processing Plant, Power Industry under similar process conditions for at least 4000 hrs. from the bid opening date.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 5 OF 113		

All equipments / instruments / system oriented items (with all its sub-systems) shall be of field proven quality both with respect to design and materials. Prototype instruments or instruments of an experimental nature shall not be offered or supplied. In general, all the supplied items by supplier shall have a well proven performance record of operating satisfactorily in an Fertilizer, hydrocarbon industry like Refinery, Petrochemical or Gas Processing Plant, Power Industry for at least 4000 hrs (as collaborated by user certificate).

PTR for field instruments shall be considered min for 4000 hours and PTR for System oriented items like , DCS, PLC, MMS, Mass Spectrometer, analyser shall be one year.



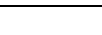
Fire and Gas Detection system (FGS system), EPABX exchange, PA system exchange, and LAN switch shall be housed in Control Room (CR).

Vendor to provide PTR for all the critical items like Control valves, Safety valves, Control System, Analysers, Gas detectors, CCTV, cables, custody transfer flowmeters, coriolis meter, transmitters, solid flow measurement devices

2.2

The Contractor's scope for all the above facilities shall cover design, engineering, procurement, installation, testing, calibration and commissioning etc. as detailed below:

- a) Preparation of general specification for Instruments.
- b) Sizing of flow instruments, control valves, pressure relief valves etc., and preparation of Technical data sheets for all Instruments.
- c) Invitation of offers, technical and commercial evaluation of offers and placement of orders on final approval from the OWNER.
- d) Preparation of engineering and construction documents like Functional schematics, I/O list for both DCS and ESD System, Logic diagrams for interlocks as per ISA5.2 with functional descriptions, Configuration diagram, Control room layout, Electrical load list, Cable schedule, Cable tray/trench layout, Instrument air requirement, Nameplate schedule, JB schedule, Instrument location layout, Electrical instrument signal interface, Instrument index, Layout drawings, Loop diagrams, Primary and secondary sketches and Bill of materials. Co-ordination with all instrumentation vendors and Package vendors for obtaining sufficient information in the form of documents, drawings for engineering and approval from OWNER.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 6 OF 113		

- e) Preparation of all engineering documents for DCS like Graphic schemes, Instrument loop data base, Log formats and any other documents necessary to carry out the system engineering of DCS and ESD. Co-ordination with DCS and ESD vendor for system engineering, implementation, software testing, supply and final commissioning and site acceptance tests. FAT and SAT is included in the scope.
- f) Preparation of specification for erection materials like cables, cable trays, pipe & pipe fittings, air tubing, junction boxes, air distribution pots etc.
- g) Site supervision of construction, erection, testing and commissioning activities of field instrumentation and control room instrumentation activities.
- h) Preparation of instrument scope for all package items like, pumps, compressors, service boilers, etc.

In case of contradiction/conflict among documents, Bidder shall refer to Owner for clarification. However, most stringent specification shall be followed with Owner's approval. Owner decision shall be considered as final.

## 2.3

### Operating Staff Training


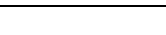
Operating courses include all aspects involved in operating the Control System from operator interface. This shall include operation under normal and abnormal conditions as may result from minor or major system malfunctions such that the trainee can take the appropriate remedial actions. The training shall include but not be limited to the following:

- Overview of the system
- Control philosophy
- User interfaces
- Messages and alarms
- Operator commands
- Generation of reports
- Predictable events and expected operator action

## 2.4

### Engineering staff training

Software Design courses shall be provided which would train the Employer's Maintenance and Design staff to be able to identify and remedy software faults, upgrade and implement data and software changes, generate/develop new software

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 7 OF 113		

for the purpose of improving the system and production of revised or new displays.  
The training shall include but not be limited to the following:

- Overview of the system architecture, hardware and software
- Software design and organisation
- Database structure, generation and modification
- Generation and modification of the VDU screen
- Customisation of report/chart/graph format
- Assembly, compilation, linking, editing, debugging, distributing, testing and integration of program modules.

### **3.0 CONTROL PHILOSOPHY (GENERAL)**

3.1 Design and installation of instrumentation shall comply with codes and recommendations listed in item 5.0.



3.2 The Instrumentation shall be designed to provide stable and accurate plant control ensuring safe plant operation and to facilitate plant maintenance, Control and Monitoring. The operating interface to the process shall display units, presenting overview, group and point displays as well as process graphics with live data. The operator will manipulate all facilities through dedicated operator's keyboard. 3.3 All elements of the Control function (DCS) and Interlock function (ESD) are to be completely separate and segregated. All Control functions are to be implemented in DCS including non-critical interlocks like for Drives, small pumps etc and all critical trips, safety, shutdown or plant trip logic functions are to be implemented in ESD.

The emergency shutdown system shall be implemented in either dedicated SIL-3 PLC or DCS with a dedicated redundant controller for shutdown system and the regulatory control / monitoring in the controller sub-system of DCS including non-critical interlocks like for Drives, small pumps etc.

3.3 Symbols of DCS, ESD system shall be totally separate.

3.4 All Start function shall be local. Stop function shall be from local/DCS. Trip functions of Rotating equipments are to be from ESD. Interlock functions are not to be initiated from DCS. Interlock initiation shall be from ESD.

3.5 Each of the trip parameters shall have individual Process Override switch, which will be used as Process Override Switch (POS) as well Maintenance Override Switch (MOS). These shall be realized as soft touch target with confirmation dialogue box in the DCS graphic and from DCS a dedicated Digital output via interface relay shall be


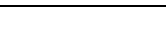
	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 8 OF 113		

wired to ESD as a Digital Input for override purpose. The status of the POS/MOS from the ESD, as read by ESD, may be communicated to Operator on DCS Operator station via DCS-ESD software communication link. Irrespective of process licensor's recommendation, these override switches shall be provided for all trip input parameters of ESD. This is applicable to each of the trip input parameter




Maintenance override switches (MOS) shall be soft type. One hardkey shall be provided in Auxiliary console for the Activation of the MOS. Process override switches (POS) shall be soft type.

- 3.6 All system/marshalling cabinets for DCS/ ESD/ PLC/ MMS/ ITCC/ Compressor Controls System/CCC/ Woodward and their PCs shall be housed in Control Room only.
- 3.7 Appropriate furniture including chairs, tables etc (Owners choice) of reputed make as per specifications for Control Room and other places shall be provided by the bidder. Chairs shall be high back with revolving type.
- 3.8 ESD shall be SIL-3 certified as per standard IEC 61508. All sensors / software switches for 2 out of 3 voting system shall be triplicate for critical trips. If necessary, Annunciator window for trip groups shall be provided for monitoring. Field switches shall be avoided to the extent possible. All trips shall be manipulated via software switches with inputs field transmitters for trip purposes and utilities packages.
- 3.9 Centralised Air Conditioning shall be provided for control room building.
- 3.10 MMS probes and proximeters, along with Transient Data Manger and Condition monitoring monitor for all plants shall be used for vibration monitoring of compressors, with LED/TFT displays inclusive orbital analysis, key phasor output etc. in the control room. Each machine shall have separate racks and each rack shall have dual power supply alongwith dual redundant serial communication with DCS. All radial and thrust bearings shall have RTD, temperature monitors with 2oo2 trip facility. All monitors shall be located in Control Room. All vibration, axial displacement and speed signals are connected with DCS through hardwired.
- 3.11 There shall be Machine Monitoring monitor enterprise license with minimum 2 user/client license. VMS shall be required for machines with capacity greater than 1 MW/OEM or licensor recommended.
- 3.12 The alarm and shut-down system shall be fail safe type and utilising field contacts that open in alarm conditions.



	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 9 OF 113		

- 3.13 DCS-PLC communication is to be used only for transferring Status and Alarm signals from PLC to DCS.
- No tripping parameters shall be interfaced through serial communication and soft links.
- Transfer of data through serial link from DCS to PLC and vice versa shall be used only for monitoring purpose and not for control & trip.
- 3.14 Fire and Gas (FGS) PLC: QMR/TMR/VMR PLC for FGS of the same type as the ESD system as per ITB.
- 3.15 For Compressors provision of SOE with 1 msec shall be there.
- 3.16 MMS/VMS: Two X-Y probes at each radial bearing and three axial displacement probes at each thrust bearing (TMR implementation in the module for tripping/shutdown) along with Condition Monitoring software and hardware shall be required along with RTD, temperature element at Radial and thrust bearing with temperature monitors with tripping facility.
- 3.17 Anti Surge Controller and Speed Governing System as per attached specification.
- 3.18 HVAC in CR: Two separate DUCTS for console room and Cabinet Room should be there with flow regulators to maintain different temperatures. 3.21 BPS for 24V DC shall be provided for each process controllers separately as per segregation philosophy having redundant bus bar.
- 3.19 DIs/DOs from MCC to DCS/ESD shall be with relays only also IRC/IRP shall be Separate for DI's & DO's and AI's / AO's. IRP/IRC shall be placed in MCC only.
- 3.20 Alarm and Annunciation System:
- Annunciation system is used to indicate and sound alarm for any process abnormality, trip/status change.
- An Annunciator window on aux console that clearly displays status of trip alarms, bypasses, trip-groups, etc. with a first-up alarm shall be incorporated near the DCS operator work stations. The operator shall also be informed of trip conditions by means of a warning sound that differs from the audible signal from the DCS alarm system. However operation of override switches to be included in operator action log.
- 3.21 If applicable, Speed Monitoring is required also for ID, FD Fan, Cooling Water Pumps, etc. Their RPM indication and trip philosophy is required from control room.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 10 OF 113		

3.22 There shall be panel segregation for various I/Os meant for DCS and ESD system. Also there shall be panel segregation for diff. type of I/Os for DCS, ESD and other control system.

3.23 All Servers shall have Raid-5 architecture as a minimum and Operator Station with a minimum Raid-1 architecture.

3.24 Bidder shall provide one documentation node. Vendor shall be responsible to supply completely engineered documentation node including necessary hardware of proper size and the software necessary to meet the requirements of the node..

Following documents should be possible to be printed from the documentation node as a minimum. Vendor shall indicate the capability of their offered system and shall engineer the same as per Owner's requirement

3.25 Bidder shall provide AIMS shall be from M/s IMAC or X-Force (M/s SSM Infotech) or equivalent reputed make meeting the specification and PTR requirement.

3.26 IAMS (Assest management) System shall be considered and provided by contractor for all (SMART) analog signals to DCS and PLC as per standard specification. All signals to DCS and PLC shall be SMART type with HART protocol. The I/O cards for DCS shall be HART protocol compatible.

3.27 The minimum instrument accuracy shall be as defined in Annexure-1.




3.28 The MMS vendor/LSTK shall submit clause wise compliance of API 670 latest edition.

3.29 All field Instruments and control system throughout the complete plant to be designed so as to maintain fewer inventories and have interchangeability at any time. Bidder to submit detailed chart for spare parts interchangeability for instruments/control system.

### 3.30 **Interfacing with DCS and Other systems at Control Room (CR)**

All DCS, Control Systems, ESD/PLC system, All Analyser PLC/ Microprocessor based system, Any Analyser system like Mass Spectrometer, CCTV, Fire and Gas System PLC, Any Package PLC shall be connected to Main DCS and Other systems at Control Room with suitable redundant interface using Optical Fibre Cables. If OPC and Firewall is required for any of the interface the same shall be provided by the LSTK Bidder with all the necessary hardware and software support.

Suitable graphics pages shall be built in main DCS for viewing these data. Suitable hardware and software required for interface of these with main control system shall be provided by the LSTK bidder.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 11 OF 113		

## 4.0

## BASIS OF DESIGN

### General

Instrumentation for the proposed Syn Gas Purification Plant is to provide a highly reliable and comprehensive control and monitoring system. To facilitate these well proven techniques shall be adopted for measurement and control.

In the event of any conflict between this specification, related standards and codes, any other attachment to this package or process packages supplied by process licensors, the contractor shall follow the following documents in the order of their priority:

Instrument Design Philosophy Section 5.2

General Standard specification attached

Licensor's recommendation




Statutory requirements and codes & standards

This document is prepared to cover the requirement that is not identified elsewhere. Hence this document shall be considered in addition to other documents and shall be read in conjunction.




In case of contradiction among documents, LSTK Contractor shall refer to PMC for clarification. However the most stringent specification shall be followed with PMC/Owner's approval. Owner/PMC's decision shall be considered as final.

The following philosophy is to be adopted:

1. The input transmitters and the Final control elements like control valves/On-off Valves being used for Control functions (DCS) and Interlock functions (ESD) shall be completely separate.
2. All control valves shall be provided with SMART valve positioner with valve position signal feedback connected to DCS system by 4 to 20 mA analog signal. It shall be HART compatible.
3. Universal HART Protocol with Latest Revision shall be used in all cases.
4. Wago/Weidmuller/Phoniex/Klippon make Panel Access. (Relay, Switch, Lamp, Push Button), screwless terminals shall be used with single tier only.
5. P&F/MTL/Stahl Barrier/Isolator/Trip Amplifier shall be used for the entire Plant.




	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 12 OF 113		

6. Speed Monitoring is required wherever VFD is used. Their RPM indication and trip philosophy is required from control room.
7. For Molten Sulphur transfer, Coriolis type mass flowmeter with +/-0.1% accuracy shall be provided.
8. For by product Ash/slag, (solid) flow measurement shall be provided, if applicable.
9. For by product Sulphur, (solid) flow measurement shall be provided.
10. All limit switches shall be proximity sensor type.
11. Cable entry to control room, analyser shelter, substations shall be through MCT blocks.
12. Entry into the Marshalling Panels in the control room shall be through bottom mounted MCT blocks/Gland Plates.
13. Bidder shall provide MCT frame of SS316 material (alongwith multi-dia blocks with peeling of arrangement and centre plug, with wedge, lubricant, stay plate Bidder shall provide at least 20% installed spares with multi-dia blocks with peeling of arrangement and centre plug.
14. No head mounted temperature transmitters are to be used.
15. General Earthing & Instrument Earthing shall be provided separately..
16. No Direct Process Switches (Pressure/Level/ Flow/Temp.) shall be used. However, if it's not possible to install transmitter for particular application online pressure/level switches (float type) may be used if the need arise. This shall be discussed during detail engineering on case to case basis.
17. Execution type for all field transmitters in hazardous/safe area shall be intrinsic safe. Flame/ex. proof enclosures shall be provided where intrinsic certifications are not available.
18. All field transmitters for pressure, d/p, level and flow shall be microprocessor based (dual compartment) SMART transmitters with "UNIVERSAL HART" protocol with latest revision. The transmitter selection shall be such that the operating maximum upper limit shall be around 70% of the total measurement range of the transmitter.
19. "HART" management / maintenance System (HMS) is required.




	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 13 OF 113		

Hart maintenance/management system (HMS) shall be used for remote calibration, configuration viewing/modifications, diagnostics & performance monitoring of HART/ field instruments. At least one HMS system shall be supplied.

20. To be added in spares list Bidder's to recommend 2 years Operational Spares and submit Itemised List with validity of 2 Years.
21. Redundant Bulk Power supply with diode arrangements shall be provided for field instruments.
22. Irrespective of licensor recommendation and area classification, SIL Study (SIL assessment study, validation/verification) has to be done for all plants and recommendations to be implemented. HAZOP Study recommendation to be implemented in PID.
23. Local / Remote Selection Switch
  - a. For START / STOP of all electrical equipments, local / remote selector switch shall be located in MCC.
  - b. Local stop push button on LCS (local control station) shall be always effective.
  - c. In Remote mode motor can be START / STOP from DCS
  - d. In LOCAL mode, both START and STOP shall be possible only from LOCAL.
  - e. Auto / Manual selection shall be in DCS / Local.
24. Trip solenoid valves shall be dual redundant, and configured and hooked up properly in such a way that failure of one solenoid doesn't initiate a false trip. Trip solenoids shall be normally in energised condition and shall be de-energised to initiate trip.
25. Air fail to open, Close or Hold of any control valve shall be as per Licensors document, to take care of process, plant and human safety. For Piston actuators necessary air volume chambers and lock up relay shall be provided to achieve the fail safe condition.
26. Inputs from thermocouples shall be provided with cold junction compensation and downscale burns out feature for high temperature shut downs and vice versa for low. Passive alarms shall warn about the burn-out.




	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 14 OF 113		

27. Each hand held communicator o (HHT) loaded with latest HART software shall be provided with minimum of 1 GB removable, plug in type memory bank, which can store a minimum of 1000 transmitters configuration data.
28. Hydrastep type level instruments shall be provided for level measurement in high pressure boiler drums.
29. Control room Floor level shall be 1.5 meter from the Finished floor Level.
30. All Analysers, GCs, Mass-Spectrometer shall be Ex-proof irrespective of area of installation.
31. Internals of All Control Globe / Ball / Butterfly valves, On-off valves, MOV Ball, MOV gate, MOV butterfly valves, MOV Check Valves, Pressure relief valves, Thermal relief valves shall be minimum SS316 irrespective of licensors's data sheet.
32. All control valves / On–Off Valves / MOVs shall be flanged type.
33. Control valve/On-Off valve, pneumatic valve shall be designed for minimum 4 Kg/cm<sup>2</sup> air pressure.
34. All Safety Valves / Thermal relief valves shall be flanged type only.
35. Thermocouples shall be duplex type.
36. Thermowell flange rating shall be 1 1/2" 300# SS316 minimum.
37. Temperature transmitter shall be used for both open loops & Closed loops.
38. Guided wave radar type instruments (SMART) shall normally be used for level measurement,. Differential pressure transmitter (Capillary type) shall be used for for services requiring purge or where liquid might boil in external portion. Capillary type DPTs shall not be used in vacuum services. Internal displacer type of level transmitters shall be not be used. Remote Seal PT/DPT shall be with minimum 5 mtrs Capillary with SS armoured in PVC sheath of Protection with DRIP RING and with Ball type Isolation Valve. For Vessel/Equipment requiring more than 5 m capillary electronic remote seal (ERS) shall be provided.
39. Air distribution pots shall be of Stainless Steel. Inst. Impulse pipes for process parameters shall be in accordance with piping specifications.
40. Main instrument air header and Branch header material : SS304

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 15 OF 113		

41. Main instrument air header shall be at least 2" (SS) minimum depending on requirement. It shall have 1" minimum takeoff (SS) with ball type isolation valve (SS304) & further distribution for each instrument through separate ½" SS line with ½" SS Ball valve single piece design with SS handle & with 6 mm OD SS316 tubing.
42. All the instruments shall be SIL certified.
  - All Smart Positioners, SIL 2
  - All Partial Stroke Testing (PST) shall be implemented by SIL3 mechanism.
  - All Transmitters - SIL2
  - All Solenoids – SIL 3
  - All Gas Detectors – SIL2
  - All Relay – SIL 3
43. Hart Compatible gas-detectors to be provided.
44. Separate Tapping shall be used for each instrument coming for trip, control & monitoring, local display.
45. Separate Sample handling system shall be used for each analyzer. Multi Channel with stream selector can be used, provided the total system including sample handling system shall be imported. Necessary sequence shall be inbuilt in the analyzer for draining the condensate.
46. For double acting valve, air accumulator shall be used for achieving fail safe operation.
47. Temperature, Pressure & Flow instruments provided in buried vessel shall be located above ground level. IP 67 shall be provided if instruments are under water.
48. System / Marshalling/ CCTV / Packages cabinet size shall be 2100 (H) X 1200 / 800 (W) X 800 (D) Rittal make preferably.
49. All field transmitters shall be dual Compartment Type.
50. For Monitoring & Control, separate nozzles/ takeoff shall be taken for all loops.. No More than 3 set of taps are allowed.
51. Smart positioner shall be considered for all Control Valves and the same shall be connected to Hart Maintenance system. For high temperature services remote feedback shall be used for the smart positioner.
52. Valve signature software is required for all Control Valves.






	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 16 OF 113		

53. For all Local panels rain cover to be provided.
54. For Analysers separate feeders to be directly taken from PDB. No sub-branching allowed at any place.
55. In general separate junction boxes shall be used for the following:
  - a) 4-20 mA DC signals (IS)
  - b) 4-20 mA DC signals (non-IS)
  - ce)
  - g) Power supply to various instruments.
  - h) Gas Detectors
  - i) Vibration signals
  - k) Telephone System
56. l) Separate junction boxes shall be used for signals connected to PLC/ESD and to DCS. No signal shall be shared between them in the field junction boxes.
57. Only metal tube Rotameter with transmitter shall be considered. Glass tube Rotameter shall not be used.
58. All Instrument Hookups shall be approved by owner/PMC..
59. Partial stroke testing shall be provided for shutdown valves. For shutdown valves, Proximity type switches shall be provided for open & close status in addition to Smart positioner.  
  
Valve Vendor shall supply the complete testing assembly duly tubed/piped/wired on a SS mounting plate thickness 3.2 mm suitable for 2" pipe stanchion mounting. Standard pre designed rigidly mounted components shall also be acceptable for PST assembly.
60. All Components in 2oo3 Trip Loop in ESD shutdown loop (Final control element, logic solver, primary element) shall be SIL-3 compliant.




## 5.0 INSTRUMENTATION CODE AND PRACTICES

S.No.	Description	Standards / Codes
1	AGA-American Gas Association	






	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 17 OF 113		




1.1	Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids- Part 1: General Equations and Uncertainty Guidelines	AGA Report No-3	Part-1
1.2	AGA Report No. 7, Measurement of Natural Gas by Turbine Meter	AGA Report No-7	
1.3	AGA Report No-9, Measurement Multipath Ultrasonic Meters of Gas by	AGA Report No-9	
2	ASME- American Society of Mechanical Engineers		
2.1	Pipe Threads General Purpose (Inch)	B 1.20.1	
2.2	Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/ Inch Standard	B 16.5	
2.3	Metallic Gaskets for pipe Flanges- Ring Joint, Spiral- wound and Jacketed	B 16.20	
2.4	Valves-Flanged, Threaded and Welding End	ASME B 16.34	
2.5	ASME Boiler and Pressure Vessel Code (BPVC), Section VIII, Division 1: Rules for Construction of Pressure Vessels	ASME BPVC-VIII-1	
2.6	Boiler and Pressure Vessel Code (BPVC), Section I: Rules for Construction of Power Boilers	ASME BPVC-I	
2.7	Thermowells Performance Test Codes	PTC 19.3 TW :2016	
2.8	Orifice Flanges	ASME B.16.36	
3	ANSI/FCI-American National Standards Institute/Fluid Control Institute		
3.1	Control Valve Seat Leakage	FCI 70-2	
4	API-American Petroleum Institute		
	Manual on Installation of refinery Instruments Part I and Control System	API-RP-550	
4.1	Part-I Sizing and Selection	API STD 520	
	Part-II Installation	API RP 520	
4.2	Guide for Pressure Relieving and Depressurising Systems- Petroleum Petrochemical and natural gas industries-Pressure relieving and Depressurising Systems	API STD 521	
4.3	Flanged Steel Pressure Relief Valves	API STD 526	
4.4	Seat Tightness of Pressure Relief Valves	API STD 527	
4.5	Manual of Petroleum Measurement Standards	API MPMS	
	Vocabulary	API MPMS 1-Vocabulary	
	Proving Systems	API MPMS 4 Chapter-4	
	Metering	API MPMS 5 Chapter-5	
4.6	Process Measurement Instrumentation- Part I - Process Control and Instrumentation	API RP 551	
4.7	Transmission Systems	API RP 552	

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 18 OF 113		




4.8	Venting Atmosphere and Low Pressure Storage Tanks	API 2000
4.9	Fire test for quarter turn valves and valves equipped with Non-metallic seats	API 607
4.10	Metal Ball Valves Threaded and welding ends — Flanged,	API 608
4.11	Valve Inspection & tests	API 598
4.12	Specifications for Fire Test of valves	AP 6FA
5	BS-British Standards	
5.1	Multi-Element Metallic Cables Used in Analogue and Digital Communication and Control- Part 7: Sectional Specification for Instrumentation and Control Cables	BS EN 50288-7
6	EN-European Standards	
6.1	Metallic materials- Types of inspection documents	BS EN 10204:2004
6.2	Dial Thermometer	EN-13190
6.3	Conductor of Insulated Cables	EN 60228
7	IEC-International Electrotechnical Commission	
7.1	Explosive Atmosphere-Part 0: Equipment- General Requirements	IEC 60079-0
7.2	Intrinsic safety code and practice	IEC 79.11/
7.3	International Boiler Regulation	IEC-79.14
7.4	Electrical Insulation - Thermal Evaluation and Designation	IEC 60085
7.5	Tests on Electric and Optical Fiber Cables under Fire Conditions - Part 1-1: Test for Vertical Flame Propagation for a Single Insulated Wire or Cable-Apparatus	IEC 60332-1-1
7.6	Degree of protection provided by enclosures.(IP code)	IEC 60529
7.7	Industrial Process Control Valves - Part 2-1: Flow Capacity - Sizing Equations for Fluid Flow Under Installed Conditions	IEC 60534-2-1
7.8	Industrial Process Control Valves- Part 2: Flow Capacity - Section Three - Test Procedures	IEC 60534-2-3

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 19 OF 113		

7.9	Industrial Process Control Valves - Part 2-4: Flow Capacity - Inherent Flow Characteristics and Rangeability	IEC 60534-2-4
7.10	Industrial Process Control Valves - Part 2-5: Flow Capacity - Sizing Equations for Fluid Flow Through Multistage Control Valve with Interstage Recovery	IEC 60534-2-5
7.11	Thermocouple Tolerances	IEC 60584-2
7.12	Industrial Platinum Resistance Thermometers and Platinum Temperature Sensors	IEC 60751
7.13	Electromagnetic Compatibility (EMC) - Part 4: Testing and Measurement Techniques Set (Contains 30 sections)	IEC 61000-4
7.14	Functional Safety of Electrical/ Electronic/ Programmable Electronic Safety related system	IEC-61508
7.11	Testing of Fire Resistant Cables	IEC 60331
7.12	Functional Safety-Safety Instrumented Systems For The Process Industry Sector	IEC 61511
7.13	Security for Industrial Automation and Control Systems	IEC 62443
7.14	Electric and optical fibre cables-test methods for non-metallic materials-Part 201: General tests-Measurement of insulation thickness	IEC 60811-201
7.15	Electrical Installation of Cables	IEC 60092
7.16	Test on Gases Evolved during Combustion of materials from Cables- Part-1,2	IEC 60754
8	IS-Indian Standard	
8.1	PVC insulated (heavy duty) electric cables working Part I -voltage up to and including 1100V	IS-1554
8.2	Specification of Thermal Evaluation and Classification of Electrical Insulation	IS-1271
8.3	Specification for pressure and vacuum gauges	IS-3624
8.4	PVC insulation and sheath of electric cables.	IS-5831
8.5	Specifications for Thermocouples	IS-7358
8.6	Thermocouple compensating cables.	IS-8784
8.7	Mild Steel wires, formed wires and tapes for armouring of cables	IS 3975
8.8	Elastomeric insulation and sheath of electric cables	IS 6380
8.9	Cross-Linked Polyethylene insulated PVC sheathed cables	IS 7098

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 20 OF 113		

8.10	Method of test for cables	IS 10810
9	ISA-International Society of Automation.	
9.1	Binary logic diagrams for process operations	ISA 5.2 (1976) (R1992)
9.2	ISA 7.0.01 Quality Standard for Instrument Air	ISA 7.0.01
9.3	Standards related to control valves	ISA-75.xx
9.4	Instrumentation Symbols & Identification	ISA 5.1
9.5	Instrumentation Loop Diagrams	ISA 5.4
9.6	Annunciator Sequence & Specifications	ISA S18.1
9.7	Environmental conditions for Process measurement & control systems - Temperature & Humidity	ISA-S71.01
9.8	Environmental conditions for Process measurement & control systems - Airborne Contaminants	ISA-S71.04
9.9	Hardware Testing of Digital Process Computers (Codes of Practice for Testing Computer Based Systems)	ISA-RP-55.1
9.10	Binary Logic Diagrams for Process Operation	ISA S-5.2
9.11	Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer Symbols	ISA S-5 3
9.12	Environmental conditions	ANSI/ ISA S71.04
9.13	Control Valve Equations	ANSI/ ISA S75.01
9.14	Control Valve Procedure Capacity Test	ANSI/ ISA S75.02
9.15	Face-to-Face Dimensions for Flanged Globe Style Control Valve Bodies	ANSI/ ISA S75.03
9.16	Control Valve sizing	ISA-S 75.01
9.17	Instrumentation specification formats	ISA-S20
10	ISO - International Organisation for Standardization	
10.1	Measurement of Fluid Flow by Means of Pressure Differential Devices- Part 1: Orifice Plates,	ISO 5167-1

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT</b>  <u><b>Bharat Coal Gasification and Chemicals Limited</b></u>  <b>Design Philosophy Instrumentation</b>	PC288/E/P-II/ SEC-5.2	0	 कोयला इंडिया Coal India  बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 21 OF 113		




	Nozzles and Venturi Tubes Inserted in Circular Cross-Section Conduits Running Full	
10.2	Measurement of Fluid Flow in Circular Cross-Section Conduits Running Full Using Pressure Differential Devices - Part 2: Orifice Plates	ISO 5167-2
10.3	Measurement of Fluid Flow in Circular Cross-Section Conduits Running Full Using Pressure Differential Devices - Part 3: Nozzles and Venturi Nozzles	ISO 5167-3
10.4	Measurement of Fluid Flow in Circular Cross-Section Conduits Running Full Using Pressure Differential Devices - Part 4: Venturitube	ISO 5167-4
10.5	Testing of valves-Fire type-testing requirements	ISO 10497
10.6	Industrial Valves-Measurement, test, and qualification procedure for fugitive emission	ISO 15848
11	Enclosures for Industrial control and systems.	ICS-6
12	NFPA-National Fire Protection Association	
12.1	Purged and pressurized enclosures for electrical equipment.	NFPA-496
12.2	Ed. Firing system	NFPA 852007
12.3	Classification of hazardous area	NFPA 70-1984 Art 500 Vol.6
13	Standard Material Requirements - Sulfide Stress Cracking- resistant Metallic Materials for Oil field Equipment	NACE MR0175 (95)
14	Oil Industry Safety Directorate	OISD
15	Occupational Safety and Health Authority	OSHA

## 6.0 HAZARDOUS AREA CLASSIFICATION & ELECTRICAL EXECUTION

6.1 Irrespective of area classification, the execution of instrumentation shall be as per area Zone 2, group IIC, T6, EExia and Protection:

Electrical / Electronic instruments	IP 67
Sensors; RTD, T/C, etc.	IP 67
Local Gauges; PG, etc.	IP 67
Pneumatic instruments	IP 67
Solenoid valves	IP 67
Local Panel / Skid Mounted Panels	IP 65

EMC compatibility and electrical safety as per latest IEC standard.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 22 OF 113		

- 6.2 Electrical instrument equipment shall be designed for and supplied as intrinsic safe certified. Analysers, Gas detectors, solenoid valves and other equipment that cannot be classified intrinsic safe shall be ex-proof in accordance with the above mentioned electrical specification.

Certification for installation in hazardous areas in accordance with IEC 60079 series is shown below:

Transmitters, positioners, I/P converters, etc.: EEx ia IIC T6

Switches: EEx de IIC T6

Analysers and Panels: EEx p IIC T6

solenoid valve EExia IIC T6

Junction Boxes and Cable Glands: EEx d IIC T6

## 7.0 ELECTRICAL SUPPLY

The electrical supply will be as follows:

Distributed Control System, trip system,

and Control Room Instruments

: 230 V AC

Solenoid Valves

: 24V D.C

Local Panels

: 230 V AC/24 V D.C

Local Illumination, equipment for air conditioning, space heaters, ventilation of

Local panels and similar purposes

: 230 V AC

Field-mounted Transmitters and switches

: 24V D.C. intrinsic safe

Safety Circuits

: 230 V AC




The 230 V AC supply will be an uninterrupted power supply (UPS) of 230V +/- 10%, 50Hz +/- 3%.

Where 24V DC is needed, it will be generated by a local rectifier units, which will be part of the instrumentation supply. The power supply to these units shall be taken from the UPS.

Wherever 24V DC are used for Safety Circuits, the rectifier units shall be duplicated and with high reliability and form a part of ESD vendor. Redundant 24V D.C. power supply shall be powered from two different sources of UPS.

There shall be minimum 2 separate earth pits for System, Panel /power / Intrinsic safe and non intrinsic safe signals with different cable color codes All earth shall be less than 2 Ohm or OEM specific, if better.



	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 23 OF 113		

The size of earthing Cable from control room to earth pit shall be min. 50 sq.mm and should be routed in proper HDPE conduit, outside the control room building. All above instrument earth pits shall be separate from Electrical earth pits and must have separate color identification from electrical earth.

Two separate AC distribution board (Dual ACDB) fed from parallel redundant UPS are essential for Instrumentation power distribution system for the improved reliability. Each DCS/ESD ACDB shall be fed from redundant UPS feeders & shall have with static switch for change over automatically without power interruption in case of any incomer failure.

UPS supplies shall not be used for utilities supplies cooling fans, panel/cabinet lighting etc. A separate non-UPS supply shall be used for the same.

A summary of all critical UPS alarms shall necessarily provided in DCS and hardwired annunciation in control room or any manned location.

Only copper cables & tin-plated copper lugs shall be considered for instrumentation power distribution system.

UPS battery back-up shall be as per Electrical specification for UPS system. .



Protection coordination with respect to fuse/MCB ratings from the supply source ACDB/DCDB to downstream distribution panels shall be thoroughly studied by the system designers/OEM and documented as a part of the system documentation and be implemented accordingly.

## 8.0 FIELD INSTRUMENTS

### 8.1 Analyser

The Analysers used for analysing the components in the process stream in the Plant will mainly be:

Infrared Analysers / FTIR	:	CH <sub>4</sub> , NH <sub>3</sub> , CO, CO <sub>2</sub> , NO <sub>x</sub> , SO <sub>x</sub> non destructive type
Thermal Conductivity	:	H <sub>2</sub>
Zirconium Oxide	:	O <sub>2</sub> in flue gas
Chemiluminiscence	:	Nox in flue gas
UV pulse flourescent/NDIR	:	H <sub>2</sub> S, SO <sub>2</sub> in flue gas

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT</b>  <u><b>Bharat Coal Gasification and Chemicals Limited</b></u>  <b>Design Philosophy Instrumentation</b>	PC288/E/P-II/ SEC-5.2	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 24 OF 113		

Paramagnetic/ : O<sub>2</sub> in air  
Zirconium oxide

NDUV / TDLS : NH<sub>3</sub>

In general CPCB guidelines, 2018 or latest edition to be followed. CEMS must have flow (velocity) measurement device installed.

All gas analysers shall be housed in pressurised shelter(s) conforming to Namur recommendations. Purge type analysers for all flammable gases shall be specifically certified for execution class of hazardous area besides the purge unit. Purging medium shall be nitrogen. LEL gas detectors shall be provided to detect leakage of gases in the purge line in each shelter. The shelters shall be pressurised through cooled air in summer and steam coil shall be provided in the duct to have warm air during winter through HVAC unit. All electrical apparatus related to the analyser shelter shall be flame proof conforming to the area classification. The gas sample conditioning unit shall be installed outside the shelter.

All liquid analysers shall be of intrinsic safe design suitable for execution class specified for the area. Liquid Analyser, sampling conditioning unit and other accessories shall be mounted on a rack suitable for field mounting. pH, conductivity shall be installed preferably in a bypass line to facilitate maintenance of the analyser. All liquid Analysers shall be smart with HART protocol and shall be configurable with HART hand held configurator.


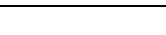
All Analysers shall be micro-processor based in general and shall be capable of providing detail diagnostic alarms, messages to help maintenance personnel. Analysers shall have manual/auto calibration facility.

Self diagnostic routines and calibration functions shall be provided as standard. The Bidder shall supply details of self diagnostic routines and calibration functions including calibration intervals. Auto calibration facility is required for Analyser. Calibration gas cylinder supplied during FAT. The Analysers shall use tried and field tested analysis technology.

Analysers shall generally be single stream. Multi stream Analyser applications shall be supplied where process requirements specify.

The Analyser range shall be as detailed on the relevant data sheet, the operating point will normally be at the midpoint of the span. The Analyser range shall be changeable without having alteration in the field hardware.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT</b>  <u><b>Bharat Coal Gasification and Chemicals Limited</b></u>  <b>Design Philosophy Instrumentation</b>	PC288/E/P-II/ SEC-5.2	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 25 OF 113		

For each Analyser the Bidder shall specify the time required for the sample analysis..

Additionally, Analysers should have provision of Ethernet (preferred) or Modbus RS485, 2 way communication ports to connect serially with plant-wide Analyser Management System (AMS). If a particular Analyser is not having Ethernet/Modbus communication facility then shall have dual analog output (4-20 mA) for each component being measured. All parameters of the Analyser shall be available through the serial port.

Each Analyser shall have local configuration and indication facilities. Local panel display shall be provided where the individual indication is not available on the Analyser. The configuration facilities shall be accessible without removing Analyser covers etc.

Each Analyser shall have as a minimum following alarm outputs wherever possible:

- Sample flow low
- Carrier Gas flow low
- Loss of purge or purge failure
- Analyser Fault

This shall be in the form of volt free contacts, , rated as a minimum 24 V DC 500mA and suitable for I.S use.




Bidder shall ensure that if an unsafe condition occurs e.g. loss of carrier gas, the Analyser shall, if required, “trip” to a safe state and an appropriate alarm be initiated.

Bidder shall detail all equipment that cannot be field mounted. The detail shall include full drawings giving as a minimum, size, weight, mounting details, termination details, power supplies required and allowable environmental conditions.

In general, the sample analysis cycle time shall be limited to three(3) minutes for control applications and five(5) minutes for monitoring applications unless otherwise specified in the data sheet.

All consumables including buffers, calibration gases, reagents, filters, probes, tapes, desiccants etc. shall be supplied for 2 year period on a deferred delivery basis as approved by Owner.

For all IR / NDIR/ UV based analysers, Calibration Cuvettes shall be used in place of calibration gas cylinders.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 26 OF 113		

All Analysers including stack analysers shall be placed in the analyser shelter only. SO<sub>x</sub> and NO<sub>x</sub> analyser shall be located in analyser shelter.

ADSU shall be as per GSTD-0003. It shall have latest Console PCs with 24" TFT, COLOR, LED, one in shelter and one located in control room as per GSTD-0003.




Analyzers for all stacks shall be supplied as per CPCB latest guidelines and shall comply with CPCB/STATE POLLUTION BOARD requirement (whichever is more stringent to be followed parameter wise). Connectivity of these analyzers with CPCB/ STATE POLLUTION BOARD portal shall be in bidder's scope. Bidder shall supply required hardware and software for connecting these analyzers to the CPCB/PPCB portal with min. 20% spare points for future use. Analyzer shall have RS485/ Ethernet / Modbus connectivity.

Analyzers for fugitive emission of Hydrocarbon (HC) / VOC & Benzene at periodicity as per the Fugitive emission standards shall be in bidder's scope.

Service, Accuracy, repeatability, Span & Zero drift speed of response Analyser's performance quality shall be in line with the following as a minimum:

Service	Accuracy	repeatability	Span & Zero drift	speed of response
CH <sub>4</sub>	+/- 2% F.S	+/- 1% F.S.	+/- 0.5% F.S	+/-<than 5 S for infrared 63% of reading
NH <sub>3</sub>	+/- 2% F.S	+/- 1% F.S.	+/- 0.5% F.S	+/-<than 5 S for infrared 63% of reading
CO <sub>2</sub>	+/- 2% F.S	+/- 1% F.S.	+/- 0.5% F.S	+/-<than 5 S for infrared 63% of reading
O <sub>2</sub>	+/- 2% F.S	+/- 1% F.S.	+/- 0.5% F.S	+/-<than 10 S for zirconia 63% of reading
O <sub>2</sub>	+/- 2% F.S	+/- 2% F.S.	+/- 1% F.S	+/-<than 20 S for paramagnetic 63% of reading
H <sub>2</sub>	+/- 2% F.S	+/- 2% F.S.	+/- 1% F.S	+/-<than 20 S for thermal conductivity 63% of reading
SO <sub>2</sub>	+/- 2% F.S	+/- 2% F.S.	+/- 2% F.S	+/-<than 20 S for ultraviolet 63% of reading
Nox	+/- 2% F.S	+/- 2% F.S.	+/- 1% F.S	+/-<than 20 S for chemiluminescent 63% of reading
S.G	+/- 2% F.S	+/- 1% F.S.	+/- 0.5% F.S	+/-<than 5 S for 90% of reading

If Mass spectrometer is considered as per licensors recommendation, then a dedicated laptop for programming of Mass-spectrometer shall be provided along with required software/cable. The lap top shall be with latest Intel hardware, OS and MS office software at the time of supply

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 27 OF 113		



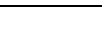
### Analyser Shelter

Number of analyser shelter, location of analyzer shelters and number of analysers along with no. of analyzers installed in each of these shelters shall be decided based upon:

- Allowable transportation time for each sample.
- Available space requirement for analyzer shelter room.
- Accessibility with respect to approaches & obstructions.
- Space required for equipment maintenance and calibration.
- Proving the analyzers as per process requirements specified by process licensor.

In no case, the transportation time should exceed the recommended figures indicated by licensor in the Process package. In case no value is indicated the transportation time should be considered less than one minute.

- Outside Area Classification **EX. PROOF ZONE-2 GR IIC T6**
- Inside Area Classification **EX. PROOF ZONE-1 GR IIC T6**
- The LSTK contractor shall house the process analyzers and other analyzers (Control units) in analyser shelter. The construction of each analyzer house shall be prefabricated in press-formed stainless steel sheet. The materials of construction shall have a fire resistance of two hours minimum in accordance with UL 555 and NFPA Standard 90A.
- HVAC system shall be dual type without any shared components. One shall be working and other standby.
- Analyser shelter shall have complete redundant air conditioning, venting, heating and/or house pressurization system.
- The analyzer house size shall take into consideration the size of each analyzer plus an allowance for 20% spare on both inside and outside walls for future analyzer and sample conditioning systems.
- Shelters shall be equipped with all safety measures like panic bar at the doors, Emergency alarm push buttons, LEL gas (hydrocarbon) detectors, Fire detection system, warning panels, Fire extinguishers, wash basin etc.
- A PLC shall be provided to execute safety logics. PLC shall have redundant

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 28 OF 113		

CPU. PLC shall be mounted in Ex-proof enclosure. PLC fault shall be annunciated

- Each analyzer house shall have common fresh air intake via a stack mounted on the analyzer house roof. These stacks shall be provided with a rain hood and a mesh to prevent entry of birds etc. also adds tie bars for support of stack. The air shall be drawn from a non-hazardous area and the air intake location shall be at least 1 meter outside the hazardous area. The design of the intake tray and the diameter and length shall be sized by Seller so as to limit the air velocity inside the traying to a maximum of 8m/second. The intake stack shall have filters 5 microns down to 99% efficiency, fire dampers and louvers
- Cable Entry into Analyser shelter shall be through MCT blocks.
- One Analyser PLC for each Analyser shelter shall be provided with redundant connectivity to CR.
- If more than 1 analyser shelters are coming then CDSU shall be considered in Control room.



## 8.2 Flow Instruments

### 8.2.1 Flow Transmitters

The signal transmitter shall normally be a 2-wire system and shall be capable of delivering rated current into external load of at least 600 ohms when powered with 24V D.C. Protection against short circuit and reverse voltage shall be provided. Bodies shall normally be in die cast Aluminium with corrosion resistant paint with SS316 internals. Integral 3- valve manifold shall be used for mounting transmitters on manifold for ease of maintenance. Material of manifold in general shall be SS316 but may vary depending upon service. Digital output indication shall be preferable on the integral output meter with the transmitter. All flow transmitters shall have sq.root extraction function.

Pressure elements in austenitic stainless steel is a requirement in hydrogen services. The transmitter shall be furnished with an output meter or gauge with a sqrt scale. Smart type transmitters will be used with Hart V protocol. Process connection size shall be 1/2" NPT through oval flanges.

All field transmitters shall be 2 wire type, 24 Volt DC, SMART with HART protocol, and shall be equipped with Local LCD type digital indicator. 2" pipe mounting, SS304 MOC brackets, Accuracy as per Annexure-1, Rangeability 1:100, Local Display

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 29 OF 113		

configurable, SS MOC, Double Compression SS cable glands, EExib IIC/T6, IP67, Wetted MOC SS316L, SS316 MOC Manifold, Housing die cast Aluminium with corrosion resistant paint, Universal Hart Protocol with Latest Revision is required.

### 8.2.2 **Rotameter**

Rotameter or variable area meters may be used in pipe sizes from 1 1/2" and smaller. The meter shall be selected for normal flow at 50 to 60% of the span. In applications with toxic or inflammable fluids, glass tubes must not be used except for low pressure analyser sample flows. They may be used for severe corrosive services and of fluid of high viscosity. The metal tube meters shall be of stainless steel, PTFE lined or any other suitable lining for the service. The Indicator assembly shall be magnetically coupled and mounted with Rotameter body. Transmitters or Indicators on float extension are not recommended except for cryogenic services. The switch assembly shall be of proximity type.

All Rotameter shall be metal tube type with transmitter.

The rotameter transmitters shall have 4-20 mA output at 24V D.C. power on two wire system.

## 9.0 **PRIMARY DIFFERENTIAL PRODUCERS**




### 9.1 **Orifice Plates**

Orifice plates of the square edged concentric type shall be specified except where unsatisfactory for the application. The maximum ratio of orifice to inside pipe diameter of 0.70 and minimum ratio of 0.25.

Orifice plates dimensions and calculations shall be in accordance with ISO 5167- latest edition

The flow range shall be selected such that normal flow rates are between 50% and 70% of the flow upper range value.

Material of construction of orifice plate shall be 316 SS except where this material is unsuitable for the service because of corrosion or erosion considerations, in which case an alloy shall be chosen whose corrosion allowance is equal to or better than line material. Orifice plates dimensions, finishing, flatness, tolerances for dimensions and identification information shall be in accordance with ISO standard. Orifice plate shall be provided with tab handle, which is welded on the orifice plate and engraved with following information on the upstream of the tab handle:

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 30 OF 113		

- UPSTREAM or UP
- Instrument tag number
- Orifice diameter
- NPS (Nominal Pipe Size) and ANSI flange class
- Material of the orifice plate
- DP range & Meter ( Flow) range

The tab shall also be in line with the Drain or Vent hole and shall indicate the direction of flow.

BIDDER shall submit the sizing calculations for orifice plates for review.

Pressure drop for orifice sizing shall generally be selected among the following values: 125, 250, 500, 625, 1250, 2500, 5000 and 10000 mm H<sub>2</sub>O with standard selection at 2500 mmH<sub>2</sub>O.

Orifice plates shall be installed on horizontal lines when practical. Vertical meter runs may be used for down flow of vapour and up flow of liquids.

Differential ranges for all liquid flow meters shall not exceed 5000 mm water. Typical ranges for gas, steam or vapor meters are as follows:

Static Pressure (in Kg/Cm <sup>2</sup> g)	Diff. Range (in mmwc)
0.35 to 2.5	500-1200
2.6 to 6	1250-2500
Above 6	2500-5000




Orifice bore with diameter less than 0.125" shall be avoided.

- 9.1.1 Flange taps orifice shall generally be used for line sizes 2" to and including 18". Above 18" line size, D and D/2 taps shall be used. Integral Orifice assembly with transmitter shall be used for line size 1 1/2 "or below (as per standard BS-1042)

Orifice assembly shall be provided with two sets of "Flange Taps" located in accordance with latest AGA standards. The orifice assembly shall be provided with jack screw for removal of orifice plate. In case of 2 out of 3 logic requirement, three transmitters shall be used. In such case six set of taps shall be provided in orifice assembly. Instrument tapping connections shall be 1/2"NPT (F).

- 9.1.2 Orifice flanges shall be in accordance with the ANSI B16.36, ANSI B16.36a and applicable piping specification. The minimum pressure rating of flanges shall be ANSI 300 lbs.

Flanges larger than 3" shall have a pair of jack-screws. The mating flanged shall be aligned in such a way that jack-screws will be diametrically opposite.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 31 OF 113		

## 9.2 Nozzles

ISA 1932 Nozzles may be used in high and medium pressure steam and BFW piping. Materials for nozzle element shall normally be AISI 316 steel unless special materials are required for the service. Dimensions and calculations shall be in accordance with ISO 5167-latest edition. Generally branch pipe is required with the nozzle the same shall be machined from higher schedule pipe than the one used for the service or forged branch pipe shall be used if higher schedule pipe is not available. The branch pipe bore shall be same as that of nozzle ID and shall have mirror finish.

## 9.3 Venturi Tubes

Venturi Tubes or nozzles as per ISO 5167-latest edition or similar type elements may be used to measure the flow of low pressure gases or liquids where loss of pressure is an important consideration.

## 9.4 Pitot Elements

Pitot Elements of the averaging type may be used where high accuracy is not required or the pipe diameter is too large for acceptable orifice plate design. Use of annubars shall be limited to combustion air, flue gas raw water and fresh water services unless specifically indicated. The annubars shall be extraction type with ball valves and pipe fittings required for installation. The connection size shall be 1 1/2" NPT. For rating 1500# and above the process connection size shall be 2" flanged.

## 9.5 Local Flow Indicator

Motion balance (Barton cell type) type differential pressure indicator shall be used for local flow indication. Body and internals shall be of 316 SS. Process connection shall be 1/2" NPT (F). 3-valve manifold with 1/2" NPT connection shall be used with the meter.

## 10.0 OTHER FLOW METERS




### 10.1 Mass Flowmeter

Coriolis type mass flow meter with local digital display of flow shall be used to measure the process flow where high accuracy is required. The sensing element shall be straight/U-tube, matl. 316 in general. For custody transfer applications all mass flowmeters shall be wet calibrated from certified NABL laboratory.

### 10.2 Vortex Meter

Vortex shedding meters may be used for wide range of flows for gases and liquids.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT</b>  <u><b>Bharat Coal Gasification and Chemicals Limited</b></u>  <b>Design Philosophy Instrumentation</b>	PC288/E/P-II/ SEC-5.2	0	 कोयला इंडिया Coal India	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev		
		Sheet 32 OF 113			

The measured flow shall be temperature compensated.

Insertion type vortex meter may be used in utility services for line size more than 6" in place of Pitot /Annubar/Pitot venturi tubes.

### 10.3 **Ultrasonic Flowmeter**

Ultrasonic flow meters (non- insertion probes preferred) based on the "time-of-flight" method shall be used. Meters based on the "Doppler" principle are less accurate and shall not be used. Ultrasonic flow meters shall be considered for large turn downs and where pressure drop is not permitted. Upstream and downstream straight lengths shall be as per applicable standard.

For all gas services flow meters, either being used as custody transfers, Flare flow measurement, Guarantee flow measurement purposes or for mass balance purpose, shall be 5-path, non-insertion probe type Ultrasonic flow meters based on Time-to-Flight measuring principle, having total RMS accuracy of +/-0.25% or better.

For flare, Ultrasonic insertion type 1 path, with accuracy of 2% and for Cooling water, Ultrasonic flowmeter (Clamp-on) with accuracy of 0.5% to be used.

### 10.4 **Electro-Magnetic Flowmeter**

Electromagnetic flowmeter shall be used for the measurement of flow with high accuracy for highly viscous and corrosive services. For custody transfer applications all electro-magnetic flowmeters shall be wet calibrated from certified NABL laboratory.

### 10.5 **Solid Flow Measurement**

For measurement of Feedstock (Coal/ Petcoke/ Flaxant), solid flow measurement with microwave type shall be provided.




## 11.0 **LEVEL INSTRUMENTS**

### 11.1 **External Displacement**

Displacer type level instrument shall be avoided and guided wave radar type or remote diaphragm seal DP shall be used in their place if suitable to process condition.

If unavoidable External displacement type instruments shall generally be used for small spans only, in specific cases it may be used upto a range of 84". The cage material shall normally be forged material conforming to the service requirements. Where the vessels are of alloy steel construction, the body material shall be



	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 33 OF 113		

equivalent or of a better material. The displacer shall be in stainless steel and the torque tube in inconel. If LVDT type transmitter in place of torque tube is selected then the range spring of such transmitters shall be Inconel and cannot be used for temp. more than 330 degree C. Process connections shall normally be 2" flanged with side-side connections.

For high temperature as well as low temperature and cryogenic services, torque tube heat insulation extension or torque tube extensions shall be applied. Radiation fins or extensions shall be used for temperature above 200 degree C or below zero degree Centigrade.




## 11.2 Guided Wave Radar/Non Contact Type Radar

Radar Level Transmitter shall be based on "Time Domain Reflectometry (TDR)". Radar Level transmitter shall be applicable for liquids or slurries, hydrocarbons too water- based media. In absence of dielectric constant for the process fluid, Bidder shall confirm the suitability of radar Level Transmitter for such applications and Bidder shall suggest the suitable model for the same. Bidder shall suggest the suitable model for Interface applications like oil on water, Hydrocarbon on water, etc. Electronics shall be capable of measuring upper liquid and interface level simultaneously. Selection shall be available for analog output signal from level transmitter corresponding to upper liquid or Interface. Process connections shall normally be 2" flanged with side-side connections. Process connection for top mounted Radar shall be 4" flanged. Still well shall be provided for all Radars level instruments. Material of wetted parts/sensor/Horn shall be SS 316 min or better as demanded by the process conditions. Chamber material shall be SS316 min. To avoid touching of probe to still well inside wall, centering disc or weight shall be provided at probe end. Material of centring disc or weight shall be SS 316 as a minimum or superior material. Grade level indicators shall be provided wherever Radar LT Display is not readable from grade. The transmitter shall have overfill protection as per WHG-19 standard. For solid measurements high frequency type Radar shall be used.

## 11.3 Boiler Drum Level Measurement

For drum level, following minimum measurements are envisaged:

- Bi colour/Magnetic Drum level gauge on both sides of drum.
- 3 Nos. differential pressure type drum level transmitters from 3 separate nozzles for (2oo3) trip signals.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 34 OF 113		

- (c) Hydra-step type (electric resistivity type) level instruments with both local indication and remote indication at CR/DCS shall be provided for drum level of steam drum. These shall be in addition to conventional level measuring instruments in compliance to IBR requirement.

All Instruments shall be spaced equidistance on the drum and shall cover maximum operating range of drum.

All level instruments shall be provided with same centre to centre distances.

For boiler drum applications special approval of IBR has to be taken for level instruments

## 12.0 LEVEL GAUGE GLASS

### 12.1 Gauge Glasses

Glass gauges shall be avoided and magnetic type level gauges shall be used if suitable to process condition. If unavoidable Gauge Glasses shall normally be reflex type for all process services, except for boiler drums bicolour types shall be used, and in corrosive services. Where transparent gauges with glass protection and illuminators shall be used, Illuminators shall be explosion-proof in hazardous areas.

Gauge glass columns will not exceed 1500 mm.

Transparent type gauge glasses (double glass) will be used for services in which a level may not be distinguishable, such as interface services, between different liquids, where mica shields are required and fluids of high viscosity or high solid content.

Level gauges shall be supplied with a pair of off-set shut off valves with ball check.

For cold services where temperature is below 0 deg C a non-frosting gauge will be used.




Glass tube level gauges shall be avoided.

Permanent platform shall be provided for level gauge above the height of 1.5m for maintenance & operation purpose.

## 13.0 PRESSURE INSTRUMENTS

### 13.1 Pressure Transmitters

Pressure Transmitters and differential pressure transmitters shall be modern inherent motion-free type. Bodies shall normally be in stainless steel with pressure elements in SS316. Pressure elements in austenitic stainless steel are requirement in hydrogen services. Two valve integral manifold of SS316 material in general shall be used with

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 35 OF 113		

pressure transmitters.

The signal transmission should normally be a 2-wire system and shall be capable of delivering rated current into external load of atleast 600 ohms when powered with 24 V D.C. Protection against short circuit and reverse voltage shall be provided. The transmitter shall be furnished with an digital output meter or gauge with a sq.rt. scale. Smart type transmitters will be used with Hart V protocol.. Process connection size shall be 1/2" NPT.

### 13.2 **Pressure Gauges**

Gauges for process and utility services shall be industrial SS Bourdon gauge/diaphragm or spring bellows type as per process requirement with the case in stainless steel. The gauge for 60 kg/cm<sup>2</sup> above pressure shall preferably be a safety type with solid front where pointer and glass are partitioned off from the sensor by a solid disc. Pulsation dampeners shall be installed with the gauges where pulsating pressure occurs. Process connection shall be 1/2" NPT (M) bottom in general. Bezel rings shall be screw on pattern. Dial Size minimum 150mm.

Blow-out discs are required for all pressure gauges except for instrument air services.

Vibration proof gauges or remote seal type shall be used if the surrounding environment is subject to vibration.

### 13.3 **Pressure Switch**

Direct mounted pressure switches shall not be used and transmitters shall be used.




### 13.4 **Diaphragm seal**

Diaphragm seals of the filled or mechanically type shall be furnished where plugging of the element may occur due to congealing and high viscous fluids or where suitable sensor material is not available in highly corrosive services.

Remote Seal PT/DPT shall be with minimum 5 mtrs Capillary with SS armoured in PVC sheath of Protection with DRIP RING and with Ball type Isolation Valve. For Vessel/Equipment requiring more than 5 mtrs capillary electronic remote seal (ERS) shall be provided.

All catalyst vessel's dP measurement shall be with ERS (electronic remote seal).

DP transmitters with diaphragm seals are envisaged, where condensing leg required to be filled in normal DP transmitters, at all those locations, remote seal type DP transmitters are to be used.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT</b>  <u><b>Bharat Coal Gasification and Chemicals Limited</b></u>  <b>Design Philosophy Instrumentation</b>	PC288/E/P-II/ SEC-5.2	0	 कोयला इंडिया Coal India	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev		
		Sheet 36 OF 113			

Also, wherever there is a control and interlock on level measurement, one transmitter shall be remote diaphragm seal type and one will be guided radar type with Material : Minimum Inconel. Guided Wave radar may be used for non-critical applications.

## 14.0 TEMPERATURE INSTRUMENTS

### 14.1 Thermocouples

Thermocouples shall normally be the sheathed type with high purity magnesium oxide insulation. The hot junction shall be isolated from ground. Sheath diameter shall normally be 6mm (1/4") Inconel 600 sheath material shall be used for design temperatures above 400 degree C, whereas ordinary SS material can be used below 400 degree C. The nominal wire diameter shall be approximately 0.19 x sheath OD.

In general type K thermocouples shall be used according to IEC 584. All temperature elements shall be duplex type, one connected and the second one shall be used as spares.

Skin thermocouples as well as multipoint thermocouples shall be used for equipment shell temperature measurement as per requirement.

The type of thermocouple shall be selected based on the following guidelines as minimum:



Copper-Constantan (ISA-Type-T)	(-) 200 to 200°C
Chromel-Constantan (ISA-Type-E)	(-) 200 to 600°C
Iron-Constantan (ISA-Type-J)	(-) 40 to 750°C
Chromel-Alumel (ISA-Type-K)	(-) 180 to 800 °C
NiCrSiI - NiSiI (ISA-Type-N)	0 to 1200 °C
Platinum Rhodium-Platinum (ISA-Type-S or B)	600 to 1600°C

### 14.2 Resistance Temperature Probes

Resistance Temperature Probes shall be considered for applications where very narrow spans and high accuracy are required as well as low temperature service.

They shall be 6mm (1.4") stainless steel sheath type similar to the thermocouples and with a Pt 100 ohms (0 degree C) element.

The sensors shall be duplex type and shall be spring loaded for vibration proof.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 37 OF 113		

The elements shall confirm to DIN 43760/IEC 751. The nominal wire diameter shall be approximately 0.19 x sheath OD

#### 14.3 **Temperature Transmitters**

Temperature transmitters shall be Remote mounted type (on 2" Pipe), Smart with latest HART protocol and integral digital output meter.

Head mounted transmitters shall not be used.

Conventional transmitter shall have universal input for thermocouple / RTD and output 4-20mA DC for 2 wire system.

Transmitter output signal shall be linear and directly proportional to the measured temperature with overall accuracy as mentioned in Annexure-1 Transmitter shall have automatic cold junction compensation for thermocouples.

Burnout protection (selectable Up Scale / Down Scale) must be provided for temperature transmitters.

Temperature transmitters shall be provided for all temperature elements in closed loops and loops connected to PLC/Interlocks.

No temperature switches are to be used. The same is to be achieved through transmitters which shall be directly connected as analog input to DCS / PLC.




#### 14.4 **Thermometers**

Thermometers shall normally be bi-metallic, heavy duty, weatherproof (IP 65), adjustable angle connected type with 150 mm dial as a minimum, dials of smaller size may be used for auxiliary services on machinery.

Liquid filled indicators will be used only where indication is required to be remote. Case and stem shall be in stainless steel. Dials shall be of white, non-rusting metal with black figures.

For local temperature control upto a maximum scale range of 530 deg C, liquid filled sensors with capillary extension shall be used.

Filled system instruments when used shall be fully compensated for ambient temperature variations.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 38 OF 113		

Capillary shall be SS armoured and length of which will not generally exceed 3 mtrs.

14.5

### Thermowells

Flanged thermowells shall be of 1 1/2" size. screwed thermowells shall be of 1" NPT(M). Flanges rating, facing and material shall be in accordance with the equipment or piping standard.

Thermowell material in general shall be of AISI 316 SS.

Special thermowell with purged termination box shall be provided for multipoint thermocouples.

Immersion length of thermowells for different line sizes shall be as follows:-




<u>Line Size</u>	<u>Immersion length (U)</u>
4" to 6"	280 mm
8" and above	320 mm
Vessels	400 mm

Immersion length is based on 200 mm length between flange face and inner well of pipe and approx. 60% insertion in the pipeline. In vessels, where fouling with vessel internals is expected, the immersion length shall be suitably modified. Other sizes and immersion lengths may be considered based on special condition/actual requirements.

The design of the wells shall be verified by means of stress analysis, resulting from stream velocity condition. The wake frequency shall not exceed 70% of the thermowell natural frequency. Wake frequency calculation is required for all thermowells. Bidder has to submit Wake frequency calculations for all thermowells as per latest PTC 19.3. Velocity collars shall not be used.

Cases wherein thermowell fails stress and WFC, modifications as mentioned below in order to pass thermowell in their order of preference shall be followed:

- Material: Alternative material with increased mechanical properties shall be considered.
- Insertion Length : Reduce immersion length into pipe or standoff height gradually

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 39 OF 113		

to reduce unsupported stem length ( Follow min 80mm insertion length in this case as well )and increase Thermowell thickness accordingly.( Response time shall not be affected by increasing T/W thickness)

- c) Tip Dia: Increase tip diameter of thermowell (Same shall be within limits as per latest PTC 19.3 standard)
- d) Root Dia : Increase root diameter of thermowell (Same shall be within limits as per latest PTC 19.3 standard)
- e) Fillet Radius : Increase fillet radius to improve strength .

Only when, after making the above modifications, if T/W fails stress and WFC, T/W with Scruton/hellical design with following specifications shall be provided :

- Construction of Thermowell shall be flanged ,drilled bar stock (Solid machined)and tapered .

Welding design of helicals on Scruton Thermowell is unacceptable.

- Design and Calculation of Scruton thermowell shall be based on latest ASME PTC 19.3 .




Straight thermowells shall not be provided in any case.

## 15.0 CONTROL VALVES

Valve types shall be selected, pneumatic diaphragm/piston operated globe, ball or butterfly shall be selected taking into account such factors as piping, operating and design conditions, fluid being handled, tangibility required, allowable leakage, noise and other special requirements.

The valves shall have SMART electropneumatic positioners with latest HART protocol.

Seat Leakage shall be chosen in accordance with process demands and safe operation of the plant and in accordance with AISI B16.104-1976. However, in general, the globe valves used shall be of class IV leakage minimum as per ANSI B6.104 in general. For vent services the leakage class shall be class V or VI depending upon process requirement.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 40 OF 113		

Noise abating devices shall be provided with valves where noise level at the outlet of valve at a distance of 1 metre all around is more than 85 DBA for valve which have operating times of 5 minutes or more in general and which are only working during start up and in upset conditions. For continuous operation the allowable sound level shall be 85 dBA. All noise abating plates, expanders, flanges, gaskets, studs & nuts shall be in the scope of valve manufacturer. The noise abating plates shall be of wafer design for easy removal for maintenance. Source treatment for noise shall be preferred over path treatment and for high noise vent applications “DRAG” type trim shall be specified.

All valve bodies shall be cast or forged. Stainless steel bodies shall be acceptable in place of alloy steel bodies, if not available, for low temperature application.

On line replaceable trims shall be considered for all high pressure valves of butt-weld or socket weld connections.

Split body design for ball valves acceptable where top entry ball design has not been considered for economical reasons. Mufflers shall be provided on ball valve vent air lines for noise suppression. Spring loaded seat and hard chrome plated ball shall be a standard feature for ball valves, in general.

All valve actuators shall be selected for a minimum operating air pressure of 4.0 kg/cm<sup>2</sup>g. The actuators shall be diaphragm or piston actuators in general. Diaphragm actuators with single or concentric multi-springs shall be used. Volume tank with airlock relay, booster relays shall be avoided as far as possible.




Rotary rack and pinion pneumatic actuators may be used with ball and butterfly valves for on-off services.

In general, if otherwise not specified in the valve data sheet the time for full travel shall not exceed 10 seconds.

Wherever handwheel is required with a valve the same shall be side mounted type.

All split range functions for valve operations shall be carried out in DCS and split range provision in valve positioners shall not be necessary.



	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 41 OF 113		

Butterfly valve bodies shall be of wafer design. Lug type body shall be considered for size above 12". Face to face dimensions shall conform to ANSI B 16.10 and ANSI B 16.47 wherever applicable.

Butterfly valves shall be used for high flow, low pressure drop below 10 kg/cm<sup>2</sup>g.

All instrumentation control and on/off butterfly valves shall be triple offset type only.

Non destructive test like radiography, ultrasonic, die penetration and magnetic particle shall be carried out for cast and forged bodies conforming to procedures laid down in ANSI B16.34. Radiography or ultrasonic test, if not specifically mentioned in the data sheet, shall be carried out for cast or forged bodied of rating 900 lb. or above.

Valve bonnets shall be in general of bolted bonnet design as per ASME B 13.3 par 307.2 with minimum four bolts.

Smart E/P positioners with position transmitter along with valve signature software to be provided for all control valves. The software shall be provided for remote configuration and diagnostic analysis too.

Actuator sizing shall be done at 4 Kg/cm<sup>2</sup> and shall be designed with 1.3 times factor of safety.




Handwheel (Side-mounted) for all regulating control valves shall be as per process requirement and licensors's recommendation.

By-pass valve provision shall be as per process licensor requirement.

The control valve % opening shall be at minimum flow 10-20%, for normal flow 50 to 70%, for maximum flow 75 to 85%.

All on – off application valve shall be fixed with necessary limit switches.

Valve Sizing shall be used on a maximum flow rate of approx. 1.5 time normal flow or 1.3 times the max. flow, whichever is greater, and the process conditions that exist at the increased flow (Pressure and differential pressure). Valve lift shall be approximately 70 % for equal percentage and 60 % for linear characteristic plug design at normal flow. It shall be checked that the calculated and the selected valve

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 42 OF 113		

also covers start-up and stop conditions. In cases where over sizing shall not apply, it will be specifically mentioned in the Instrument Data Sheets.

The fluid velocity at outlet flange shall not exceed 6 m/sec for liquids whereas the velocity of gas or vapor shall not normally exceed 0.3 Mach under operating conditions. To meet this, valves shall be selected having reduced trim, labyrinth plug or cage trim as manufacturer standards.

Bidder shall submit the sizing calculations for all control valves.

Face to face dimensions of the control valves shall be as per ANSI/ISA-S75.03 latest edition.

Direction of flow indication shall be engraved or embossed on the body.




Stroke time of the antisurge valves shall be 2-3 seconds and for critical services shall be as defined by process licensor or as mentioned in individual data sheet.

#### 15.1.1 Control Valve Test and Inspections

Valves shall be tested in accordance to individual specification which shall cover but not limited to:

- Visual Inspection and dimensional check
- Liquid Penetrants examination on stellite coating as per ASME B16.34 ann D.
- Radiographic, ultrasonic, magnetic particle as per ASME B16.34
- Hydrostatic Body Test - Duration 3 min. (including all parts in assembled condition like body, gland, all joints)
- Impact test
- Seat leakage test as per ANSI B16.104/FCI 70.2
- Performance tests and Functional tests
- Leakage test from actuators and seals and packings
- Diaphragm head test
- Complete actuator leak test
- Helium leak test for control valve with bellow seals
- Stroke calibration
- Stroke speed test

#### 15.2 Limit switches / Position Switches:

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT</b>  <u><b>Bharat Coal Gasification and Chemicals Limited</b></u>  <b>Design Philosophy Instrumentation</b>	PC288/E/P-II/ SEC-5.2	0	 कोयला इंडिया Coal India	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev		
		Sheet 43 OF 113			




- 15.2.1 All type of limit switches shall be 2 wire, proximity type, intrinsically safe certified. Limit switches shall be provided both for close and open positions for all shutdown valves.
- 15.2.2 The sensor shall be generally cylindrical NAMUR sensor type proximity switch. The diameter and sensing range shall be selected based on application.
- 15.2.3 The MOC of sensor shall be SS316..
- 15.2.4 All limit switches sensor shall be adjustable with the threaded length and check nut arrangement.
- 15.2.5 Flying lead type loose connections for NAMUR sensors are not acceptable. All these NAMUR sensors installed on any instruments to sense the position shall be housed in a closed box certified for weatherproof to IP65. The gland size shall be ½” NPT(F).
- 15.2.6 All ON-OFF type application valves taking in part in interlock/shutdown shall be provided with Open and Close type NAMUR sensor as limit switches. The sensors along with enclosure shall be installed in control valve in such a way that it can be removed with ease for maintenance.

### 15.3 Actuators




- 15.3.1 Generally, control valve actuator shall be of the spring and diaphragm, pneumatically actuated type. Standard air control signal to positioner shall be 0.2 to 1.0 kg/cm<sup>2</sup>g. For larger dP shut offs, higher spring range/higher areas shall be considered.
- 15.3.2 Piston type actuators (spring return type) with or without fail-safe capacity tanks (minimum of 2 strokes to be possible in case of air failure) shall be considered for high-pressure drop services or if actuator force requirements fall beyond the normal range of diaphragm actuators. All actuators shall be adequate to fully stroke the valve under the maximum differential pressure specified by the process requirements.
- 15.3.3 Air filter Regulator filter to be 5 micron. Miniature type, plastic body & drain assembly etc as parts of air filter regulator are not acceptable.
- 15.3.3.1 Actuator / Positioner make shall be as per approved vendor list or valve OEM make.

### 15.4 Motorised Actuator (MOV)

- 15.4.1.1 Each MOV actuator shall include the motor, actuator unit, gears, position indicators, limit switches, hand wheel, electrical starter and controls, terminal box etc. as a self-contained unit. The actuator shall be sized to provide adequate torque and / or thrust to ensure the complete intended travel of the valve under the worst operating and electrical power supply conditions.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 44 OF 113		

- 15.4.1.2 The enclosure of the complete MOV actuator including motor , integral starter, control transformer unit and all control devices shall have minimum IP-65 degree of ingress protection.
- 15.4.1.3 Direction of operation of the hand wheel / wrench shall be in clockwise direction while closing the valve.
- 15.4.1.4 Motor:-
- 15.4.1.5 3 –Phase squirrel cage induction type unless specified otherwise in the data sheet. It shall have totally enclosed non-ventilated construction.
- 15.4.1.6 The motor shall be provided with thermostat / thermister embedded in the hot spots of motor winding for protecting the motor.
- 15.4.1.7 The motor shall be able to operate the actuator at 75% of rated voltage.
- 15.4.1.8 The motor shall have class “H” insulation with temperature rise limited to class “B” limits.
- 15.4.1.9 The rated torque output of electric actuator shall be at least 1.3 times the break torque required to operate the valve under max. Differential pressure corresponding to the valve class rating. [Vendor shall submit the break torque of the valve & rated torque output of selected actuator for each MOV].
- 15.4.1.10 Encoder for Position sensing.
- 15.4.1.11 Torque and Travel Limit Switches: Electronic torque limit switches shall be provided to protect the motor over-loading by cutting-off the power supply to motor during opening and closing operations. The switches shall be provided with requisite number of potential free contacts for valve actuator operation and for indication on remote panels as specified in data sheet. Instead of mechanical torque limit switches, magnetic pulse counter / encoders to measure and control the stroke of actuator shall be provided, wherever this feature exists in the manufacturer’s design
- 15.4.1.12 Control Facilities:  
The internal controls and monitoring circuits shall be incorporated within the integral starter along with transformer and control unit of valve actuator. Following remote control and monitoring facilities are to be provided as a minimum:-
- MOV open command
  - MOV close command
  - MOV open status indication
  - MOV close status indication

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 45 OF 113		

➤ Position status of Remote / Local / Off selector switch

Remote control facilities shall be provided for all the actuators. The remote control circuits shall be powered from internally derived control supply voltage. In order to cater to remote control and indication requirements for “Position of Remote / Local / Off selector switch” an additional Monitoring relay / auxiliary relays shall be provided as a part of the valve actuator. As an alternative , a common status contact indicating the availability of the MOV actuator for remote control may be provided by the monitoring the following :-

- Loss of one or more phase of power supply
- Loss of control circuit supply
- Selector switch in local mode
- Local stop push button set to “OFF”
- Motor thermostat tripped
- Any other local fault / abnormal condition

15.4.1.13 **Hand operation:** - A hand wheel with hand / auto lockable lever shall be provided for emergency operation of the MOV. The energisation of the motor shall automatically re-engage power operation

## 16.0 PRESSURE REDUCING AND DESUPERHEATER STATION

16.1 Desuperheater design shall ensure that temperature at the outlet shall be maintained within + /- 5 deg. C of desired outlet temperature, unless otherwise specified by the Licensor.




16.2 Separate liquid injection valve and steam valve, if provided must be installed along with block and bypass valves.

16.3 The body and trim material of construction shall be suitable for the service. In general trim including spray nozzle shall be fully stellited.

16.4 The PRDS/ DS in steam application shall be IBR certified including valve in boiler feed water line.

16.5 The CV shall be calculated in accordance with manufacturer’s calculation procedure and selected based on following points:

- Valve sizing shall be based on the maximum capacity of 1.25 times the normal flow or 1.1 times the max. Flow, whichever is greater.
- The minimum flow capacity shall be suitable for rangeability of 30:1. The valve stroke shall not be less than 20% opening at the minimum flow capacity.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 46 OF 113		

- Fluid velocity at the outlet shall be selected suitably in consideration of the property of fluid, the differential pressure of the valve and the line size etc.
- Noise level at 1 meter downstream of DS and at distance of 1 meter from the pipe surface at normal flow shall not exceed 85 DBA.

16.6 A manual operator, limit switch, solenoid valve or any other auxiliary devices shall be provided.

16.7 Mfr. Standard manual operator / Hand wheel shall be provided.

16.8 Direction of flow shall be permanently affixed on DS body.

## **17.0 PRESSURE RELIEVING DEVICES**

### **17.1 Pressure Relieving Devices**

All Pressure Relieving Devices shall be sized in accordance with applicable local and national code requirements. Formulas shall be in accordance with API RP 520, 1990 and ASME Codes section I and VIII.

Percent Overpressure and Accumulation used in calculation of sizes of relieving devices shall be:

Overpressure


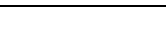
- 3% - Steam services where ASME Power Boiler Code applies.
- 10% - Gas or Vapour service.
- 15% - For liquids and pump discharge lines with 6% system accumulation (Power Boiler Code) and with 10% system accumulation (Pressure Vessel Code)
- 21% - Fire exposure on unfired pressure vessels.
- 10% - Liquids for thermal relief of pipelines or vessels Accumulation
- 10% - Gas , Vapour and liquid where ASME Pressure Vessel Code applies
- 16% - Gas , Vapour and liquid where ASME Pressure Vessel Code applies and the system is protected by means of multiple valves.

### **17.2 Nomenclature**

Nomenclature used shall be in accordance with API RP 520.

### **17.3 Safety and Relief Valves**

Safety and Relief Valves shall normally be direct spring loaded type.

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		Document No.	Rev	
		Sheet 47 OF 113		

Balanced bellows valves shall normally be furnished for relief into closed flare and slowdown systems, if the developed back-pressure exceeds 10% of the set pressure. Bellows shall also be specified where leakage of gas from the seals are not permitted during normal plant operation.

Steam jacketing may be considered necessary to keep some valves and lines warm at all the times to avoid the solidification of the lading fluid.

Full nozzle types of valves shall be specified for sizes 1" or above. Nozzle and disc MOC shall be SS316+stellited as a minimum requirement

Test gags shall be furnished on all safety and relief valves. Test gags shall be removed and transferred to Owners possession after testing, clearly labelled with the tag number of the valve.

Lifting levers shall be furnished for exposed spring bonnets on valves on steam and hot water services, on air valves and hot water service valves with closed bonnets.

Bonnet construction shall be plain closed bonnet for toxic and inflammable gases as well as vapour and liquids. Exposed bonnet shall be specified for steam service and in Boiler feed water service above 200°C. Bonnet extension shall be used above 400°C.

Springs shall be of carbon steel for normal process operating temperature of (-) 25°C to 200°C and tungsten alloy or high temp. alloy steel above 200°C. Stainless steel spring may be used for services below (-) 25°C. Carbon steel is permitted above 200°C for open bonnets.

Blowdown shall be between 5% to 7% for gas service and 10% for liquid service. For steam services under Power Boiler Code as per ASME the blowdown shall be 3% - 4%.

All connections shall be flanged in general with facing and rating in accordance with the piping specification or API 526 whichever is higher.




Centre to Centre dimensions shall be in accordance with API 526.

#### 17.4

#### **Rupture Discs**

Rupture discs may be used in lieu of or in combination with safety and relief valves, where applicable or required. For disc rupture trip or alarm disc shall be with bursting sensors. Rupture disks shall be sized and specified in accordance with API RP 520 or ASME sec. I & VIII. Any restriction in the discharge area caused by the disc holder



	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 48 OF 113		

assembly shall be considered in the calculations. Orifice calculations and corresponding selected body sizes shall be submitted for review.

Rupture discs shall be reverse buckling and non-fragmenting type, in general and shall be supplied in pre-torque holder assembly which shall fit inside the inner diameter of the bolt circle of standard flanges. Disc and holder material shall be SS316 min or better and shall be compatible with the process fluid & bursting requirements.

Rupture disc devices shall be supplied as a complete unit i.e. disc holder and the required number of discs. The scope shall also include pre-assembly screws, jackscrews, companion flanges, studs, nuts & gasket. For vacuum service, vacuum supports shall be provided. Retainer ring shall also be provided to hold the vacuum support & rupture disc in place.

#### 17.5 **Pressure and Vacuum Relief Valves**

Pressure and Vacuum Relief valves for storage tanks shall normally be of the weight loaded or pilot operated type, and sized in accordance with API RP-2000 Tank Venting Code, or Local Codes if they govern.

#### 17.6 **Thermal Relief Valves**

For thermal relief of accumulated liquids in pipelines and vessels shall be used in general. Thermal relief valves shall be flanged type

#### 17.7 **Centre-to-Face**



Centre-to-face dimensions shall be in accordance with API 526.

#### 18.0 **SOLENOID VALVES**

Solenoid valves shall normally be used to actuate other instruments/valves connected directly to the process. The SOVs shall be direct acting type. Protective enclosure shall be IP 67 and the coil insulation suitable for continuous operation in 85 degree C ambient temperature (max. surface temperature in sun) for outdoor service. All SOV's body, trim, coil housing and spool piece MOC shall be SS316 only Solenoid valves will be powered by 24V DC, and insulation class 'H'. The D.C. solenoids shall not have in built rectifier to operate with A.C voltage. The d.c. solenoids shall be used as an alternative to A/C solenoids only for low current intrinsic safe operations.

All solenoid valves shall be fitted with 1/2" NPT (F) SS316 double compression, IP-65, EExd cable gland connection



	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 49 OF 113		

## 19.0 CONTROL AND SHUTDOWN SYSTEM

### CONTROL AND SAFEGUARDING DESIGN CRITERIA

#### EXPANDABILITY

Systems shall be designed with 20% installed pre-wired spare capacity for all I/O type cards of each category for project development. The sparing supplied shall be for “complete loop”; i.e. corresponding marshalling, power supply, terminals/barriers, interposing relays, pre-fab cables other accessories, etc. and its space, and panel cut outs where appropriate, etc.

To allow for future expansion 20% spare capacity shall be allowed & terminated in multi core cables, junction boxes, marshalling racks, etc.

Communication networks and cables shall have a spare load capacity of 50% as a minimum.

Plant wide networks shall have a node connection spare allowance of 50 % as a minimum.




Local networks shall have a node connection spare allowance of 20 % as a minimum.

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The control system shall be a modern Digital Distributed Control System (DCS) located in the Control Room. The system shall be reliable, fault tolerant and build up in modules from the suppliers’ standard components and software. The system shall have facilities for plant control monitoring and alarm handling. It shall be self-diagnostic, self documenting and contain all the functions necessary for advanced regulatory control.

The control system shall comprise racks with I/O devices, control cards, CPU cards, hard disk, system buses, and a sufficient number of operator stations with Large Videos Screen (LVS) of 70” with dynamic graphic generation capabilities to ensure complete access to the process during normal operation, start-up, and upset conditions. The operator shall use dedicated operator keyboards to manipulate the DCS.

The DCS shall have the following main components. Detailed specifications of each of them are given in subsequent sections. The system shall be 100% fault tolerant and dual redundant, except the redundancy at I/O cards levels. This means, all central control processors, all communication processors and all other central rack and individual node’s common cards, all the communication cards, networks and

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 50 OF 113		

cables, etc. shall be 100% fault tolerant and dual redundant, except individual IO cards of the system. All the system hardware of DCS shall have ISA G3 level corrosion protection. Since redundancy at I/O card level is not envisaged, the failure of a single card from complete system shall not affect more than the I/Os supported by that particular I/O card. It means all the hardware except I/O cards shall be 100% fault tolerant. All the hardware including control/communication processors, networks, cables, all type of system cards, all type of I/O cards shall be hot replaceable.

The DCS will be housed in a control room designed strictly in compliance with the requirements for electronic instrumentation.

Necessary hardware and software shall be provided with the LVS for connectivity to the DCS system. Provision for projecting any of the screen from DCS OS/ES to screen of LVS shall be provided.

Facility of projecting a particular display on a selectable area of the screen upon activation of a predefined event shall be provided.

Master Control Unit- Master Control unit shall be provided for controlling this LVS in control room.. It shall be capable of projecting HMI displays over a part a part of screen to multiple screens. Any configuration of windows shall be possible. Facility for overlay shall be provided. Minimum Hardware Specs of Master Controller as follows:



## 19.2 DCS Functions

The DCS will perform, as a minimum the following functions:

- Data Display
- Process Control
- Process and system alarms
- Logging
- Real Time trends & Historical trend
- Dynamic Graphics
- Report Generation (shift, daily, weekly, monthly and on demand)
- System diagnostics

## 19.3 Data Storage and Retrieval

Data storage and retrieval will be provided on hard disc and on DVD or DAT. The trend shall be recorded as follows:

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 51 OF 113		

Analogue signals

Last hour Every 1 second.

Last 24 hours Every 1 minute.

Last 30 days Every 1 hour

Last 1 year Shift averages

Last 2 years Daily averages

Alarms Last 48 hours (Minimum)

#### 19.4 **DCS Operator Interface**

For Details of OS/ES please refer Annexure -3 System configuration.

##### **Other Devices**

2 Nos. Set of emergency push buttons to be engineered and wired to Emergency Shutdown System

1 No. Interface for ESD (redundant)

1 No. Interface for machine monitoring system (redundant)

2 Nos. Ethernet connectivity (spare)



2 Nos. Modbus connectivity (spare)

#### 19.5 **Process Controller Cabinets**

The process controllers will contain the microprocessor based system capable of combining continuous, sequential and discrete functions in order to the requisition of analog and discrete signals, sequential and continuous control.

The process controller cabinets shall/may have incoming and outgoing cable marshalling facility. All field cables shall be terminated in marshalling cabinets in single tier cage clamp type terminals. Isolators shall be provided for all intrinsic safe input and outputs. All thermocouple signal wiring from terminal to respective isolator/input card shall be through field mounted temperature transmitter. Head mounted temperature transmitter shall not be used.

The signal I/O cards may also be installed in Process Controller Cabinets. Some marshalling/I/O racks may be installed in remote safe areas by extending the system bus, especially in MCC rooms where lot of inputs from drives shall directly be terminated in the marshalling I/O racks.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 52 OF 113		

## 19.6 DCS Redundancy Philosophy

In order to increase the system availability and then the continuity of plant operation, redundancy shall be provided as follows:

100% fault tolerance and dual redundancy in DCS shall be for Controller cards, all communication cards and buses, all control buses, all type of common cards in the system, all power supply modules, all I/O modules for closed loops and interlock I/Os, buses, Ethernet modules. The failure of any single I/O module for open loop shall not affect more than the channels being catered by that particular I/O card. Dual redundant power supply modules for each dual redundant controller shall be dedicated.

Redundant communication from controller to IO cards shall be criss-cross so that failure from one card or controller shall not affect the other cards connected with that controller and vice versa

## 19.7 Multiloop Controllers and Input/Output Cards

All multi loop shared controllers will be redundant with 1:1 redundancy. The control processors shall be of fault tolerant type and both shall be active with cyclic changeovers. All I/O cards for close loop applications shall be capable of holding the last value in case of open condition of input. Input cards for specific open loop inputs used for calculation functions must also be capable for holding the last value. As otherwise the same function shall be built up in DCS software.

### 19.7.1 I/O Segregation:




The I/O card segregation for DCS shall be. Additionally, if there is more than 1 machine in one section/unit of the plant, all type of I/Os for diff. machines shall be segregated at I/O module level. This means one I/O module shall not cater to I/Os of more than one machine, within same section also.

### 19.7.2 Controller Loading




Each Controller loading shall not exceed more than 50% (hardware and software load of each controller) in any case, after implementation of complete project and running at peak load. In case more controllers are required to meet 50% loading criteria, CONTRACTOR to include additional controllers without any cost implication.

### 19.7.3 DCS/ESD requirements

- a) All DCS/ESD systems' all cards shall be supplied with ISA G3 level or equivalent coating for environmental protections.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 53 OF 113		

- b) All digital output from DCS and ESD shall drive interposing relays of OMRON make, 4 Change over (4 NO/NC) with socket mounted relays with LED indicators and built in surge suppressor. The contact rating shall be minimum 230 V AC/ 5 amps. Any DO Channel from DCS/ESD shall not be directly connected to any devices without interposing relays.
- c) DCS shall be a large and expandable type system available with the vendor.
- d) Vendor to provide unit performance monitoring for DCS and the following functions are required:
- Material and Utility Balances
  - Unit production and utility (steam, fuel, and electricity) balance calculations and (periodic) reporting.
  - Process Performance Monitoring
  - Energy consumption related to production. Monitoring and reporting of final product Qualities.
- e) The system architecture shall be compliant to IEEE 802.XXX with dual redundant and 100% fault tolerant. System shall be fully open with DDE/OPC&ODBC compliant. System availability shall be better than 99.999%.
- f) One OPC server shall be provided with DCS/PLC system with OPC connectivity to ERP/MIS system/data exchange. Vendor shall also provide necessary software / hardware (OPC server & software) and manpower support / assistance for establishing connectivity of the system with ERP & other systems.
- g) Real Time data base Management System (RTDBMS):
- The LSTK vendor should supply and commission Real time Data Base Management system (RTDBMS) to collect plant data (Set values, Actual values, Control valves openings, Modes etc) on real time basis from individual process plants DCS / PLCs system, online plant analysers, etc. The RTDBMS system should be able to store, maintain and retrieve plant history data for a period of at least 24 months. The system should capture and store unlimited number of tags (Process tags, Manual tags, Calculated tags etc.) without any limitation on the software.
- It shall have web enabled Graphical User Interface (GUI) for viewing remote plant graphics, mining, trending, analysing large volume of real-time and historical time series process data on at least 25 PCs connected in network for remote monitoring of plant performance.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 54 OF 113		

The database should be compatible to run various multivariable controllers and conventional APC controllers. The vendor shall provide the list of such controllers along with their supplier's name.

The trending package should have variable time scale (15.min/hourly/bihourly, daily etc) with scale adjustment for individual tags.

The system should accept queries with conditional statements that will give the values/values of the tag/tags when the condition is fulfilled.

System should provide a utility to configure virtual tags to store values depending on the logic assigned to the virtual tag.

Database must provide on-line functions to add new tags or modify existing tag attributes and scan frequency without having to rebuild or reinitialize the system and these new tags or modifications should be automatically invoked.

Database should provide statistical analytical tools with various forms of reductions over a specified time period. These reductions should also include minimum, maximum, average, standard deviation, difference, total and rolling averages.

RTDB RDI should be compatible with various latest types & version of DCS.

- h) Complete Advance Process Control (APC) optimization system with hardware / software shall be implemented for complete Plant. Minimum Hardware / software shall be as per following:

Minimum Hardware / software

- Online Server Raid-5 (1 No.)
- Offline Server Raid-5 (1 No.)
- APC Software with 1 license
- Separate OPC communication server Raid-5 1 no. for implementing APC
- Latest Windows server Software/ MS office, Acrobat
- Any Other software and hardware needed to implement the APC.
- Firewall, if applicable



- i) DCS and ESD I/O cards channel density shall be as per following:

I/O cards' Channel density shall not exceed the following limits

Analog Input 16 Channels

Analog Output 16 Channels

RTD/T/C Inputs 16 channels

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 55 OF 113		

Digital Input 32 Channels

Digital Output DCS-32 Channels /ESD-16 Channels

- j) All I/O cards in individual category shall be of same type/model/revision only. No diff bulk I/O cards or I/O cards with degraded features shall be accepted in any of the category in a mix mode supply.

k) ISOLATIONS

Analog I/Os to Field : Galvanic Isolation through safety barriers

Analog I/Os Module : Channel to Channel Galvanic Isolation

If individual channel to channel isolation is not available with DCS/ESD vendor, then only Isolation shall be provided in a group of 4 channels as per DCS/ESD vendor design.

Digital Input to Field: barriers + optical isolators on cards.

Digital Output to Field: Interposing relays + smart barriers for monitoring purpose.

l) PANELS:

All panels shall be either 1200 mm (wide) x 800 mm ( depth) x 2100 mm ( height) ,




Panels shall made of Industrial grade material- Grade D as per IS 513, (Thickness- Door 2mm, side panels, top cover, bottom cover, rear cover, bottom cover 1.5mm thick, Mounting plate 3mm, gland plate 1.5 mm) manufacturing as per IEC 62208 standard and mechanical impact resistance as per IEC 62262 protection class and option for two levels of mounting inside enclosure and option for baying. Panels should have a temperature withstand range from -30 degree to 80 degree without any change in properties and avoids entry of external substances/ dust/ water. Complete panels/enclosures for project plant shall be RoHS compliant, UL certified and shall be tested/certified according to UL 60950-1 standard, IEC 61439-1 standard, UL508A standard and IEC 60297-3-100 standard

Surface finish shall be RAL 7035. Enclosure Corrosion protection shall be provided as per EN-IS 12944-6/ DIN 55634 standard. All Panels shall be IP65 certified

This applies to all types of instrument panels to be used in the whole project like various PDB, Electrical / Instrument panels, Third party device panels like digital governors, Machine monitoring system hardware panels, etc.

Fan-and-filter units with diagonal fan technology shall be used. The Fan must have



	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 56 OF 113		

UL approval and shall have air flow volume as per cabinet requirement

For Outdoor cabinets mounted in non-AC areas, Energy efficient panel AC shall be provided with fully wired ready for connection (plug-in terminal strip) Protection category for Panel AC shall be minimum IP-54. For Chemical / Corrosive area, Panel AC shall be suitable as per environmental condition with protection category UL type Nema 4/4X.




- m) PLC (ESD) and DCS marshalling panels shall be separate. PLC (ESD) and DCS system hardware cabinets shall also be separate.
- n) All A/D converters and D/A of system I/O cards shall have resolution of min. 13 bits
- o) There shall be 20% installed spares minimum 1 no., installed and wired capacity for I/O cards of each category in DCS, including all peripheral termination modules, prefab cables, Relays, Safety barriers, etc
- p) All marshalling and system panels shall have minimum 20% wired spare capacity for future expansion (should be possible with the same wiring philosophy).
- q) There shall be time synchronization facility available in DCS for diff. other sub-systems like ESD, SCADA, etc. In this case DCS clock shall remain a MASTER clock and it will synchronize all other sub systems of the plant.

#### **DCS System Redundancy**

Following system redundancy shall be available as a minimum.

- a. Controller : 1:1 (Criss-cross)  
(CPU for control, I/O communication, network communication)
- b. Input / output cards : Redundant  
closed loops
- c. Communication Bus : 1:1
- d. I/O communication modules with CPU : 1:1  
(I/O bus between CPU and I/O with all necessary hardware)
- e. Main data highway : 1:1
- f. Communication Cards : 1:1
- g. System Device : 1:1
- h. Power supply : 1:1



	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 57 OF 113		

(Power supply for all CPUs,  
I/O power supply modules)

- i. Serial (RS-485) Modbus (For Interlock PLC) 1:1
- j. In case of client-server system, 1:1  
server shall be redundant (Raid-5 Configuration)

I/O bus and I/O interface card at controller rack shall be redundant and shall be in criss-cross configuration.

Connectivity from Upstream redundant device to downstream redundant device shall be through redundant device or cable.

#### **Loading philosophy (with 20% installed spares and 20% future expansion)**

Control Processor	50%
Communication Processor	50%
Communication Bus	50%

#### **19.8 Scanning Time**

40 msec. for anti surge control loops  
200 msec. for flow and pressure control loops.  
500 msec. for all other control loops  
1 sec. for temperature acquisition loops  
1 sec. for all other acquisition loops



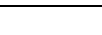
#### **19.9 System Communication**

All communication devices such as bus and cards shall be redundant with 1: 1 redundancy

The system will be interfaced with the following foreign devices:

ESD System  
Burner Management System  
Machine monitoring system  
FGS

Analyser system

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 58 OF 113		

Any other PLC system provided in packages.

Any other system from where data has to be sent to control system.

Customer LAN through hardware firewall.

Other Interfacing shall be as per project requirement.

At least 4 Nos. redundant foreign device interface shall be provided as spare in both for future use.

#### 19.10 **DCS System Power Supply**

The system shall be powered from uninterrupted power supply at 230 V A.C. The system shall further provide redundant D.C. power for all the control stations, communication devices, I/O cards etc., however the LED units shall operate on A.C. only.

#### 19.11 **Operators' Keyboard**

This shall be used by plant operators along with each Operator station display unit for operation of the plant. It will have multiple assignable keys to directly open pre-programmed display as well as few other system typical templates for selected tags including controller group display, trend, configuration display, alarm summary pages, etc. There shall be both numeric and alphabet keys and dedicated function keys on membrane type operator keyboard each of which must be freely programmable. There shall be one no. of operator keyboard with each of the operator stations.

This shall be membrane type fully dust proof and spill proof & corrosion proof.

Key lock switch / password switch shall be provided for operator/supervisor/engineer security levels

Dummy Consoles/Filler Panels shall be provided to maintain aesthetic and mounting instruments like indicators, annunciators etc. as well as for push buttons, lamps, key switches, paging system hardware.



Entry into the Marshalling Panels shall be through bottom mounted Gland Plates.

#### 19.12 **Consumables**

One No. Spares like printer cartridges with each printer to be provided.

### 20.0 **EMERGENCY SHUTDOWN SYSTEM (ESD)**

#### 19.1 **General**

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 59 OF 113		

The ESD shall be a system with a very high degree of reliability, SIL-3, TUV certified. The system shall be microprocessor based programmable logic control (PLC) with fault tolerant redundant processors based on TMR/QMR/VMR technology or DCS with a dedicated redundant controller for shutdown system as per IEC 61508/IEC 61511 with PFD (Probability of failure on demand) value 0.001-0.0001 and RRF (Risk Reduction Factor) value 1000-10000.



The emergency ShutDown System shall perform any of the following functions for safety of the plant from control room.

- Total Shut Down
- Unit Shut Down
- System Draining and Depressurisation

ESD system shall be a standalone fail safe system independent of other areas of the plant. ESD system instruments, junction boxes and marshalling cabinets shall be independent of other systems.

The following shall be adhered to while selecting the TMR/QMR/VMR system

- a) TMR/QMR/VMR CPU's shall be applied or DCS with a dedicated redundant controller.
- b) If a CPU fails, the other(s) shall continue to operate. Single CPU operation system to be certified to operate without any time limitation of faulty CPU repair.
- c) TMR/QMR/VMR buses shall be applied.
- d) TMR/QMR/VMR analogue inputs and outputs shall be applied.
- e) TMR/QMR/VMR digital inputs shall be applied.
- f) TMR/QMR/VMR digital outputs shall be applied.
- g) Redundant communication interfaces shall be supplied. Redundant communication from controller to IO cards/bus shall be criss-cross so that failure from one card or controller shall not affect the other cards connected with that controller and vice versa
- h) Redundant Power supplies shall be supplied.
- i) In the event of a failure of a fault tolerant component, power supply or other function, of the system shall change over to "single mode" operation without causing nuisance trips and also generate alarm on DCS Operator and Engineering console, also on ESD/SGS Engineering Station.

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		Document No.	Rev	
		Sheet 60 OF 113		

- k) In case of failure of complete processor system, i.e., system outputs shall take fail safe state automatically unless otherwise specified.

Operator interface for critical trips shall be mosaic display with illuminated push button for trip, reset, inactivation etc. and LED indication for each element of trip & actions.

The operator will be informed about a trip situation by a warning sound (to be different from the audible signal from the alarm system), and a LED display will clearly inform about the alarms in trip position. The first up alarm will flash.

PLC shall be with at least 3/4 sets of CPU's & other supporting module corresponding to front and & back end.

Scan time shall be maximum 250 msec. CPU shall be QMR/TMR/VMR. CPU loading shall not exceed 50%, Bus Communication modules, Power Supply and I/O cards shall have 100% redundancy and fail safe certification.


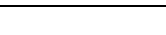
#### **System Redundancy**

Following system redundancy shall be available as a minimum.

- |   |                   |
|---|-------------------|
| 1. Controller<br>(CPU for control, I/O communication,<br>network communication)                       | 1:1 (Criss cross) |
| 2. Communication Bus  | 1:1               |
| 3. I/O communication modules with CPU<br>(I/O bus between CPU and I/O<br>with all necessary hardware) | 1:1               |
| 4. Main data highway  | 1:1               |
| 5. Communication Cards  | 1:1               |
| 6. System Device  | 1:1               |
| 7. Power supply<br>(Power supply for all CPUs,<br>I/O power supply modules)                           | 1:1               |

However, lamp drive cards, supporting mosaic need not be redundant also. Active isolator / barriers need not be certified for fail safe operation.

The operator can bypass trip alarm inputs, which may be necessary in abnormal situations. A lamp shall indicate that the trip alarm is inactivated. The operator will be warned by sound and fast flash if the inactivated circuit goes in alarm status.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 61 OF 113		

Alarms generated from the DCS will be provided for most trip-alarms as pre warnings.

The system shall include an event recording system, Sequence event recorder of 1 msec, resolution to be envisaged.

Display colours shall be in accordance with the following:

Alarm and Trip (safety operations) : Red  
Pre-alarm for trip (safety operations) : Orange  
Indication for by pass of trip (safety operations) : Red  
Equipment in operation (alarms and pilot lights) : White  
Ready (standby of equipment) : Green

The critical trip shall be displayed on Annunciation window.




Consumables like printer paper, cartridges, fuses etc shall be supplied along with the ESD system for a minimum period of one year duration.

#### 20.1.1 ESD requirements

Some of the ESD requirements have been covered in DCS sections also.

- ESD system shall be fail safe, TUV certified for all hardware and software, SIL-3 compliant and more than 99.99% availability.
- Fuse terminal blocks with blown fuse indicator is required for DO's.
- All interlocks shall be realized in ESD only. This ESD shall be SIL-3 as a minimum, as per IEC61508, irrespective of plant's safety integrity level.. The crippled mode running for unlimited time period, without degradation in safety class is a mandatory feature of safety ESD.
- The redundancy shall be implemented at Processor level, for all common hardware of central racks, all communication cards, highway and all type communication and control buses, power supply modules, all type of I/Os. All I/O cards shall be of fail safe and testable modules in the whole system. The complete interlock shall be realized for whole plant in this centralized Safety ESD only, irrespective of process safety integrity level of the plant.
- The ESD shall have scan time of 250 msec and SOE with 1 msec resolution.
- I/O segregation and channel density as specified in DCS section.

POS & MOS philosophy shall be implemented in soft in DCS with its actuation feedback from ESD system for all individual sensors. Further One hardkey with three independent switching elements for 2003 voting logic shall be provided in Auxiliary

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 62 OF 113		

console for the Activation of the MOS.




g) Auxiliary Hardwired console

Auxiliary consoles shall be provided for high priority discrete hardwired safety functions, which shall be manually operated. The console shall be installed adjacent the operator station console, near 24" TFT/LCD color monitors in the control room. The console shall be equipped with, Mushroom top Emergency push buttons for emergency shut-down action only. All Emergency stop and manual start push buttons shall drive an interposing relay located at IRC and one contact of this relay shall be wired to MCC for manual start/stop of pump/motor and another contact shall be wired to ESD for feedback in SOE as pot-free DI.

All trip parameters shall have override switches and their output status lamp on console.

Indication for trip by-pass shall be through LED on DCS auxiliary console.

- h) Information exchange between DCS/ESD shall be one way (From ESD to DCS) only and shall be used only for information purpose. No control/decision making shall be realized based on this information on either side. For this purpose, all necessary signals shall be hardwired between ESD and DCS. Each ESD shall have its own dual redundant link with DCS.
- i) All interlock and control transmitters shall be separate right from field junction box to ESD/DCS marshalling panels.
- j) Those parameters, which are directly or indirectly tripping the plant or may cause production loss, shall be wired with 2 out of 3 transmitter trip voting interlock in ESD. There shall be three separate analog input channels in three diff. AI cards shall be used for this purpose in ESD. Same thing is applicable to Digital inputs also.
- k) All critical control valves, which are covered under SIL-3 requirement shall be equipped with double solenoid valves with two separate output channels from ESD from two diff. DO cards, via two separate interposing relays, MCB's & fuses.
- l) All shutdown related On-Off valves, for which the position switches are used in interlocks shall be with 2 out of 3 philosophy right from the position sensor, field junction box and wired to three diff. Digital input cards three diff. channels in ESD.
- m) All MCC DI/DOs and all Process DI/DOs (SOV, Lamps, interface with DCS, etc.) shall be wired in separate DI/DO panels. All MCC DI/DOs shall be wired in Digital Interface panel for electrical/instrument interface IRP.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 63 OF 113		

- n) Centralized DCS and Centralized ESD marshalling panels shall be separate.
- o) Centralized DCS and Centralized ESD system hardware panels shall be separate.
- p) All major machines/units' Emergency trip push buttons on Field local panels and those located on Dummy Operator console at Control room shall be triplicated with 2 out of 3 philosophy with one actuating device with three element push buttons and switches connected to three separate digital input channels of three separate input cards of ESD.
- q) Smart barriers with line monitoring features shall be used and shall be taken as DI in the system
- r) OEM commissioning engineers shall be present for all the commissioning activities for specialized instrumentation systems like ITCC/ CCC antisurge /Performance controllers, Condition monitoring Systems, Woodward Governor and Gas Chromatographs Gas Analyser, DCS, ESD etc. The OEM engineer for DCS, ESD shall be present for 2 month after successful commissioning of the plant or as per ITB time whichever is more.
- s) In addition to the specified training, CONTRACTOR is responsible to impart DCS/PLC configuration/operation and maintenance training to OWNER's personals at sub vendor's works as per ITB. Also training for specialized instrumentation systems like Antisurge/ Performance controllers, Condition monitoring Systems, Speed Governor and Gas Chromatographs shall also be imparted to OWNER's personals at sub vendor's works for minimum 10 man days (1 week for 2 persons) on each system, by CONTRACTOR.




## 20.2 **ESD Cabinets**

### 20.2.1 **ESD Marshalling Cabinet**

Marshalling cabinet(s) are foreseen for both incoming to Interlock system and outgoing from Inter ('from' and 'to' field) termination. The interlock marshalling cabinet(s) shall also accommodate the repeater power supplies for the field transmitters, galvanic isolators for all inputs, trip amplifiers, output relays etc.

The termination strips shall be arranged or grouped for inputs/outputs 24VDC, 230 VAC, etc. both for inputs as well as outputs.

The terminals shall be of the WAGO/WEIDMULLE/PHOENIX make cage clamp type single tier design (double tier design shall be avoided). Terminal stack for each unit

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 64 OF 113		

shall be supplied with approx. 20% extra terminal points as spare/future provision in addition to the existing inputs and outputs.

Physical separation between the terminal stacks/points shall be maintained for the intrinsically safe and normal termination. Also the termination area shall be physically separated from the electronics area there by sealing the latter from dust ingress.

#### 20.2.2 **ESD System Cabinet**

An interlock system cabinet is foreseen, containing the interlock and trip system PLC, circuitry for the interlock display/operator stations, connectors for the display/operator stations and event recording system.

Cards of identical/similar functions shall be grouped together in the racks.

The system design including layout shall take into account the following factors.

- Ease of testing and simulation
- Ease of maintenance and operability
- Ease of modification and expansion

#### 20.2.3 **Interconnection Cables**

All interconnection cables beyond termination strips in the Interlock marshalling cabinet shall be part of interlock system and would include cables between:

- Interlock marshalling cabinet and interlock system cabinet.
- Interlock system cabinet and panel mounted display/operator stations.
- Interlock system cabinet and event recording system
- Event recording system printer and video display
- Any other cables required within the IMC and ISC not covered above.




About 20% additional I/O cards (each type) shall be pre-wired into the system over and the total number of inputs/outputs indicated. This will include galvanic isolators, trip amplifier, isolating power supplies for transmitter etc. alongwith different type of logic cards.

The Interlock system shall also include following test diagnostic tools:

- Logic tester
- Test adapter
- Test signal generator

#### 20.2.4 **Power Supply**



	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 65 OF 113		

An uninterrupted Power Supply to ESD shall be provided to the power distribution cabinet of ESD at 230 VAC +/- 10%, 50Hz +/- 3%.

In case rectification to DC is involved, rectifiers shall be dual redundant and both shall be 'hot' (on line) so that failure of one rectifier will not cause a system trip. Provision shall be included in the system to annunciate the rectifier/D.C. power supply failure.

Philosophy of power isolation and over load protection (switch fuse units) or only over load protection shall be extended upto individual card level, while designing the system, so that, minor card failures can be localised for easy rectification. Also this will avoid major down time on the system.

Earthing /Grounding bus bars for terminating shields of the cables shall be provided on the cabinet.

#### 20.2.5 **Annunciator**

Annunciator shall be LED(24") type mounted on aux console

#### 20.2.6 **DCS & PLC, Spare Philosophy:**

Installed Spares	I/O Level	20%
	Marshalling	20%
Spare Space	I/O Level	20%
	Processor	50%
	Marshalling	20%
	Rack	




### 21.0 **CONTROL ROOM**

Control room (CR) is not in bidder scope. Control System shall be supplied by others (LSTK-1 Control Room). However Panels shall be installed in others (LSTK-1 Control Room). LSTK-2 bidder to provide the following details to LSTK-1 bidder (Erection & commissioning shall be in LSTK-2 bidder only, details shall be provided alongwith bid):

- No. & Size of the panels to be placed in control room,
- HMI BOQ
- Laying of cables and cable tray upto LSTK-1 control room
- UPS panel size & Battery size
- Heat dissipation requirement along with the suggestive layout

Control Room shall be suitably furnished with Tables / chairs of reputed makes.

The instrumentation cable entry and all other cable entries (UPS room, HVAC etc) to the control room shall be through MCT (multi-cable transit). Cable way in control room shall be below access level through cable trays

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 66 OF 113		

The overground cable trays shall terminate just below the cable entry opening in the control room to have a natural slope for cable laying at the entry. The electrical power and control cables terminating in the UPS room shall have separate entry.

**a) International Norms/Certifications followed for Designing Control Room & Control Desk**

**i) International Design Norms:**

- ISO 11064 – Ergonomically Designed Control Room & Control Desk

**ii) Quality Certifications for Control Desk:**

- Greenguard by Underwriter's Laboratory
- Greenguard Gold by Underwriter's Laboratory
- Shall have BIFMA X5.5 Test Certificate for Control Desk
- FSC (Forest Stewardship Council) for Control Desks
- ASTM e-84 for Surface Burning Characteristics.
- RoHS (Metal & Electrical Components)
- Seismically Tested Console (For Zone 5)



**iii) Quality Certifications for Control Room (Wall Paneling/ Partition & Ceiling)**

- ASTM e-84 for Surface Burning Characteristics for Wall Paneling & Partition.
- Sound transmission class (STC) value of 35db for Wall Paneling & Partition. (according to IS: 9901 (Part III) – 1981, DIN 52210 Part IV-1984, ISO:140(Part III) -1995
- Noise Reduction Coefficient (NRC) value is 0.30 for Ceiling – Sound Absorption Coefficient by diffuse field method; IS: 8225-1987 "Measurement of Sound Absorption Coefficient in Reverberation Room" (Equivalent to ISO: 354- 1985 and ASTM 423-90 Sub-Div#5.07/A/Doc.3/TP#14)

- iv)** The Console shall be designed with vertical and horizontal cable trays to allow for continuous cable management between the cabinets. Wire shall be routed into the cabinet through gland plate. All bolts shall be of SS material to avoid rust due to environment.

**b) Instrument Calibration Work Bench and Test Equipments**

Apart from a central cabinet room (size: as required), control room (size, as required) and a central engineering room, one room for shift Technicians and one room for

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 67 OF 113		

Instrument calibration shall be considered in the same building with central air conditioning.

The room shall be designed/sized and constructed based on various following requirement:



- i. It shall accommodate a full-fledged test/calibration work bench of approximately 4 meter x 1 meter size.
- ii. It shall allow storage of various documents cupboards/test catalog/manuals, and file racks for various calibration report.
- iii. It shall include a wash basin.
- iv. It shall have instrument air tapping inside the room at work bench.
- v. The test/calibration room shall be preferably in the vicinity of adjoining instrument technician's maintenance and rest room.

Licensed Configuration software of all the smart instruments (PT, DPTs, RADAR, Ultrasonic meters, specific gravity analysers, mass flow meters, positioners etc), isolators (temperature isolators etc) with suitable connectors having USB connectivity with laptop shall be provided.

#### c) **Instrument Maintenance Room**

The maintenance room will be located in the control room. The minimum requirement of instrument maintenance room shall be as follows:

- i. It shall be equipped with file racks/cupboard and pigeon hole lockers for storing various instrument tools/tackles.
- ii. It shall be equipped with wash basin and instrument air supply.
- iii. It shall be without air conditioners.
- iv. It shall be provided with 110V AC /230V AC (non-critical) for testing/calibrating control valves/solenoid valves and will be used to perform these type of heavy jobs like dis-assembling, washing, cleaning of various flow meters, tubes, sensors, etc. It shall also be provided with Instrument air header with sufficient tapings.
- v. It shall be provided with lockable doors.
- vi. It shall be furnished for minimum 4 technicians and two working tables.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 68 OF 113		

- vii. It shall also have two nos. heavy but small metallic stools, vice and grinding machine, etc.

## 22.0 PACKAGE UNIT INSTRUMENTS

- 22.1 The use of field instruments, control systems/panels for typical equipment packages will be defined as follows as typical. Contractor/Vendor to select any one of the package type (whichever is applicable)




### Package Type 1

Package Vendor shall design and supply all instruments as detailed on the Vendor PID's, wiring materials to junction boxes and piping/tubing materials for impulse line and air line inside Vendor's battery limit. Control and/or interlock shall be carried out via Purchaser's own system (DCS and/or ESD system). Vendor shall be responsible for providing all drawings and information necessary for Purchaser to correctly configure his DCS and/or ESD system. Vendor shall design for control/logic and indication to be implemented in Purchaser's system.

### Package Type 2

Package Vendor shall design and supply all instruments as detailed on the Vendor PID's, wiring materials to junction boxes and piping/tubing materials for impulse line and air line inside Supplier's battery limit. Package Vendor shall also design and supply its own stand alone control system located within a Vendor supplied local equipment. The control system shall preferably be PLC type. The control system will communicate with Purchaser's own control system (DCS) via Redundant Modbus TCP/IP or Modbus RTU for monitoring. Control and interlock signals shall be hardwired. The Vendor shall supply all data and function (including logic, control and sequence narratives, wiring details etc).

- 22.2 Vendor's scope supply includes:
- 22.2.1 All instruments for safe and efficient running of the machine. The supply shall include control valves, suction and discharge auto block valves, relief valves, shut off valves, solenoids, speed indicators, transmitters, electronic governors, pressure and temperature gauges, switches, sensors etc.
- 22.2.2 Gauge Board to be located near each machine with local gauges mounted on it.
- 22.2.3 All instrument erection materials such as cables, pipes, pipe fittings, supports, trays, conduits, junction boxes etc.
- 22.2.4 Tools for service calibration and maintenance

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 69 OF 113		

22.2.5 Spares parts for Commissioning.

22.2.6 Engineering documentation

22.27 Mandatory spares, , shall be supplied as per Instrument spares list attached with the NIT.along with the main item.

## 22.3 **Process Alarm, Motor Alarm and Shut Down System**

### 22.3.1 **General**

Critical alarms and shut downs must be derived from direct process sensors and shall be entirely separated from any other system (including process connection). All trip alarms shall always be preceded by a passive alarm from an independent primary measurement. However, the same primary element can be used for measurement of vibrations and displacement. Critical alarm sensors shall also be independent of shut down sensors, but may be common with sensors used for control or indication. Filled temperature elements shall not be used. Alarm signals from analogue loops shall be derived via a trip amplifier. Inputs from thermocouples shall be provided with cold junction compensation and downscale burns out feature for high temperature shut downs and visa versa. A passive alarm shall warn about the burn-out.

The alarm and shut-down system of the compressor and turbine shall be co-ordinated to accommodate all the relevant equipment for compressor, as well as for turbines, within the main panel in the local control room.

The alarm and shut-down system shall be fail safe type and utilising field contacts that open in alarm conditions.

The logic for alarms (process and motor) and the logic for shut down system shall be independent.




For all motors current indication shall be provided in DCS for rating more than 5 KW

The contact shall be potential free and suitable for low level signals, i.e. gold plated.

### 22.3.2 **Physical Description**

The process alarm and motor alarm systems shall be supplied with displays, logic and power supply as an integrated package for flush mounting on the main panel front. Alarm facias may be separated from the electronics by prefabricated cables.

The shut-down system shall be shown in a logic graphic display on 22" TFT LED. panel front as well as on operator console containing the various trip alarms, by-pass

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 70 OF 113		

lamps and switches, including open and closed positions of any automatic block valves. The logic and duplicated power supplied shall be located inside the panel.

### 22.3.3 **Power Supply**

The internal power packs shall have an output of 24V DC, full wave rectified, generated from the 230V AC supply with 50% loading.

### 22.3.4 **Alarm Sequence**

The annunciator sequence for process alarms shall be ANSI/ISA-SI8.1, Type “A-14”. The sequence required is automatic reset: “The sequence returns to normal state automatically after acknowledgement when process condition returns to normal”. The display for motor alarms would consist of two windows per motor, one for running indication and one for “ready-to-start” indication. The annunciator sequence for motor alarms shall be as mentioned above, but with steady light for running and “ready-to-start” respectively and light off by acknowledgement and motor stopped.

### 22.3.5 **Display and Colour Coding**

Annunciator window engraving shall include a brief state description and the Tag No. Each window shall measure approx. 24x48 mm and be engraved with a character size and style and state description to be read from a distance of 3 meters with normal eyesight.

The window colour shall be specified for OWNER’s approval.

Each window shall be back lighted by two lamps. The lamps shall be underrated for extended lifetime. MTBF shall not be less than 7000 hr.



### 22.3.6 **Shutdown System**

The shutdown system for the unit consists of an alarm annunciator and related Interlocking that stops the unit. The unit cannot be restarted before the failure is cleared.

The various shut-down groups shall be sub-divided in such a manner that a trip alarm shall be connected to one interlock group only and any subsequent action shall take place from one shut-down group to another.

The shut-down system shall provide access for contact inputs and outputs from/to outside the process unit, and a common output contact identical to the one for the alarm system shall be provided.

### 22.3.7 **Shut-down Presentation**

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 71 OF 113		

The annunciator sequence shall be type ANSI/ISA S18.1, Type F1M-14.

The sequence required is “First out” with subsequent alarms to appear in the acknowledged state - no flashing device operates when subsequent trips occur. On acknowledge first cause of trip continues to flash.

“Manual Reset”	The sequence returns to normal state after acknowledgement when the process has returned to normal and the reset push button is operated.
“Manual Restart”	The interlock module returns to normal state after Manual Reset of the alarm modules and the restart push button is operated.
“Lamp Test”	Operation of the test push button lights the visual display lamps only.
“Manual Stop”	Operates the interlock modules, but not the annunciator, to stop the unit.

### 22.3.8 Display and Colour Coding

The shutdown display shall be arranged as a logic graphic display in the panel front built up out of windows back lighted by two lamps of a colour as defined in General Specification for Instrumentation of this Annexure and with identifying name plates. The lamps such as the alarm annunciator lamps shall be under rated for extended life. MTBF shall not be less than 7000 hrs. Switches and push buttons shall be logically arranged in the graphic display also.

The maximum execution time for an alarm signal input shall be 50m sec.

### 22.3.9 Interlocking Module



The interlock logic is locked in by any shutdown alarm. The logic can be reset only when all shut down alarms are back in normal process condition and are reset, the logic is reset manually by operating the “restart” push button.

The output relay for shutdown shall be with normally open contacts (open in shut down state and power less state), contact rating: 220V AC, 2A.

Extra contacts, wired up to terminal strips, are required for signalling shut down status to control room, contact rating: 24VDC, 10mA.

### 22.3.10 Checking of the Shut-down System



	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 72 OF 113		

The shut down system shall have provision for on-stream testing without affecting the output relay. Push buttons for test purposes may be placed inside the panel.

By-pass switches shall be provided for each trip inlet.

An alarm display shall indicate which one of the inputs is inoperative and a special sound and flashing light shall warn the operator if the trip circuit goes into alarm status during the by-pass states.

#### 22.3.11 **Monitoring and Protection of Machine( rotary,turbines/Compressor Train/Pumps etc.)**

For the purpose of monitoring the “health” of the machine and for automatic shut-down in case of emergency, a highly reliable continuous monitoring system shall be supplied.

It shall be either through ITCC (Itegrated Turbine Compressor Controls) or individual dedicated control systems. i.e CCC series 3++ for antisurge and Woodward / Braun model for Speed governor and overspeed protection.

The monitoring system comprises machine mounted sensors and transducers and the monitoring instruments installed in the auxiliary panel the control room.

The monitoring system shall have built in computer interface unit(s) for connection to an overall monitoring and diagnostic computer system.

#### 22.3.12 **Sensors**

The complete system shall be from the same instrument manufacturer, in order to have single source system responsibility.




Below is listed the minimum number of sensors required. The list is indicative and should not preclude the vendor from including other parameters which in his judgement are necessary for the safe and reliable operation of the train.

Temperature sensors shall be mineral insulated duplex RTD elements. In all sliding surface babbitt bearings, the temperature sensor should normally be between 0.75 mm to 1.5 mm under the surface of the babbitt to ensure that the wall thickness is sufficient to prevent the oil pressure from penetrating the babbitt.

Two sensors per radial bearing (one for redundancy) at the calculated maximum load deflecting bearing under abnormal conditions.

One sensor in each two shoes for thrust bearing on both the active and inactive side.



	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 73 OF 113		

Sensors on the machine case at various locations in accordance with the machine vendor's recommendation.

Vibration and Thrust position sensors shall be Eddy current proximity sensors in accordance with API 670 latest edition. To allow adjustment and replacement during operation, external probes with no connectors or probe lead wires inside the machine is preferred. If internal probes are provided, they should be mounted on rigid brackets that will not vibrate and the armoured lead wires shall be sufficiently long to terminate in weatherproof connectors outside the bearing housing. Necessary supports, strain anchors and suitable feed shall be used where required inside the machine.

Two sensors at or near radial bearing, 90 degrees apart and normally 45 degree from each side of the vertical centre. Installation at the nodal points shall be avoided under any circumstances. The X-Y probes shall be in the same radial plane through out the machine train. It is desirable that one of the mid turbine probes is a dual probe consisting of a seismic velocity transducer and a proximity probe. The seismic transducer may be un-monitored and used for connection to diagnostic instruments.

Two axially oriented sensors at each thrust bearings with at least one of them observing a surface i.e., integral to the rotor. It is preferred that none of the probes are monitoring the thrust collar, as the thrust collar may get loose and the axial probe monitoring the thrust collar no longer measure true rotor movement.

One key-phasor radian on the driver of the machine train with a corresponding one event per revolution marking groove under the probe. It must be ensured that thrust float and differential expansion do not move the mark out from under the key-phasor probe.




Key phasor measurement shall be provided for compressor and turbine.

22.3.13

. The monitors for the machinery protection system shall be installed on the panel in the local compressor control room. Installation and area classification shall be in accordance with the plant requirement. All instruments shall be highly reliable and shall conform to API 670 latest edition. The machine supplier must ensure that the potential free contacts are available from the system for all alarm and trip signals. The monitoring system shall comprise of the following instruments:

Power supply for provision of the DC voltage necessary for the system but with a separate power source for the key-phasor.

Digital shaft speed indicator operated from the signal supplied by the key-phasor probe. The indicator shall have provision for repeating the speed signal to the control

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 74 OF 113		

room. The repeater signal shall be a pulse signal. Local indication of speed shall also be available near the machine.

Dual voting thrust position monitor for each casing, designed to prevent false trips due to transducer or collar failure. The monitor shall have built in adjustable time delay of 0 - 3 secs.

Sensor output panel for termination of unmonitored transducers used for periodic checks and diagnostics.

Temperature indicators with high alarm relays form radial and thrust bearings.

All information from the backplane electronics of monitoring instruments in the local control room shall be available in the control room. The transmission shall be through serial communication. However all vibration, axial displacement and speed signals are connected with DCS through hardwired. All interfaces, bus cables and PC shall be supplied by the vendor. The computer for transient data management system shall be located in the control room.

Two plane radial vibration monitors for each casing for continuous monitoring of the outputs of the two radial probes mounted 90 degrees apart at the same bearing. The installation shall be such that either of the transducer pairs from the same casing can be connected to the monitor. The monitor shall be designed to prevent false trips due to transducer failure and shall be provided with built in time delay.

Transient Data Manager shall be provided for monitoring data from all compressors.



VMS/MMS I/O modules shall be with in built Barriers. 4-20mA for DCS. MMS to be provided with CMS monitor. Rule Packs also to be provided.

Interlock, shutdown and trip signal shall be hardwired to PLC (Contact signal from machine monitoring). All analog signal from VMS to DCS shall be hardwired. RS232C/485 Communication shall be given as an additional provision. Also Ethernet port shall be provided for connecting the VMS to configuration & diagnostic station (PC based).

#### 22.3.14 **Speed Control of Turbines**

All the over-speed trip and monitoring system shall be implemented in latest Woodward/Braun make systems.

The speed control system shall be designed to provide maximum economy of operation and high reliability with a minimum of maintenance, and shall fulfil the requirements in API standard 512.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 75 OF 113		

Speed control and over-speed systems shall be independent. There shall be separate TMR over speed trip system for the rotating machines as per the relevant API Code.

The speed governor shall be electronic type and have remote speed setting from the main panel and the control room as well.

The system shall be digital governor suitable of providing an accurate speed control.. The governor shall be installed in the CR with serial communication to DCS.

The electro-hydraulic type converters for turbo machinery shall be Voith make only. Hazardous area classification of the field devices shall be suitable for plant hazardous area classifications. The required power supply to these units shall be fed from central cabinet room PDBs. Dual redundant 24 V DC bulk power supply for these systems, if required. These power supply units shall be installed in PDB located at central cabinet room and required power cables (with proper sizing and armouring) shall be laid in overhead cable trays/ducts between PDB and field devices.

The steam inlet and extraction valve shall be cam or bar lift multi valves to provide maximum efficiency for all turbine load conditions. Because of the well known wear and vibration problem with mechanical linkage system to those valves, special attention shall be paid to the design of these systems.

The points mentioned below shall be carefully observed when designing the control system.

The valves shall be positively held stems to prevent spinning, chattering and sticking.

Surface hardened stainless steel bushings shall guide the valve stems into lapped seats, sealing the valves against leakage.




All linkage shall be external to provide greater accessibility and freedom to perform visual inspection.

each cam or bar shall be individually adjustable to give the desired rate of opening and to provide maximum efficiency during all loads.

External location of cams or bars and visible valve stems with position indication shall be foreseen.

#### 22.3.15 **Over-speed Trip Systems for Turbines**

All the over-speed trip and monitoring system shall be implemented in latest Woodward/ /Braun make systems.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 76 OF 113		

To protect the operating personnel and equipment, the turbine shall be equipped with a 2oo3 overspeed trip device that shuts down the turbine, when rotating speed exceeds the maximum speed by approximately 10 percent. The emergency governors shall operate totally independent of the normal controlling speed governor.

The whole overspeed trip system ( 2oo3) shall be very carefully designed to ensure that the turbine will trip in all situations of overspeed, especially the time lag in the mechanism shall be kept to an minimum, ensuring very fast operating of the trip and throttle valves. The trip valve shall be provided with a limit switch for indication of closed position (running light) in the control room.

The following shall be provided as a minimum:

- 3 Speed probe required for measurement & control –
- 3 Speed probes for 2oo3 trip.-

All Speed Probes shall be of Braun / Protech make.

2oo3 trip system shall be of Protech/Woodward only.

The system shall close not only the trip and throttle valve, but also steam admission valves.

A hand trip device for emergency manual tripping shall be located in front of the turbine where it is readily accessible.




It shall be possible to verify trip set points while the turbine is coupled to the compressor.

The secondary hardware of these system shall be installed in central cabinet room in a standard RITTAL or equivalent panel of 1200mm (W) x800mm (D) x 2100mm (H) or with RAL7035 color shade.

A dedicated laptop for programming and back up of all machines' Woodward/Protech 2 out of 3 devices shall be provided along with required software/cable. The lap top shall be with latest Intel hardware, OS and MS office software at the time of supply.

#### 22.3.16 **Control and Anti-surge Control**

The typical surge protection control systems are to be shown on respective P&I diagrams. The control system shall be electronic with the controllers installed in the main panel. The controllers shall be with bumpless change over from manual to auto and vice-versa and wherever required anti reset wind up feature shall be provided. It

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 77 OF 113		

is extremely important that all instruments are carefully specified for high quality and fast action. The scanning time for digital controllers shall not be more than 40 msec.

The valves in anti-surge service shall be with linear characteristic and high energy absorption trim and suitable for continuous operation for long periods with partly open valves. The noise level must not exceed 85 dB.

The valve shall be provided with limit switches, handwheel, and mechanically adjustable limitation of the valve capacity. It is also important that the valves have a very high stroke speed and still are stable in operation. The valve capable of recirculating 100% of the designed flow rate shall normally a full stroke speed in the order of one second. Complete designed data for the anti-surge valves would be submitted for review and approval by OWNER.

The secondary hardware of these systems shall be installed in central cabinet room in standard RITTAL make preferably, 1200mm (W) x800mm (D) x 2100mm (H) with RAL7035 color shed.

BIDDER to supply suitable cables between field sensors and control room.

#### 22.3.17 **Lubrication, Shaft Sealing and Control Oil System**

Everything possible shall be done to design the oil systems to provide a continuous, cool, clean supply of oil at the required constant pressure to suit the need of the user. Generally, the instrumentation for the oil system shall comply with API standard 614.




It is not the intention with this chapter of the specification to cover the complete instrumentation for the oil system, but only to highlight a few important parameters. As such it is not described which events that shall shut down the train. The complete system proposed by the machinery vendor shall be subject to the approval of the OWNER.

All local pressure gauges and temperature indicators shall be mounted on gauge boards.

No pneumatic system shall be used for lube oil and seal oil tanks.

#### 22.3.18 **Lube Oil System**

The reservoir which shall be steam heated for start up purpose by means of a manual operated control valve shall be provided with a local level gauge, level transmitter with indication, with low level alarm at the main panel.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 78 OF 113		

The lube oil system shall be furnished with two identical lube oil pumps, one turbine driven and one electric driven. Either one shall be selectable for normal operation, while the remaining one automatically becomes stand by with auto start, if the normal one fails.

“Running”, “ready to start” and “On Auto” lights shall be provided for the lube oil pumps in the main panel. A low lube oil pressure switch in the pump discharge lines shall start the spare pump and alarm the condition in the main panel. A low lube oil pressure switch in the lube oil header after the coolers and the filters shall give alarm. The oil coolers shall be controlled by a temperature control loop with separate high and low alarms in the main panel. The cooling water control valve shall be provided with handwheel. The dual filter units with manual switching shall have main panel mounted indication of the differential pressure across the filter and a high alarm to warn the need for switching and filter element replacement. A pressure control loop on the system shall be provided to ensure the required constant oil pressure for the turbine lube oil and compressor lube oil. Each of the system pressures for lube and control shall be recorded in the main panel.

All drain lines shall be provided with sight glasses and local temperature indicators.




22.3.19

### **Seal Oil System**

The instrumentation of the seal oil system shall basically be similar to the lube oil system. The main difference is in the control at the delivery end. To ensure the correct pressure to the elevated seal oil tanks, the pressure shall be controlled by recycling the oil to the reservoir before filtration. The pressure control valve in the spill back line shall, because of the high pressure drop, be with solid stellite trim.

The oil rate to each seal is maintained by the tank indicating level controller which manipulate the valve in the supply line. The tanks shall be provided with high and low level for alarm on the main panel. In addition, the low switch shall start the spare pump.

Operation at 230 VAC and certified for the hazardous area as per general specification for instrumentation of this annexure. Further, the valves shall be designed for the operating under tropical conditions with a relative humidity upto 100% and with a shade temperature upto 50°C. The solenoids shall be with class “H” high temperature insulation. The valves for instrument air shall be designed for 10 kg/cm<sup>2</sup>g at 70°C and the operating differential shall be from 0 to 10 kg/cm<sup>2</sup>.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 79 OF 113		

“Running” “ready to start” and “On Auto” lights shall be provided for the Seal oil pumps in the main panel.

## 23.0 NOISE IMMUNITY OF ELECTRONIC INSTRUMENTS




The electronic Instruments shall have a susceptibility of less than 0.5% of span for a frequency range of 20 - 200 Mhz in a field strength of 20 Volts/metre.

## 24.0 LOCAL CONTROL PANELS

All local panels under the scope of package vendor shall follow the minimum specifications listed below:

- 24.1 Panels shall be free standing close cabinets, constructed in sections of min. 1000 mm wide. The panel construction shall be welded or bolted frame construction with upright and and additional framing in modular construction. The panel front sheet thickness shall be min. 3 mm. The front of panel shall be stiffened where necessary with profiles tack welded to the rear. Top, sides and doors can be made out of 1.6 mm thick plate.
- 24.2 The panels shall have environmental protection conforming to IP 65 min.
- 24.3 Instrument air shall be provided for purging of local panels.
- 24.4 Panel face, sides and doors shall be sand blasted and cleaned before primer and two coats of paints are applied. The colour of paint shall be bright grey. The final surface shall be semi mat, free from blemishes and paint runs.
- 24.5 230 V A.C. +/- 10%, +/- 3% Hz power at one point to the local panel shall be provided by the client. Any other voltage level if required preferably 24 V, DC, the same shall be arranged by the vendor. Redundant rectifier units shall be provided for the generation of d.c.by the vendor.
- 24.6 Earthing lugs for both power and system earthing shall be provided by the vendor.
- 24.7 The wiring shall preferably contained in polymer ducts. Instrument safe wiring shall be laid separately from others. The colour of IS wiring shall be light blue.
- 24.8 Cage clamp type terminals shall be used for cable termination and wiring. 20% terminals shall be kept as spares in each terminal strip and box.
- 24.9 Gland plates shall be provided alongwith cable glands( ex. proof wherever required) in each panel for cable termination.
- 24.10 A miniature circuit breaker shall be provided for each power supply.
- 24.11 All panels shall be provided with vibration dampening pads.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT</b>  <u><b>Bharat Coal Gasification and Chemicals Limited</b></u>  <b>Design Philosophy Instrumentation</b>	PC288/E/P-II/ SEC-5.2	0	 कोयला इंडिया  बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 80 OF 113		

- 24.12 Each panel section shall be provided with illumination level of 300 Lux min.
- 24.13 Name plate/labels shall be provided for each panel mounted instruments, equipments and accessories mounted in the front or rear of the panel.
- 24.14 Purged panels shall be provided with purge fail alarm. Purge fail trip shall be provided with a bypass switch.

## **25.0 INSTALLATION**

### **25.1 INSTRUMENT LOCATION**

- 25.1.1 The location of instruments, control valves. Including junction boxes shall permit easy access from grade, permanent platforms or stairways for operation, inspection and maintenance.
- 25.1.2 The use of portable ladder or mobile platform shall be limited to access root valves, thermowells and line mounted flowmeters.
- 25.1.3 Locations shall be decided to minimize the possibility of damage from passing or falling objects and the possibility of tripping hazard or obstruct on walkway.
- 25.1.4 Permanent accessway/platform shall be provided for Instrument mounted on top of Tank, vessels etc. Access via oing from Handrail is not acceptable.
- 25.1.5 Permanent access to be provided for laying of Instrument main cable tray.

### **25.2 INSTRUMENT CABLE**

#### **25.2.1 Overhead Runs**

Instrument main cable tray from field junction boxes to main control building or local control room shall generally be laid in aboveground cable tray.. Tray protection cover shall be provided only for the tray on top of tray layer.




Instrument branched cable runs from junction box or local panel to each instrument in the field shall also be routed aboveground and supported with trays, steel angles and channels.

Aluminium perforated cable trays with adequate supports shall be used for instrument signals. Single pair cables from instrument to junction box and branch cable tray shall be through perforated aluminium cable trays.

For Signal 900mm/ 600mm tray and for power 600mm/ 300 mm tray to be considered.

Cable trays, Elbows, junctions and brackets, channels, special pieces and secondary



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT</b>  <u><b>Bharat Coal Gasification and Chemicals Limited</b></u>  <b>Design Philosophy Instrumentation</b>	PC288/E/P-II/ SEC-5.2	0	 कोयला इंडिया Coal India  बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 81 OF 113		

cable support shall be made of galvanised steel/suitable material.

Main metal conduits or raceways shall generally be anchored along piperacks and/or structures of the plant.

Cable tray segregation shall be based on the voltage level. Cable tray shall be supported at every 2M. 20% spare to be considered in the cable tray filling.

Instrumentation cables that form part of intrinsic safe (IS) circuits, if any, shall be segregated from other instrument signal cables.

Instrument power supply (AC) cables shall not run in the same tray of instrument signal cables. Cable tray shall be dedicated for laying instrument power cables separately from the signal cable tray.

Alternatively, cable ducts of suitable size shall also be considered for main cables. When common cable ducts are used for running both power and signal cables, necessary air gap partition shall be used to segregate the cables.

## 25.2 CABLES

The primary insulation material shall be XLPE (cross linked polyethylene) for all types of multi pair cables

Inner and outer jacket shall be made of extruded flame retardant 90 ac PVC to IS-5831 latest edition.




All cables shall be FRLS as per standard IEC 332-3 Part 3 Cat. A latest edition. Fire resistance cables whenever specified shall be as per me 331 Cat. A latest edition.

The insulation grade shall be 600 V/1000 V as a minimum and shall meet insulation resistance, voltage and spark test requirements as per BS-5308 Part-2 latest edition.

All cables shall be armoured. Armour over inner jacket shall be of galvanised steel wire/flat as per IS-1554 part I latest edition / IEC 502 latest edition. All the cores of single pair or multi-pair shall be twisted and numbers of twist shall not be less than 10 per metre.

For signal and control cables, inner jacket colour shall be black. Outer jacket colour shall be light blue, for intrinsically safe application and black for others. For thermocouple extension cables the inner and outer jacket colour shall be as per IS-8784.

L/R ratio of adjacent cores shall not exceed 40  $\mu$ H / 0 for cables with 1.5 mm<sup>2</sup> conductor and 0.25 pH / 0 for cables with 0.5 mm<sup>2</sup> conductor.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 82 OF 113		

Contractor shall ensure a minimum of 20% of quantity of each type of cables supplied as spare including any special cable and in each multipair cables 20% pairs shall be kept as spare.




#### **25.2.4 Instrument Signal Cable**

- a) Single pair shielded signal/alarm cables shall be used between field instruments switches and junction boxes/local control panels.
- b) Multipair individually and overall shielded signal/alarm cables shall be used between junction boxes/local control panels and control room.
- c) The single pair/triad cables shall be 1.5 mm<sup>2</sup> conductor size made of annealed electrolytic copper conductor of 7 strands with each strand of 0.53 mm diameter. Multipair cables with 0.5 mm<sup>2</sup> conductor size shall have 7 strands of annealed electrolytic grade copper conductor with each strand of 0.3 mm diameter. Multi triad cable or multi pair cable with 1.5 mm<sup>2</sup> conductor shall have 7 strands with each strand of 0.53 mm diameter. Colour of core insulation shall be black blue in pair and black, blue and brown in a triad.
- d) Shield shall be aluminium backed mylar/polyester tape bonded together with the metallic side down helically applied with either side having 25% overlap and 100% coverage. The minimum shield thickness shall be 0.05 mm in case of single pair/triad and 0.075 mm in case of multipair/triad cable.
- e) Drain wire shall be provided for individual pair and overall shield which shall be 0.5mm<sup>2</sup> multi stranded bare tinned annealed copper conductor. The drain wire shall be in continuous contact with aluminium side of the shield.
- f) All multi pair cables shall have 6 pair/12 pairs only while multitriad cable shall have 6 triads/8 triads only.
- g) All single and multipair cables for vibration monitoring system shall be instrument cables with copper braided shielding for individual pair and overall.

#### **25.2.5 Cables and Multicore Cables for Solenoids etc.**

Cables and multicore cables for such items as flame detectors shall normally have a conductor size of 1.5 mm<sup>2</sup>. However, conductor sizes for power cables shall be co-ordinated with the Electrical Group to avoid too many different cable types.

#### **25.2.6 Thermocouple Extension Wires**

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 83 OF 113		

- a) Single pair shielded thermocouple extension cables shall be used between thermocouple head and junction boxes transmitters/ local control panel mounted instruments.
- b) Multipair individually and overall shielded thermocouple extension cables shall be used between junction boxes and main control room mounted devices.
- c) The type of thermocouple extension cables shall be compatible with thermocouple used. In addition the colour coding of the primary insulation shall be as per ANSI latest standards.
- d) The cable shall have 16 AWG and 18 AWG solid conductors for single and multipairs respectively.
- e) All thermocouple extension cable shall be matched and calibrated in accordance with MC-96.1 latest edition.
- f) Shield shall be aluminium backed by mylar/polyester tape bonded together helically applied with the metallic side down with either side having 25% overlap and 100 % surface. Minimum shield thickness shall be 0.05 mm for single pair and 0.075 mm for multipair cable. Drain wire shall be 0.5-mm<sup>2</sup> multi-strand bare tinned annealed copper conductor. The drain wire shall be in continuous contact with the aluminium side of the shield.
- g) Inductance shall not exceed 4mH/Km.
- h) All multi-pair cables shall have 6 pairs/12 pairs only.




### 25.2.7 Power supply Cables

All power supply cables shall be as per IS-1554 Part I latest edition and shall have copper conductors. Minimum conductor size shall be 2.5 mm<sup>2</sup>. The cables shall be PVC insulated and armoured. The higher size conductors shall be used in case of long distance power cable where voltage drops more than 3 volts than required supply.

Any other special cable required for instruments that should also be supplied as per requirements. CONTRACTOR shall ensure that these cables are armoured type and shall meet all other requirements.



### 25.3 JUNCTION BOX

- a) Junction box shall be of SS304 for IS signal and for Non IS signals Die-Cast Aluminium (copper free) with Anti-corrosive paint shall be provided. Junction boxes shall be certified for weather proof with IP 65 certification for IS signal.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 84 OF 113		

For non IS signals, Junction boxes shall be flame proof for IEC Zone 2 & Gas group IIC Ex. Proof. Junction box shall have screwed covers. All entries to junction box shall be side or bottom.

- b) In general a junction box shall contain only signal of same class. The signal class is categorized as following type:
- i) Signal Level
    - Analog Input
    - Analog Output
    - Digital Input
    - Digital Output
    - Instrument Power
  - ii) System
    - DCS
    - ESD
    - F&G
  - iii) Type of protection
    - Non IS, Ex d
    - IS
- c) The multi-cable entry for 6/12-pair & 8 Triad JB shall be 1" & 1 1/2" NPT (F). Each junction box shall be provided with 2 multi-cable entries from the bottom of the junction box with one plugged with weather proof plugs. All Cable entry shall be at the bottom only,.
- d) All spare cable cores shall be terminated in the Junction box, at the marshalling panel end and wired through spare barriers / isolators or relays (as the case may be) right upto the corresponding spare channel of I/O module.
- e) All spares hole of JB's, T/C head etc to be plugged with metallic plugs. The metallic plugs, Junction box hinges, Handle, DIN rail, Allen screws shall be SS material of construction.
- f) Cable glands shall be provided with Cables shrouds. 20% spare terminals shall be supplied in each junction box.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 85 OF 113		

- g) To the extent possible the Field Instrument Signal Distribution Junction-Box wise should be such that the signals terminated from individual Junction Box shall be terminated in the same DCS I/O module, i.e., signals from one junction box shall not be terminated in different I/O modules.

h)

#### 25.4 CABLE GLANDS



- a) Contractor shall supply all cable glands required for glanding the above mentioned cables both at field instrument and local control panel side, junction boxes side and at control room side.
- b) Cable glands shall be Ex-proof, SS316 double compression type

#### 25.5 INSTRUMENT VALVES AND MANIFOLDS

- a) Contractor shall supply instrument valves (miniature type) and valve manifolds wherever required.
- b) Body rating shall be as per piping class or better. All valves and manifolds shall be forged type only.
- c) Valve body and trim material shall be SS 316 unless otherwise specified. Superior trim material shall be selected as requirement by process conditions. Packing material in general shall be of PTFE.

#### 25.6 INSTRUMENT IMPULSE LINES

- a) In general ½" OD annealed seamless SS 316 tubing shall be used in preference to piping.
- b) Tubing standard shall be used upto 600# only where the same is required as per job specification. For rating above 600# and hydrogen/lethal service, only piping standard shall be used. The tubing shall be 1/2" OD tube with all fittings suitable for the same. Valves used shall be threaded. At the first isolation / root valve end suitable pipe tag to tubing conversion fittings shall be used. For remote installation suitable unions / couplings shall be used.
- c) Piping standard shall be used for all installation where specified in job specification. For rating upto 600 #, the connection to the transmitters shall be with a male connector and tubing 1/2" OD. For rating higher than 600 #, no tubing shall be used. The connection to the transmitters shall be with 1/2" piping with flanges in between piping standard, all pipes shall be 1/2" NB




	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 86 OF 113		

unless higher sizes required to meet the "requirements, with all fittings suitable for the piping. All the joints shall be welded or flanged as required. For instrument end connection i.e root valve of orifices and other items, level gauges vent and "drain connection, seal welding shall be provided. For non diaphragm seal instruments and instruments where provided with threaded connection, no welding is required at instrument end.

- d) Steam, tracing of all instruments shall be considered on steam traced Process lines as per P&ID and other documents. For steam tracing of instruments SS tube & SS fittings shall be used, Tube fittings shall be double ferrule type. For each instruments steam trace bore shall be provided with steam trap duly connected to plant.
- e) All instruments shall be provided with isolation, drain and/ or vent valves with vent/drain end duly capped. This isolation valve shall be in addition to the first isolation /root valve provided on the pipe or vessel at instrument take off.
- f) For diaphragm seal type instruments, spacer ring with vent and drain connection along with vent / drain valve with end capped.
- g) Contractor shall supply flareless compression type of tube fitting and of three piece construction with design similar to Swagelok/Parker Hannifen etc.
- h) Socket-weld type forged pipe fittings of suitable material and rating shall be supplied for pipe fittings. The minimum rating shall be 3000 #. Weld neck fittings shall be used where socket weld type are not allowed by piping class.
- i) All pipe fittings shall be according to piping material specification as per piping class of the pipe on which instrument is connected. In case of vessel/equipment/reactor, PMS of equivalent piping class shall be considered.

## 25.7 INSTRUMENT AIR SUPPLY DISTRIBUTION

Instrument air headers, pipes and distributors shall be of SS 304. Instrument air manifold shall be used for supplying instrument air to control valves and other instruments. These shall be with 10 nos. of tappings and be with ½" NPT (F), SS 304 valves. From the nearby air manifold, instrument air shall be supplied to the control valves. For the purpose, all tubing shall be used shall be of SS316, 6mm, 1/2" OD, seamless tubes, laid in perforated aluminium trays. All intermediate fittings shall be double compression, SS316 MOC,. Solenoid valve operated condensate auto draining points to be provided on the header at regular intervals.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 87 OF 113		

## 26.0 FIRE AND GAS DETECTION SYSTEM (FGS)

### GENERAL:

The FGS shall be a distributed system covering all process units and comprising the following components. Integration of non process-related facilities will also be considered when requirements of these facilities are defined:

Fire Alarm System shall also cover all the buildings including all Control Rooms ()

Fire and Gas (FGS) PLC : QMR/TMR PLC for FGS of the same type as the ESD system as per ITB. This shall include smoke detectors and all points of ISD/UV/ Manual call points shall be fully addressable. VESDA not required

Fire Alarm system and Fire Gas system shall be separate independent system.

- Field and building mounted sensors and call points.
- CR controller stations, including input/output interface.
- Fire station and control building located operator monitoring stations.
- Fire station located graphic mimic panels.
- Field and building located alarm horns and beacons and activation devices.
- Field MCP shall be housed in Ex-proof type housing.



The FGS shall provide fire and gas detection and alarming functions. Output functions shall also be provided to initiate fire protection systems. (Fire water pumps start, extinguishant release, deluge, etc.).

In general, however, only a limited range of automatic actions shall be implemented and fire- fighting systems will be initiated by the FGS operator and/or fire-fighting crews.

Automatic process shutdown shall not be implemented, but the FGS shall include this capability by both direct and hardwired communication to the ESD system.

### SYSTEM STRUCTURE:

The fire and gas detectors and hardwired alarm outputs of the process units shall be connected (via connection cabinets and I/O modules) to the FGS controllers located in the Control Room (CR). The FGS controllers shall be connected on the ESD/FGS redundant (fibre optic) communication network. Connections between buildings shall be made via this network, i.e. there shall be no hardwired inter building cabling. FGS operator stations with alarm printer shall also be provided in the fire station and all

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 88 OF 113		

control buildings. These stations shall be connected on the ESD/FGS communication network to provide access to FGS data for monitoring of FGS I/O status via a series of graphic and alarm displays.

A LVS of 70" shall be provided in the Central fire station, showing a geographic layout of the with key common alarms, group alarms, system status information and fire water pump status indication (including jockey pump) and start facility. The alarms shall be connected as hardwired outputs from an FGS controller located in the fire station for this purpose.. In the Control Room common alarms for each process unit or fire zone shall be provided on the respective operator console. These shall be generated as hardwired outputs from an FGS controller located in the CR for this purpose. FGS alarm data will be logged on the common ESD/FGS Sequence of Event Recording (SER) facility located in the CR and provided as part of the ESD requisition.

#### EXTERNAL CONNECTIONS:

The FGS shall have the following interfaces to external systems:



- Redundant serial connection to DCS for process operator monitoring of fire and gas alarms.
- Hardwired interface to heating, ventilation and air-conditioning systems.
- Hardwired interface to fire protection systems (deluge systems, building extinguishant systems).
- Hardwired or serial link connection to non-process related fire protection systems.

#### FGS ALARM PHILOSOPHY:

FGS alarms are provided for three (3) purposes:

- Alert personnel to hazard to allow safe evacuation or other action as appropriate.
- Alert the FGS operator and/or fire-fighting crew to allow appropriate action to be initiated to deal with the hazard.
- Alert the process operator to allow appropriate process operation to be initiated to minimize the hazard.



	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 89 OF 113		

Alarming shall be based on fire zones defined (by others) with consideration of geographic layout, potential sources of hazard, unit operations and applicable regulations. Alarming shall be provided by means of the following:

- Hardwired audible and visual alarms located in the field and in buildings.
- FGS operator consoles located in the fire station and control rooms.
- LVS located in the fire station,.
- DCS operator consoles located in control buildings.
- Hardwired alarm lamps located on DCS operator consoles.

### **Clean Agent System**

Automatic fire detection and suppression system for control room & cabinets room shall be of clean agent type extinguishing media.

Suitable Clean Agent System as per NFPA 2001 latest edition shall be provided for All Control Rooms.

## **26.1**

### **Gas Detector**

Gas Detector of Hydrocarbon/IR type, CO/Electrochemical Type, Hydrogen/Catalytic type will be required.

Hooters/Electric Type and Beacons/Rotating Type are required.

Gas Detectors will be required at least in the following Area:

- 1) Gas Purification System (CO shift, H<sub>2</sub>S removal, CO<sub>2</sub> removal, SRU, Nitrogen wash)
- 2) Storage section
- 3) Analyser Shelters
- 4) HVAC of Control Room
- 5) All Substations
- 6) Battery Sections
- 7) Other area where Hazardous gases will be present.




Bidder to list out sufficient Gas Detectors (each type), Hooters, Beacons to cover the entire plant in consultation with PMC/Owner

## **27.0**

### **OPERATOR TRAINING SIMULATOR**

## **27.1**

### **System Description**

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 90 OF 113		

System will be a high fidelity customised process simulator. The scope of the simulator is training of fresh and experienced operators on the followings:

- DCS console operation philosophy
- Process upset and emergency operation
- Steady state operation
- Shutdown and start-up
- Operation concepts and principles

The simulator scope will not include:

- Actual plant optimization

Simulator will be developed based on process design data, not on actual operating data. The resulting accuracy will be therefore not respondent to optimisation purposes.

Furthermore, simulator models will be based on static design data. The resulting accuracy will be therefore greater for steady state situations and lower during dynamic transients.

Fine tuning of the simulator is possible, but only following to long term operating data collection and model parameters identification.

## 27.2 Description of the Simulated Process



Model shall perform also the simulation of following situations, in order to allow training on the emergency procedures:

- Start up
- Shut down
- Failure of main instruments - valve and transmitter
- Loss of various compressors
- Loss of various pump
- Loss of power supply
- Loss of cooling water

## 27.3 OTS Hardware

Hardware architecture will be composed of the followings:

- 1 (one) simulation computer and instructor workstation including 22" LED monitor and A3 colour printer

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 91 OF 113		

- Terminals will be “emulated consoles”, imitating aspect and functionality of real DCS consoles and using actual or look-alike operator keyboard.
- 1 Licensor Model PC
- 2 (Two) Field Operator Station with 24” DUAL LED monitor for operation of the field equipment and for displaying Emulated ESD Panels (switches, lights, etc) in graphical form.
- 1 No. Engineering. Station With 24” LED monitor Station
- All of the accessories necessary to get the full functionality of the system (magnetic storage devices, touch screen, mouse etc if present on the DCS, cables, etc.).

#### 27.4 OTS Software

The package will include:

- General purpose operating system license
- Real time dynamic simulation package for the considered processes, including graphic displays and a set of preconfigured typical drills
- Engineering/development facilities to allow the user to develop and modify the simulation model.
- Report and alarm logging facilities




#### 28.0 FACTORY ACCEPTANCE TEST (FAT)

FAT is inspection for verification that all equipment and devices function properly with integrity.

Prior to notification of FAT to Client/Purchaser, all the involved contractual documentation shall be completed and all the cabinets, equipment and components of DCS/ESD shall be assembled and installed in one area at one time.

Seller shall demonstrate all the function of DCS/ESD working properly in FAT. Each test shall be carried out on the procedure reviewed and accepted by Client/DEC/Purchaser after submitting Manufacturing Internal Test Certificate.

FAT certificate shall be issued by seller at the successful end of the test activities. All the hardware and software failures and problems shall be documented. All the failures and problems shall be resolved before shipment to site; all series of actions shall be taken in accordance with the FAT procedure.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 92 OF 113		

FAT will start with Visual Inspection including the following activities as minimum;

- Quantity of all the cabinets, equipment and components.
- Installation of all the cabinets, equipment and components.
- Tagging of all the cabinets, equipment and components.
- Wiring of all the cabinets, equipment and components.

Once Visual Inspection has been successfully completed, Hardware Testing shall start including the following activities as minimum;

Power-On

- Redundancy of Power Supply on failure
- Diagnostics of the main equipment
- Redundancy of the main equipment on failure
- Redundancy of network on failure
- 100% I/O Accuracy Check at 5 point (0%, 50%,100%,50% and 0%) for all the hardwired points (sample check may be allowed if 100% I/O Accuracy has been checked Manufacturer Internal Test)




Once Hardware Testing has been successfully completed, Software Testing shall start including the following activities as minimum;

- I/O Database implementation
- Graphic implementation
- Control implementation
- Logic and sequence implementation
- Historian implementation
- SER implementation
- AMS implementation

## 29.0 **SITE ACCEPTANCE TEST (SAT)**

SAT is inspection for checking that all the conditions are good after installation at site.

Prior to notice of SAT to Client/Purchaser, seller shall submit all the "As-Shipped" documentation incorporating all the FAT correction.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 93 OF 113		

Prior to start SAT, all the cabinets, equipment and components of DCS/ESD shall be installed in proper location as designed.

Seller shall demonstrate all the function of DCS/ESD working properly in SAT. Each test shall be carried out on the procedure and its criteria reviewed and accepted by Client/Purchaser.

Test certificate shall be issued by seller at the successful end of the test activities. All the hardware and software failures and problems shall be documented.

SAT shall be identical to FAT but at reduced amount to check hardware without any damage, installations completed properly and interface working properly. Seller shall provide special tools and test equipments.

### 30.0 CCTV

CCTV System IP based

All Cameras shall be installed in outdoor and PTZ type.

No. of cameras shall be sufficient for surveillance of all the units of the plant and shall be decided in consultation with PMC/Owner.




Bidder shall give a CCTV system which shall have complete provision of connecting sufficient numbers of camera in consultation with PMC/Owner.

Closed Circuit Television system for the PLANT units shall consist of the following elements:

### 30.1 DESIGN CRITERIA

The Closed Circuit Television (CCTV) system shall consist of the following units as a minimum:

- IP based Colour electronics Digital Video Camera Unit. With day and night viewing under very low light conditions.
- Video management software, Video analysis system along with LED monitors
- Server with video management software recording, storing and playing, Colour Video Monitors, Mouse-Keyboard, PC for System Administration / Management / Maintenance etc.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 94 OF 113		




- d) Enterprise Level Server and Storage e) CCTV System cabinet (same shall be matched with Marshalling and System Cabinet specification mentioned elsewhere in tender)
- f) Power supply distribution board
- g) Coaxial cables, control cables, optical cables, connector etc. of required type & size, cable glands, connectors and other accessories
- h) Network switches (Layer-2 Managed)
- i) Ceiling hung CCTV monitors (LED type) minimum 55" size or Stand mounted CCTV monitors minimum 55" size such that these can be suitably matched with control room aesthetics by dimensions, appearance etc.
- j) Network Video Recorder (NVR), will be located in main Control Room
- k) Automatic computer based switching device
- l) Media convertors (shall be IP 65 or better)
- m) System should be expandable system with provision addition of more NVRs and more cameras
- n) Data storage of minimum 90 days to be provided.

### 30.2 CAMERA UNIT

Camera unit shall consist of High resolution IP Based Digital Video Camera with inbuilt IR camera unit enclosure, remote controlled pan and tilt unit, remote controlled washer and wiper assembly, sun shield -and thermostatically controlled heaters, receiver units, junction boxes etc.

### 30.3 Video Camera

- a) The video camera shall be colour type comprising of 1/2.8" CMOS sensor with wide dynamic range and resolution 2 Mp as a minimum with Full HD 2MP minimum resolution 30x Zoom.
- b) The camera shall have Automatic Gain Control (AGC) facility with gain adjustment of typically up to 18dBA. The video amplifier shall ensure a signal to noise ratio of 50.
- c) The camera shall be able to operate satisfactorily under varied light intensity levels. The light sensitivity of the CCTV camera shall be 0.65 lux low light sensitivity in color/Normal mode, and 0.2 lux low light sensitivity in "night"

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 95 OF 113		

mode and shall be able to view objects in illumination level of 45 lux at the distance of 50 m as a minimum.

- d) Automatic lens iris control facility shall also be provided as per the background light levels.
- e) The focal length of the camera shall be based on the distance of the objects from the camera. The lens adjustment for focus control and zoom control shall be motorized and remote controllable. F=4.3 to 129 mm.
- f) The camera shall have feature of backlight compensation.

#### **30.4 Camera unit enclosure**

Camera unit enclosures in safe areas shall be weather proof to IP-65 as per IS-13947. Camera unit enclosures in hazardous areas shall meet the following requirements, as a minimum:

Weather-proof : IP-66 Type NEMA 4X

Camera unit enclosure shall be suitable for the area classification indicated in the datasheets.




#### **30.5 Pan and Tilt Unit**

The factory integrated pan and tilt arrangement shall be able to adjust camera within an angle of 0° to 360° horizontally (i.e. pan range) and a minimum of 180° (±90) vertical (i.e. Tilt range). The movement of the device shall be smooth. Pan speed shall be 6 degrees /sec and tilt speed shall be 3 degree/second as a minimum. Pan and tilt action shall be operable from video management system in control room. Pan and tilt unit shall be suitable for area classification as indicated in the datasheets. Pan and tilt units shall also be weatherproof to IP66 Type NEMA 4X. 30x Zoom shall be there.

#### **30.6 Wiper and Washer**

Wherever camera is for outdoor installation or the application necessitates. The glass window shall be provided with a wiper and washer unit. The washer unit shall comprise of washer tank, motor & pump and associated tubing Vendor shall indicate the media to be used for actual washing with requirements like flow, pressure etc. Whenever specified, the washer tank shall have a capacity of 10 litres as a minimum and the minimum flow rate of the pump shall be 0.5 litres per minute. Inbuilt Wiper shall be provided from OEM.

#### **30.7 Space Heater**

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 96 OF 113		

For outdoor applications and where there is a possibility of condensation on the glass window, the camera unit shall be provided with a thermostatically controlled anti-condensation heater.

### 30.8 Junction Box

The junction boxes for housing the accessories shall be suitable for outdoor installation with minimum IP-65 weatherproof protection and shall be certified for the specified area classification as per datasheets.

### 30.9 Camera Mounting

Cameras shall be provided with suitable mounting accessories for mounting on structures, roofs, poles. If mounted on the pole, the pole shall have ladder for camera maintenance.

### 30.10 Video Management System/Video Recording/Video Analysis

The system shall support the virtual matrix capability (i.e., software based matrix) to allow the operator to assign any camera to any local or remote monitor on the network. Also it shall be possible to Control and monitor any camera on the network.

The video management system shall be able to permit online selection of:



- Camera Units
- Monitors
- No. of views on one monitor
- Recording Commands
- Pan-tilt Control
- Sequential Switching of image on monitors
- Focus, wiper, wash and zoom operating for each camera unit.

The monitors shall be 55" colour LED monitors with necessary controls like colour brightness, contrast adjustment and monitor ON/OFF control. These functions shall be possible from the monitor front.

The camera views on the monitor shall be populated based on the operator request. The operator shall be able to view 1/4/9/16 views per monitor. The operator shall be able to enlarge the views.

The operator shall be able to view cameras through simple drag and drop commands.



	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 97 OF 113		

The system shall be equipped with the web based client software to allow users to view the cameras on the Microsoft explorer browser from any PC on the network, provided if they are given the permission and password.

The user interface shall present the operator with a camera tree that shall show the list of all the cameras and camera sequences that are available to the operator. The Vendor shall present the hierarchy of the camera tree together with the grouping of cameras and the way in which the user! operator shall interact with it.

The NVMS user interface shall have a map to allow viewing the graphical representation of the area together with allowing the operator to place camera icons on the map. The Vendor shall present the full features and operations of the map and shall present the way in which the user/ operator shall interact with the map.

The operator shall be able to perform pan/ tilt zoom/ washer and wiper unit control for PTZ cameras.

The operator shall be able to enable/ disable Motion detection for cameras.

The operator shall be able to write macros/scripts for the cameras to do the following as a minimum:


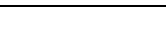
- (i) To define the sequence of cameras to be viewed on a given monitor
- (ii) To define the period and start/ stop time for viewing a camera on a monitor

The viewing and control of cameras shall be controlled by use of passwords. Two levels of password shall be provided:

- a) The operator level in which the operator shall be able to perform PTZ controls, viewing, recording and playback.
- b) The supervisor level in which the supervisor shall be able to make configuration changes in addition to the PTZ controls, viewing, recording and playback.

### **30.11 Video Recorder**




- a) Whenever specified the system shall also supplied with video recorder to record video images automatically or on manual demand. The recorder shall meet the following requirements as a minimum.
- b) The video recorder shall have disk space to store on-line video storage for duration as specified in the datasheets and access to high capacity archiving mechanisms for removal of stored video to off-line storage media.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 98 OF 113		

- c) The vendor shall size the video recorder hard disc space based on the number of cameras, number of days (minimum 90 days) for which the recording has been done, the resolution of recording and the number of frames per second to be recorded, as indicated in the datasheets. Vendor shall submit calculations/ equations for storage requirements. Use of software without supporting calculations shall not be acceptable.
- d) The system shall mark the events with time and date stamping during monitoring and recording. The system shall allow the operator to view stored information with respect to time and date of recording with scan and search of the marked events/ timing.
- e) The operator shall be able to playback the recorded events in slow and fast motion with variable speed.
- f) It shall be possible for the operator to schedule recordings for each individual camera taking place in the future. The operator shall be able to configure the Start and Stop time for the scheduled recording.
- g) The operator shall be able to exports previously stored video to DVD or latest storage option as specified in the datasheets.
- h) The exported video shall be able to retrieve archived video from DVD or the latest storage option as specified in the datasheets.
- i) Captured images or videos shall be easily distributed to any remote locations through the LAN/WAN environment, if required. The operator shall be able to export previously stored video from a recorder to any other network storage devices including a network drive. An exported file must be in MPEG-4/ MJPEG format and, as such, should be readable using any MPEG-4/MJPEG compliant decoding software..

### 30.12 Video Analysis

- a) System shall generate alarm on motion detection in areas where no motion is expected.
- b) System shall generate alarm on no motion detection in areas where motion is expected.
- c) System shall generate alarm on flare flame failure.
- d) System shall generate alarm in case fire is detected.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 99 OF 113		

- e) System shall generate alarm when toxic cloud is observed.


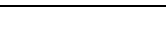
### 30.13 Alarms & Events

- a) The operator in the control room shall be able to get an indication of the faults occurring in any of the devices connected over the network. This includes faults occurring in the cameras, video encoders, computers, and video recorders. Faults occurring in each of these devices shall generate an alarm in the operator console.
- b) The operator shall be able to view the chronology of events by device, date, time and description.
- c) The system shall support logging of events for reviewing and analysis in the future.
- d) Upon detecting a fault, the system shall be able to automatically send an E-mail alert.

### 30.14 Configuration

The following facilities shall be provided for configuration of the CCTV system as a minimum:

- a) Assign an ID or name to each camera.
- b) Add/delete cameras.
- c) Change the camera details (e.g. Camera location, Camera ID, Camera number, etc)
- d) Configure the camera encoding parameters in terms of number of frames per second.
- e) Configure the camera encoding resolution in terms of setting it to CIF, 2CIF, or 4CIF.
- f) Creation of schedules for recordings.
- g) Configure recording either on demand, continuous recording or based on motion detection.
- h) Add/ delete monitors to the system.
- i) Add/ delete computers to the system.
- j) Creation of a camera group, view a camera group, view a camera sequence, and view a multiple view screen.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 100 OF 113		

- k) For an IP based system, assign IP addresses to video encoders, computers of video management system, video recorders, video wall controllers as applicable.

- l) Program external outputs based on certain events.

No interacing to be done with DCS system. It shall be independent system.

### 30.16 CCTV CABINETS




The CCTV cabinet(s), Rittal make shall house the following components: (i) Computer(s) (ii) video encoder(s), (iii) video recorder(s), (iv) control unit (v) network switches (vi) Transceiver modules, if any (vii) indoor fibre patch panel, if any (viii) VGA boosters, if any (ix) Line drivers, if any (x) Miniature circuit breakers etc. as applicable. The CCTV cabinets specification shall same as of Marshalling & System cabinet mentioned in the NIT elsewhere.

The color of the CCTV cabinets shall be matched with the existing cabinets at control room.

### 30.17 OPTICAL FIBER CABLE

The Optical Fiber Cable (OFC) used for the CCTV system shall conform to the following specification as a minimum:

- The OFC shall be CSTA (corrugated steel tape armored, electrolytically chrome plated low carbon steel) armored cable.
- The OFC shall have FRP strength member, loose tubes for single mode optical fibers filled with moisture resistant jelly, moisture barrier of polymer coated Aluminum tape or water swellable tape, inner sheath of HOPE and outer sheath of PVC.
- Optical fibers shall be single mode fibers compliant to ITV-T G 652 and fibers colours shall correspond to IEC 793-2 and 304. Optical fibers shall be coated with UV cured double acrylic resin. It should not have any reaction with cladding or core material. The coating should provide maximum resistance to micro-bending & abrasion and ensure mechanical & optical strength. The coating shall be easily stripped with mechanical tools.
- The number of fibers in the OFC shall be decided depending upon the requirement with 8 fibers as a minimum.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 101 OF 113		

- e) The cabled fiber attenuation shall be -S 0.37 dB/km for 13] 0 nm wavelength range and 0.22 dB/km for 1550 nm wavelength range.
- f) The tensile performance shall be as per IEC-794-IEI and with tensile load of 9.81 W Newton with attenuation change -S 0.05 dB/km at 1310 nm. W is weight of OFC/km.

### 30.18 Network Switch

The network switch used for the CCTV system shall conform to the following specification as a minimum:

The network Switch shall be configured to provide communication paths and provide the facility for adaptive packet and message routing through any available communication link. The network Switch shall provide the facility of multiple protocol router and bridge that provides high bandwidth connections into backbone networks for remote sites. It shall be managed switch (L2).

The network Switch shall support both intra-area and inter-area routing for transporting messages between nodes and shall support the network routing! bridging services for OSI, TCP/ IP, X.25, LAT and other industry standard wide area networks/ protocols. The network switch shall be adaptive 10/100/1000 Mbps interface port, supporting pass through Crossover adaptation of port. The network switch shall be provided with optical fiber module interface suitable for long distance transmission.

### 30.19 POWER SUPPLY



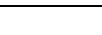
The system shall operate on 110 VAC/ 230VAC (as required) with the following specifications:

Voltage variation	± 10%
Frequency	50 Hz± 3 Hz

Any other power supply required shall be derived from this power supply by the vendor.

Power Supply distribution for all items related to closed circuit television system shall be carried out from the system cabinet itself. Vendor shall supply any hardware required for conversion/distribution. Power supply for each item shall be provided with a separate switch and fuse for isolation and protection of the system.

The CCTV system shall have the capability for future expansion to add cameras and additional storage in video recorders.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 102 OF 113		

## 31.0 TELEPHONE EXCHANGE AND ASSOCIATED ACCESSORIES

### 31.1 BASIS OF DESIGN

The system and all the equipment shall conform with all relevant and the latest edition of Indian, International, OISD and CCITT/ ITU latest standards as applicable. As a minimum, the following standards shall apply:

- IS: 2148 Flameproof enclosures for electrical apparatus.
- IS:13346 General requirements for electrical apparatus for explosive gas atmospheres.
- IS:5572 Classification of hazardous areas (other than mines) for electrical installation areas having flammable gases & vapors.
- IEC:79 (Applicable parts) Electrical apparatus for explosive gas atmosphere.
- IS:13408 Code of practice for the selection, installation & maintenance of electrical apparatus for use in potentially explosive atmospheres.
- IS:13408 Code of practice for the selection, installation & maintenance of electrical apparatus for use in potentially explosive atmospheres.
- IS:5571 Selection of equipment for Hazardous areas.

The telephone system shall be interconnected with the PA/GA systems such that communications can be automatically established by authorized subscribers of any of the systems without operator intervention.



The telephony system shall also be connected to the Public Switched Telephone Network (PSTN) through the EPABX, and shall comply with the entire telecommunication carrier's requirements; technical compatibility between the public and private networks shall be ensured.

### 31.2 Service Conditions

All the equipment shall be suitable for the site conditions as specified in design basis. Indoor equipment shall be installed in a HVAC controlled environment.

### 31.3 Area Classification

All the out-door equipments shall be suitable for installation in hazardous area and shall be Flameproof to Ex-d IIC/T6 and weatherproof to IP67 as per IEC529, irrespective of plant's hazardous area classification.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 103 OF 113		

All the outdoor equipments shall have certification for use in Zone-2, Gas group IIC/T6, irrespective of plant's hazardous area classifications and by the recognized testing and certification authorities such as 'CMRI' Dhanbad, BASEEFA (UK), UL (USA) etc., or the relevant authorities of the country of origin.

Indigenous equipment for hazardous areas shall be approved by CCEO and all flameproof equipment shall be under a valid BIS license.

The exchange shall be fit operate on the following power supply:

- a) UPS Supply voltage 230 A.C.  $\pm 10\%$
- b) Supply frequency 50 Hz  $\pm 3\%$

### 31.4

### DETAILS OF DESIGN

#### DESIGN SPECIFICATIONS:

The system shall comprise of fully microprocessor based digital central exchange(s) consisting of system control hardware, which shall be located at control room. It should be an expandable system. The system capacity shall be decided in consultation with PMC/Owner. It should support IP / Digital / Analogue phones.

A redundant interface for connecting any other Telephone Exchange.

An Internet Protocol (IP) based telephony system shall be provided. The Exchange shall have facility of connection to the LAN system with POE/non-POE switches.


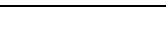
The Telephone Exchange shall be interfaced with FGS system via 2 wire, RS-485 serial interface over MODBUS. The Telephone Exchange system shall provide general failure alarm signals for presentation on the DCS system in the Control Room (CR).

The telephony system shall be interconnected with the PA/GA systems such that communications can be automatically established by authorized subscribers of any of the systems without operator intervention.

The EPABX and a Main Distribution Frame (MDF) shall be located at the control room. There shall be 100% redundancy(criss-cross) between EPABX and MDF.

CPU and power supply shall be provided with 100% redundancy.

Each office (or equivalent) telephone set shall dispose of two connection possibility points as a minimum. The additional connection points could be used either to change location inside the room or to add further telephone subscribers.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 104 OF 113		

The cable supply and installation rules shall follow the same rules than the instrumentation cables.

The telephone JB supply and installation rules shall follow the same rules as the instrumentation items.

The system shall have automatic broad casting of alarm when a fire or gas alarm signal is initiated from the fire and gas system.

Bidder has to provide complete layout of the Telephone network in its scope of the building.

Complete supply, erection of the exchange system shall be in bidder scope.

Bidder has to provide complete system in fully working condition.

### 31.5

#### **CENTRAL EXCHANGE**

The central exchanges shall be fully digital, microprocessor based freely programmable exchanges, working independent of each other. Programming shall be by means of user friendly menu driven software via a dedicated lap top, which shall also be supplied by the system vendor. The specification of laptop shall be latest Intel hardware, Microsoft OS and MS Office software at the time of supply.


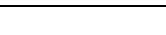
It shall be possible to program / re-program the exchange through external laptop PC, using text/graphic editor, via USB/RS 232 or other suitable interface. This shall enable the user to carry out the following operations without any additional software.

It shall be possible to interface the system with Fire Alarm system via RS485 serial interface over MODBUS protocol and with the central EPABX system via EPABX digital lines.

Complete hardware racks related to both these exchanges shall be accommodated inside control room at central cabinet room in a common panel/cabinet. The cabinet shall be fabricated out of minimum 16-gauge sheet steel, naturally ventilated, dust and vermin proof with IP-54 enclosure as a minimum. The panel shall be with swing out assembly of plug-in-card racks.. It shall be possible to locate faults by monitoring from the central cabinet.

The central exchange shall have a processor module for the control of the central exchange. The exchange shall have a completely non-blocking type switching system and associated circuitry for call recognition and acknowledgement.



	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 105 OF 113		

The offered system shall be flexible and modular in construction with the possibility of expanding to a bigger system in the future.

The construction of the type, size and make of panel, wiring, colour codes and ferruling philosophy of various signal and power cables shall be exactly same as those of DCS/ESD panel specifications as prescribed in this ITB. Panel shall be min. 1200 mm wide x 800 mm depth x 2100 mm height and of RITAL make with same colour shade as those of DCS/ESD panels.

Each of the central exchanges shall have built-in fault diagnostic unit using test and monitoring modules. It shall be possible to locate faults by visual signalling and monitoring by means of test plugs from the central cabinet.

All hardware necessary for fault isolation and troubleshooting shall be supplied as a part of the cabinet along with each exchange.

### 32.0 **LOCAL AREA NETWORK (LAN) FOR CR**

The Bidder shall lay the LAN required for Main CR area.



#### **BASIS OF DESIGN**

The system shall have as a minimum the following for CR:

1. Manageable L2- 48 port switch with 1G/10G port with 48 port Jack panel with cable manager.
2. Switch shall have with 8 redundant Fibre optic port. One redundant Fibre Optic Port shall be used for connection to main Plant LAN switch/servers.
3. Cabling shall be CAT6A cabling
4. 24 Nos 3 m/Cat 6A patch cords
5. 24 Nos 6 m/Cat6a patch cords for end user
6. UTP CAT6A cabling shall be done with one spare cable.
7. Cable and passive components shall be from AMP. I/O – 24 nos, Faceplate with cover 24 Nos.
8. Provision for LAN /telephone sockets in all rooms in all Plant buildings.

### 33.0 **Compressor Controls System (CCS)**

CCS will continuously monitor and control centrifugal compressors through performance control (including energy efficiency), remote adjustment of speed set point and anti-surge protection. Moreover a CCS may be interfaced with a Machine

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 106 OF 113		

Monitoring Systems (MMS) for machinery protective functions and with a Safety Instrumented System (SIS) for all safety and shutdown actions.

DCS shall provide the integrated operator interface for start-up, shutdown and continuous control, through delicately configured graphic displays.

CCS and its associated hardware shall be totally independent from all other DCS hardware, with the exception of communication links, and will not require the correct operation of any other system to fulfil its own functions.




The architecture shall be based on redundant data communication, control processors and power supplies. A failure of a single supply voltage shall not cause any disturbance in system function. A dedicated and independent CCS shall be provided for each compressor or each compressor train requiring CCS control in each plant area. This includes all System hardware and software, I/O and marshalling cabinets. There shall be no common equipment shared between two or more plant area, with the only exception of control, maintenance and supervision networks, and Engineering Workstation's (EWS) which will be common to all Systems present in the same DCS Area. Systems and Engineering Workstations shall be on-line for monitoring, diagnostics, configuration and software maintenance.

The Human-Machine Interface (HMI) for CCS, as per all DCS sub systems and applications, will be through DCS Operator Consoles in CR. These will include DCS Operator Workstations, auxiliary panels containing hardwired buttons and lamps, peripherals such as printers, and communication equipment.

For this purpose each CCS shall interface the respective DCS plant area through redundant communication link. No interface with auxiliary panels shall be foreseen for CCS. Interface with all other systems, including compressors local panels, shall be via hardwired signals. All interconnecting type and quantity among the CCS and other systems/subsystems shall be shown on the above mentioned drawings.

### **34.0 Instrument Workshop**

Instrument Workshop is in the LSTK bidder's scope. Bidder shall provide all the workshop equipment required for maintenance and calibration of the instruments.



	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 107 OF 113		

## ANNEXURE -1

### INSTRUMENT ACCURACIES

The instrument reference accuracies shall be as per the table below. Accuracy of the Instruments shall be minimum as follows. Custody Transfer accuracies shall be as defined in the ITB in terms of rms.




Type of Instrument	Accuracy
Process Gas Analyzer – All type	+/- 2% FS
Conductivity , pH meters	+/- 0.5 % of Reading
Belt weighers	+/- 0.5 % of range
Differential pressure & Pressure transmitter - SMART	± 0.050% of span within TD ratio of 1: 100 or better
Diaphragm seal transmitter & Pressure transmitter - SMART	± 0.10% of span within TD ratio of 1: 100 or better
Rotameter with transmitter	± 2.0% FS Note (1)
Vortex flow meter	± 0.7 % FS
Positive displacement flow meter	
- Raw material and Product	± 0.2% FS
- Others	± 0.5% FS
- Turbine meter or Mass flow meter	
- Raw material and Product	± 0.2% FS
- Others	± 0.5% FS
- Electromagnetic type flow meter	± 0.5% FS
- Mass flow meter (Coriolis Type)	± 0.1% FS
- Ultrasonic type flow meter(clamp on)	± 0.5% FS
- Ultrasonic type flow meter( 5 – path)	± 0.25% FS
- Ultrasonic type flow meter( 1 – path)	± 2% FS
Orifice plate : Normal Application	+/- 2% of flow rate
Orifice plate : Special Application	+/- 1.5% of flow rate
Venturi	+/- 1 % of flow rate
- Displacement type level indicator	± 1.0% FS
- Displacement type level transmitter	± 0.2% FS (Smart)
- Tank gauge (Custody Transfer)	± 1 mm with +/- 1 mm resolution

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 108 OF 113		

- Servo type tank gauge	± 2 mm (up to 20 m height)
- Radar type tank gauge	± 1 mm or better for custody transfer ± 5 mm or better for normal application
- Pressure gauge	± 1.0% of span for Bourdon type , 1.5% for diaphragm
- Temperature Transmitter	± 0.15 % of calibrated span for RTD & T/C
- Filled system/Bimetallic	± 1.0% FS
- Small size pressure gauge	± 3.0% FS
- Draft gauge	± 3.0% FS
- Receiver gauge	± 1.5% FS
- Thermocouple & Resistance Bulb	Applicable Codes/Standards

Note: 1. Vendor's standard accuracy is applied to local indicator type




**Remarks:** 1. Accuracy of instrument and special articles except for the above mentioned instrument shall be in accordance with the applicable codes/standards, or Vendor's standards as approved by Purchaser.  
2. FS: Full scale.  
3. Overall rangeability of transmitter except for draft range shall be 1: 100. Draft range transmitter rangeability shall be 1: 30 for the accuracy indicated above.

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 109 OF 113		

## **ANNEXURE -2**

**Field instrument connections shall be as follows.**

<b>Instrument Type</b>	<b>Process / Vessel Connection</b>	<b>Instrumentation Connections</b>
DP Flow Instruments	½" NPT (M)	½" NPT
External Displacer on Vessel ( Min. Rating ANSI 300#)	2" Flanged	2" Flanged
Internal Displacer ( Min. Rating ANSI 300#)	4" Flanged	4" Flanged
External Ball Float on Vessel ( Min. Rating ANSI 300#)	2" Flanged	2" Flanged
Internal Ball Float ( Min. Rating ANSI 300#)	4" Flanged	4" flanged
Magnetic Level Gauge ( Min. Rating ANSI 300#)	2" Flanged	2" Flanged
D/P Level	½" NPT (M)	½" NPT
D/P Level with Remote Seal Diaphragm ( Min. Rating ANSI 300#)	2" Flanged	2" Flanged
D/P Level Direct Vessel Mounted ( Min. Rating ANSI 300#)	2" Flanged	2" Flanged
RADAR – Direct Mount on vessel ( Min. Rating ANSI 300#)	3" flanged	3" flanged
GW RADAR – Side/Side Chamber Mounted on vessel (Min. Rating ANSI 300#)	2" flanged	2" flanged
Internal GWR on Equipment ( Min. Rating ANSI 300#)	4" Flanged	4" flanged
Special Level Instrument on Equipment (Ultrasonic)	2" flanged	2" flanged
Tank Level Instruments (Servo) on Atmospheric tank/ Pressurized Equipment	6" flanged	6" flanged
Tank Level Instruments (Radar) on Atmospheric tank clean service / Pressurized Equipment	8" flanged	8" flanged
Tank Level Instruments (Radar) on Atmospheric tank viscous service / Pressurized Equipment	24" flanged	24" flanged
Tank Level Instruments (Ultrasonic) on Atmospheric tank / Pressurized Equipment	2" flanged	2" flanged
Pressure Instruments	½" NPT (M)	½" NPT
Press.Gauge	½" NPT (M)	½" NPT
Pressure with diaphragm seal, (Min. Rating ANSI 300#)	2" Flanged / 3" Flanged	2" Flanged / 3" Flanged




	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 110 OF 113		

Pressure Instruments on Vessel	1 ½" Flanged	½" NPT
Pressure Instruments on Standpipe	¾" SW/BW/Flanged	½" NPT
Chemical Seal pressure Instrument gauge on Vessel	1 ½" Flanged	½" NPT
Diaphragm Seal pressure Instrument gauge on Vessel	1.5" Flanged	1.5" Flanged
Thermowell ( Min. Rating ANSI 300#)	1 ½" Flanged	1 ½" Flanged
Multipoint Temperature Element for Tanks	2" Flanged / 3" Flanged	2" Flanged / 3" Flanged
Standpipe	3" Flanged	-

Note:-

- There shall be a separate tapping for each of the instruments on any pipeline/vessel. No multiple instruments from one tapping is acceptable (for example PG and PT from single pipe line tapping with single or double mechanical isolation valves are not acceptable). However, as an exception to this, three transmitters on clean gas services from one orifice (with two pairs of tapping) is acceptable, where multiple (2 out of 3, etc.) transmitters are to be installed.
- In case of multi-transmitter installation from a single orifice, a separate identical pair of tapping to be provided with a separate transmitter i.e. no branching from a single tapping is allowed.
- Min. 3" Flanged remote Seal connection.
- All type of instrument tapping flange rating shall be minimum ANSI 300#, irrespective of minimum design pressure. However for pressure rating of 900# class and above, RTJ flange shall be used. At few locations, double isolation valves shall be used as per table given below.

INSTALLATION RATING	PRESSURE TAPPINGS	LEVEL TAPPINGS	FLOW ELEMENTS	CONTROL VALVE
300 #	SINGLE	SINGLE	SINGLE	SINGLE
600 #	DOUBLE	SINGLE	DOUBLE	SINGLE
900 # / 1500 # / 2500 #	DOUBLE	DOUBLE	DOUBLE	SINGLE

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	 
		Document No.	Rev	
		Sheet 111 OF 113		

### **Annexure – 3**

#### **SYSTEM CONFIGURATION**

The system configuration is defined as a minimum here. The Bidder has also to consider any other item defined in the Section 5.2 (e.g. , CCTV, FGS system, etc. requirements). Any other system required has also to be provided by LSTK bidder.

#### **DCS**

- 3 Nos. Operator Stations with, 24" TFT, COLOR, LED type dual monitors
- 1 no. of Membrane Operator's Keyboard and 1 no. of QWERTY engineer's keyboards with mouse with each operator station with touch screen, mouse
- 1 Nos. ES/OS dual personality, 24" TFT, COLOR, LED type
- 1 No. Supervisor Station
- 1 No. Annunciator with LED type (24")
- 1 No Auxiliary Console

#### **ESD**



- 1 No. ES/OS dual personality, 24" TFT, COLOR, LED type
- 1 No. SOE PC, 24" TFT, COLOR, LED type

#### **Printers**

- 1 No. A4 Heavy duty Black and white HP make Laser printer
- 1 No. A3 Heavy duty Colour HP make Laser printer
- 1 Nos. (70") LVS with KVM switch.

#### **Common Stations**

- 1 No. AIMS PC with 1 TB Harddisk, 24" TFT, COLOR, LED type
- 1 No. Instrument Asset Management System with HMS, 24" TFT, COLOR, LED type
- 1 No. OPC Server with interface package station, 24" TFT, COLOR, LED type
- 1 No. Documentation Node 24" TFT, COLOR, LED type
- 1 No. Fire wall / DMZ
- 1 No. Terminal Server, 24" TFT, COLOR, LED type
- Real Time data base Management System (RTDBMS) System complete with Server etc.
- OTS Hardware and software
- Mass-spectrometer (if applicable) with Laptop

	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 112 OF 113		

CCTV System

FGS system:

1 No. Unified Gateway Service Both Way system with OPC with 24" TFT Color LED monitor with requisite software/hardware for Remote Viewing.

2 Nos. View station for top management connected to PLANT LAN via Firewall / OPC, 24" , COLOR, LED type.

Suitable Hardware, software & support (erection, commissioning) required for the interface of the Syn Gas Purification Plant Control system; with 1 nos. Operator Stations placed in different Control Room within the plant complex (approx. Distance 1 km.) through redundant fibre optic cable communication.


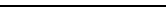
Provision of additional 100 IOs wired upto Marshalling Cabinet/System cabinet separate from Spares shall be considered to integrate other Packages. It shall also be considered in Controller loading.

### **Analyser PLC**

One Analyser PLC with laptop for each Analyser shelter shall be provided with redundant connectivity to Control Room.

### **Annexure – 4**



	<div>SYNGAS PURIFICATION UNIT</div> <div><u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>Design Philosophy Instrumentation</div>	PC288/E/P-II/ SEC-5.2	0	
		Document No.	Rev	
		Sheet 113 OF 113		

**Indicative Sample format for PTR**

Customer	Plant Location	Plant Type	Feed	Licensor	Status	Year of Supply	Model

	PROJECTS & DEVELOPMENT INDIA LTD	GSTD-0001	0	
			Rev	
		SHEET 1 OF 34		

# GENERAL SPECIFICATION

## FOR

## ANALYSER SHELTER


0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0	
			Rev	
		SHEET 2 OF 34		

### **Instruction to the Bidder**


1. The Vendor shall submit complete Analyzer shelter GA drawings, BOM , HVAC details, BOM etc.
2. The construction of each analyzer house shall be prefabricated in press-formed stainless steel sheet. The materials of construction shall have a fire resistance of two hours minimum in accordance with UL 555 and NFPA Standard 90A
3. Vendor shall supply the **complete redundant air conditioning, venting, heating and/or house pressurization system**
4. **ORDER OF PRIORITY**
  - A) Instruction to Bidder
  - B) Design Philosophy
  - C) SHELTER SPECIFICATION

In case of conflict, it shall be brought to notice of PDIL / OWNER for conflict resolution.

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0	
			Rev	
		SHEET 3 OF 34		


## CONTENTS

1.0	GENERAL
2.0	DESIGN AND CONSTRUCTION
3.0	NAMEPLATE
4.0	INSPECTION AND TESTING
5.0	UTILITY SERVICES
6.0	SAFEGAURDING SYSTEM
7.0	ELECTRICAL UTILITIES
8.0	DOCUMENTATION
9.0	PACKING AND SHIPPING
10.0	SERVICE AND SUPPORT
11.0	SPARES
12.0	SHIPPING

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0	
			Rev	
		SHEET 4 OF 34		

#### Abbreviations:

AARH	Arithmetic Average Root Height
CMRI	Central Mining Research Institute
DCS	Distributed Control System
DPDT	Double Pole Double Throw
Deg C	Degree Centigrade
ERTL	Electronics Regional Testing Laboratory
NPT	National Pipe Threads
AMS	Analyzer Management System
ESD	Emergency Shutdown System
FAT	Factory Acceptance Test
HVAC	Heating Ventilating & Air Conditioning
PLC	Programmable Logic Controller
SAT	Site Acceptance Test
SCS	Sample Conditioning system
UPS	Uninterruptible Power Supply

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0
			Rev
		SHEET 5 OF 34	

## 1.0 GENERAL

### 1.1 Scope

The main purpose of an analyzer house/shelter is to ensure continuity of safe operation of analyzer systems at a specified rate of reliability by providing a suitable operating environment for analyzers which cannot otherwise operate properly. i.e. if exposed to outdoor or ambient conditions. the operating environment may be affected by requirements concerning

- Outside Area Classification **EX. PROOF ZONE-2 GR IIC T4**
- Inside Area Classification **EX. PROOF ZONE-1 GR IIC T4**
- Environmental conditions, mainly temperature and humidity
- Sample handling and conditioning
- Effective maintenance

Hazardous situation arising from the toxicity of gases and vapors which have to be handled shall be the subject of a special study, on the basis of which the appropriate measures shall be decided on and submitted by Vendor to client for approval

The following measures are necessary to ensure the safe conditions in the Analyzer house:

- The quantity of flammable materials retained in the analyzer house shall be kept at minimum.
- An efficient ventilation system shall be provided to continuously dilute any internal release of flammable gas or vapors, in order to reduce the concentration at all time below 20% of the lower explosion limit.
- The provision of safe disposal arrangement for samples.

## SCOPE OF SUPPLY

### WORK INCLUDED


Analyzer house vendor shall be responsible for the design, fabrication, construction and commissioning of each house. The house shall be delivered as a fully assembled analyzer house complete with all monitoring equipment, sampling systems, calibration gas supports, tubing, The electrical equipment, fire and gas detectors, alarm beacons, annunciation panel, safe guarding system and HVAC equipment in place, wired and connected.

For Field mounted analyzers, Vendor shall be responsible for the design, construction and commissioning of shelter along with the sample conditioning system, sample lines including sample probes and test or calibration gases.

The analyzer house vendor shall be responsible for the supply of all associated auxiliary equipment that will be mounted remotely from the analyzer house and for field mounted analyzers.

The analyzer house vendor shall supply all the necessary calibration gas cylinders for each analyzer.

Vendor shall be responsible for the installation and commissioning of Analyzer Management System along with all necessary hardware in analyzer house, SRR and Central Control Building (CCB).

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0	
			Rev	
		SHEET 6 OF 34		

## STANDARDS

1.1.1 This specification, together with the data sheets covers the requirements for the design, materials, nameplate marking, inspection, testing and shipping of analyzer shelter with HVAC system complete with accessories, which are required for housing industrial process analyzers and their associated piping, wiring and auxiliary instruments.

1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the purchaser's enquiry :

ANSI/ASME American National Standards *Institute*/American Society of Mechanical Engineers.

B 1.20.1 Pipe Threads General Purpose (Inch)

ANSI/ASME B 31.3 Chemical plant & Petroleum refinery piping

B 16.5 Pipe Flanges and Flanged Fittings *NPS* 2 through *NPS* 24

B 16.20 Metallic Gaskets for Pipe Flanges, Ring Joint, Spiral wound and Jacketed.

EN 10204 Inspection Documents For Metallic Products.

IEC-60079 Electrical Apparatus for Explosive Gas Atmosphere.

IEC-60529 Degree of Protection Provided by Enclosures (IP Code).

IEC-61000-4-X Electromagnetic Compatibility for Industrial Process Measurement and Control Equipment.

IEC-61511 Functional Safety instrumented system for the process industry sector.

IS-13947 Specification for Low Voltage Switch gears and Control gears.

IEC-61285 Industrial Process Control - Safety of Analyser Houses.

IS-2148 Electrical Apparatus for Explosive Gas Atmospheres-Flame proof Enclosures d'.

IS-5780 Intrinsically safe electrical apparatus and circuit electrical equipment with type of protection 'i'.

NFPA496 National Fire Code

API RP 540 Electrical Installations in Petroleum Processing Plants


API RP 551 Process Measurement Instrumentation

API RP 552 Transmission Systems

API TP 555 Process Analyzers

NACE MR-01-75 Sulphide Stress Cracking Resistance Metallic Materials for Oil Filled Equipments

ASTM A269 Seamless Welded Austentic Stainless Steel Tubing For

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0	
			Rev	
		SHEET 7 OF 34		

## General Service

C15 Procedures for Cylinder Design Proof and Service Performance Tests

IEC 60079-016 Electrical Apparatus for Explosive Gas Atmosphere Part16  
– Artificial Ventilation for the Protection of Analyzer houses

NEMA ICS6 Industrial Control and System Enclosures

NFPA Standard 90A Two hour fired rated

NFPA 496 Standard for Purged and Pressurized Enclosures for Electrical Equipment

BS 476 Test on Building Materials and Structures

BS 3463 Observation and Gauge Glasses for Pressure Vessels

IS 2147 Degree of protection provided for enclosure

IS 2148 Flameproof enclosure for electrical apparatus

IS 875 Part (3) 1987 Indian Wind Code

IS 5771 Guide for the Selection of Electrical Equipment for Hazardous Areas

IS 5572 Classification of Hazardous Areas (other than Mines) having Flammable gases and vapours for Electrical Installations

EEMUA (Engineering Equipments and Material User Association) – Design and Installation of On Line Analyzer System

IS 5572 Classification of Hazardous Areas (other than Mines) having flammable gases and vapours for Electrical Installations

UL 555 Fire and Smoke Dampers

1.1.3 In the event of any conflict between this specification, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:


- a) Statutory Regulations
- b) Data Sheets
- c) Standard Specification
- d) Codes and Standards

1.1.4 Purchaser's data sheets specify the minimum acceptable materials. Alternate superior material construction shall also be acceptable provided vendor assumes complete responsibility for the selected materials for their compatibility with the specified operating conditions.

## 1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to vendor attached with the material requisition.




	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0
			Rev
		SHEET 8 OF 34	

1.2.2 Whenever a detailed technical offer is required, vendor's quotation shall include the following:

- a) Compliance to the specifications.
- b) Whenever the requirement of detailed specification sheet for analyser shelter is specifically indicated, a detailed specification sheet for each analyser shelter shall be furnished, which shall provide all the details regarding type, material of construction as applicable. The material specifications and the units of measurement for various parts in vendor's specification sheet shall be to the same standards as those indicated in purchaser's data sheet.
  - c) Proven references for each offered analyser shelter inline with clause 1.2.3 of this specification.
  - d) General arrangement / Layout drawing of each shelter.
  - e) List of utilities with expected consumption of each shelter.
  - f) A copy of approval from local statutory authority, as applicable, such as Petroleum and Explosive Safety Organization / Chief Controller of Explosives (CCE), Nagpur or Director General of Mines Safety (DGMS) in India, for the electrical and electronic equipments installed in electrically hazardous area along with:
    - i) Test certificate from recognized test house like CMRI/ERTL etc. for flameproof enclosure/intrinsic safety, as specified in the data sheet, as per relevant standard for all Indian manufactured equipments or for items requiring DGMS approval.
    - ii) Certificate of conformity from agencies like LCIE, BASEEFA, PTB, CSA, FM, UL etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.
  - g) Deviations on technical requirements will not be entertained. In case vendor has any valid technical reason, they must include a list of deviations tag number wise, summing up all the deviations from the purchaser's data sheets and other technical specifications along with the technical reasons for each of these deviations.
  - h) Catalogues giving detailed technical specifications, model decoding details and other related information for each type of analyser shelter and other equipments / instruments covered in the bid.

1.2.3 All items, as offered, shall be field proven and should have been operating satisfactorily individually for a period of minimum 4000 hours on the bid due date in the process conditions similar to those specified in the purchaser's data sheets. Items with proto-type design or items not meeting provenness criteria specified above shall not be offered.

1.2.4 All documentation submitted by vendor including their quotation, catalogues, drawings, installation, operation and maintenance manual etc. shall be in English language only.

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0
			Rev
		SHEET 9 OF 34	

1.2.5 Vendor shall also quote for the following:

- a) Unit rate of any special items.
- b) Any special tools and tackles needed for maintenance work. In case no special tools are necessary for maintenance for the offered shelter, vendor must certify the same in their offer.

### 1.3 Drawings and Data

1.3. Detailed drawings, data, catalogues and manuals required from the vendor are indicated by the purchaser in vendor data requirement sheets. The required number of reproducible, prints and soft copies shall be dispatched to the address mentioned, adhering to the time limits indicated.

1.3.2 Final documentation consisting of design data, installation manual, operation and maintenance manual etc. submitted by vendor after placement of purchase order shall include the following, as a minimum:

- a) Specification sheet for analyser shelter and its accessories.
- b) Certified drawing for each analyser shelter, which shall provide following details;
  - i) Overall / Mounting Details of the complete shelter in millimetres
  - ii) Clearance space required for maintenance work.
  - iii) Schematic diagram for the complete assembly including utilities required for the shelter.
  - iv) Heat load calculations and dehumidified air flow rate calculation.
  - v) LEL level of gases present with calculation for safe limit dilution of inside shelter air.
- c) Copy of type test certificates
- d) Copy of the test certificates for all tests indicated in clause 4.0 of this specification.
- e) Installation procedure for analyser shelter.

### 1.4 Definitions


#### 1.4.1 Analyser Shelter

Enclosed prefabricated building or part of a building containing process / stack analysers and associated equipment where streams for analysers are brought in and which is regularly entered by authorised personnel for operation and maintenance.

1.4.2 Analyser Shed Structure with one or more sides open and free from obstruction to the natural passage of air, in which one or more analysers are installed. The maintenance of the analyser is normally performed in the protection of the shed.

#### 1.4.3 Analyser rack

An open analyser mounting structure with / without canopy used for mounting analysers, sample handling system and their accessories individually or together in combination.

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0	
			Rev	
		SHEET 10 OF 34		

#### 1.4.4 Analyser cabinet

Small housing in which analysers are installed individually or grouped together.  
Maintenance is performed from outside the cabinet with door(s) open.

### 1.5 LOCATION AND SIZE OF ANALYZER HOUSE

In general, Analyzer house shall be located in Non-hazardous area. Where this is not possible, the highest area classification acceptable for the location of an analyzer house shall be Zone 2.

Analyzer house and field mounted analyzers shall be located as close as practically possible to their relevant sample points in order to minimize sample transport lag and prevent sample degradation. Analyzer house location under pipe racks or other structures shall be avoided.

Additional to the requirements of IEC 61285, the location of analyzer house or shelter

- Shall be at least 15meters away from furnace / reactor.
- Shall be such that the vibration level does not exceed that specified for the equipment accommodate inside the analyzer house
- Shall be free from spills of water and process liquids

Vendor shall size each analyzer house. The analyzer house size shall take into consideration the size of each analyzer plus an allowance **for 30%** spare on both inside and outside walls for future analyzer and sample conditioning systems. Analyzers shall be installed along the longitudinal walls of each house; they may be mounted on the wall, using 'Unistrut' or equal or on free standing racks in such a way that all parts are freely accessible for maintenance. The analyzers shall bear clear identification plates stating their service. The preferred analyzer house sizes are listed below, vendor to select the best suited for the application :


- TYPE 1 – 3m(L) x 3m(W) x 2.8m(H)
- TYPE 2 – 4m(L) x 3m(W) x 2.8m(H)
- TYPE 3 – 6m(L) x 3m(W) x 2.8m(H)
- TYPE 4 – 8m(L) x 3m(W) x 2.8m(H)
- TYPE 5 – 10m(L) x 3m(W) x 2.8m(H)

The minimum walk space between fixed obstacles should be 1 meter taking into account the constraint that cabinet doors may be locked in the open position on one side. There shall be sufficient clearance between cabinets and equipments to allow for maintenance access. Sufficient space shall be provided inside the analyzer house for installation of sink, work bench and auxiliary equipment such as control units and if required recorders, signal converters, printers, computer terminals, etc.

### 2.0 DESIGN AND CONSTRUCTION

#### 2.1 General requirements

- The construction of each analyzer house shall be prefabricated in press-formed stainless steel sheet. The materials of construction shall have a fire resistance of two hours minimum in accordance with UL 555 and NFPA Standard 90A. The material shall be resistant to attack from oil and chemicals and other environmental factors such as high humidity and solar radiation, etc. All fittings, supporting framework, cable trays etc. shall be compatible with the house construction to minimize corrosion. Vendor shall indicate their proposed type of construction in the offer.
- When the house structure is used for equipment support, there shall be sufficient rigidity to minimize vibrations. If required, anti-vibration pads and flexible pipe connections shall be used to isolate vibration sensitive equipments from the pipe work or structure.

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0	
			Rev	
		SHEET 11 OF 34		


- Each analyzer house shall have unobstructed internal headroom of at least 2.5mtr. Dead corners, trenches and spill or drain pits that may collect gases are not allowed inside the house.

- 2.1.1 The analyzer shelters are provided for housing industrial process analyzers and their associated piping, wiring and auxiliary instruments. The analyzer shelters are designed:
- a) To create a space within a hazardous area (Zone-I) in which under normal operating conditions a non hazardous atmosphere exists, so that testing or calibration of analyzers and maintenance can be performed with opened casings and electrical circuits alive.
  - b) To create a controlled environment in which analyzers and their associated equipment are adequately protected against adverse weather conditions.
- 2.1.2 The analyzer shelter shall be fully prefabricated, assembled, tested and shall be supplied as ready-to-install at project site with all items including analyzers and their accessories duly mounted, wired, tubed and tested before shipment.
- 2.1.3 The arrangement of equipments shall be such that it provides enough access to front/back/sides of the equipments as necessary during normal operation as well as during start up and maintenance. Sufficient space shall be provided for workbench, signal and power cables entries and routing, power sockets, utility supplies, auxiliary and control equipments. Suitable arrangements shall also be made for locating devices like recorder, portable printers etc. near each equipment.
- 2.1.4 Shelters shall be equipped with all safety measures like panic bar at the doors, Emergency alarm push buttons, LEL gas (hydrocarbon) detectors, Fire detection system, warning panels, Fire extinguishers, wash basin etc.
- 2.1.5 Shelter shall be provided with ventilation and air-conditioning to maintain the temperature and humidity suitable for the analyzers stable performance, maintenance and human comfort.
- 2.1.6 Shelter shall be provided with both internal and external lighting for proper operation and maintenance.
- 2.1.7 All electrical equipments, fittings, fixtures shall be Flame proof suitable for hazardous area classification.
- 2.1.8 Analyzer shelter shall be sized considering 30 % additional spare space and facilities like HVAC load, power load etc. for future use.
- 2.1.9 The design shall be in compliance with the electromagnetic compatibility requirements as per IEC 61000-4.

### 2.1.1 Design Consideration

Analyzer house design calculations shall be based on the following loads:

- Dead load including weight of analyzers, analyzer house, HVAC equipments, and all other equipments forming the part of installation
- Fixtures for HVAC equipment
- Transport loads (Vertical & Horizontal)
- Live loads including furniture & analytical equipment trolley, etc.
- Roof live load and concentrated loads

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0
			Rev
		SHEET 12 OF 34	

• Wind & rain loads

If straightening or flattening is required, it shall be accomplished in a manner that will not damage the material or detract from its appearance

### WALL

The External walls of Analyzer house shall be fabricated from 2mm thick Stainless Steel sheet. All mating joints shall be fully welded and fixed by welding to a main support frame and each section to have gussets welded in position.

The Interior walls of Analyzer house shall be of a smooth design and fabricated from 1.5mm thick Stainless Steel sheet. The inner wall panels may be riveted in place provided that the panels are suitably sealed against the framework and that the floor is continuously extended vertically at the walls to provide a continuous skirting 150mm high (not at doors).

Each analyzer house shall have mineral fiber insulation (UL Approved for fire resistant construction) sandwiched between the inner and outer walls to meet the 2 hour fire rating. The insulation shall have a minimum thickness of 75mm. Asbestos or other hazardous material for insulation shall not be used. Vendor shall consider the use of stiffeners between cavities. Vendor shall ensure that gas or liquid cannot build up within the cavity.

Additional wall supports shall be provided as required to adequately support all wall mounted equipments. Equipments shall be mounted using supports bolted to the inner wall.

### ROOF

Analyzer house roofs shall be constructed of the same material as the main house (stainless steel) and be insulated. Houses shall have a centre pitch for rainwater drainage, complete with gutters and down pipes and designed to withstand uniform loadings at 0.75kMN/m<sup>2</sup>. The rainwater drainage system shall be sized to cope with the rainfall of 61mm/Hr and 522mm/24Hr.

Roof and ceiling panel shall be made of 18(1.3mm) gauge stainless steel sheet as minimum.

Roof shall be flat type with minimum practical slope of 25mm per meter.

Roof panels shall provide a net overhang of 300mm on all sides. The analyzer house shall have a canopy along each side of the house to protect external equipments. They shall be designed to withstand a wind speed of 50m/s. This canopy shall be "free venting".

Roof panel joints shall be interlocked in such a way to provide a complete watertight fit.

### DOORS

Analyzer house door shall be constructed of the same material as the main house (Stainless Steel).

Each analyzer house shall have outward opening doors at both the ends. One door shall be used as main entrance and other shall be used as Emergency exit. The minimum dimensions for both the doors shall be 900mm wide and 2100mm high. It shall be possible to remove all analyzers or other equipments installed inside the house through main entrance without disassembly.

Doors shall be hung on three recessed stainless steel butt hinges and fitted with weather strips. Each door shall have suitable gasket to prevent ingress of air, rain, etc. and loss of conditioned air and heat.

Each door shall be fitted with a panic bar and self closing spring system. Two hour fire rated double glazed viewing panels shall be fitted on each door, constructed from shatterproof safety glass and installed with suitable gaskets. Each door shall have lock with a master key for main entrance.

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0
			Rev
		SHEET 13 OF 34	

Both the doors shall be fitted with limit switches which shall initiate an alarm if left opened for longer than 30 Seconds.

### FASTENERS

Bolts, nuts, and washers for structural connections shall conform to ASTM A325, and shall be hot dipped galvanized. Prior to final bolting, all galvanized A325 bolts shall be lubricated.

All sheet metal and/or self-tapping screws, self-drilling screws shall be Class 410 stainless steel.

Fasteners which penetrate the wall or roof covering shall be installed with a neoprene washer under the head.

### FOUNDATION & MOUNTING

Each analyzer house will be mounted on a concrete base which shall be impervious to hydrocarbons (supplied by Client). Vendor shall use fully welded Durbar floor plates (or equal). The floor shall be coated with a durable anti-skid, acid resistant epoxy coating on wear surfaces. The floor of the analyzer house shall slope to the door(s). The doors shall not have an entry lip. This will allow any spillages to be swept out of analyzer house.

The Supplier shall supply detailed drawing mentioning the location, alignment and size of the anchoring bolts.

There shall be no openings at the base of the Analyzer House, including around support members.

The Analyzer Shelter shall be designed with provisions for a building-to-foundation seal after installation upon the concrete slab or structure.

The base of the Analyzer Shelter shall be minimum 6 inches (150 mm) deep steel channels and/or beams, which will also serve as the skid for shipping.

The skid frame shall be designed to support the Analyzer House with all the equipment while being lifted.

The skid shall be designed so that it is flush on all sides with the outside walls of the Analyzer House. The joints between the sidewalls and the base shall be sealed.

Lifting of each analyzer house shall be by Vendor specified "eye-bolts", mounted on each analyzer house roof, at suitable locations and sized to take load of analyzer house fully fitted with all equipments. If any special equipment such as Spreader Bar is required, they shall be supplied by House seller.


### PAINTING

After primer has cured, two finish coats of epoxy resin, fire retardant paint shall be applied. The surface preparation and painting shall not be carried out until all welding is complete, including all brackets, mounting plates, etc. Surface finish should be applied to all external and internal surfaces including surfaces that will be enclosed with the double skin.

### ALYZER SHELTER

The analyzers which are not mounted in Analyzer house shall be installed in a Shelter.

Shelter shall be provided with its own lighting and local switch mounted outside of the shelter

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0	
			Rev	
		SHEET 14 OF 34		

certified for use in the hazardous area in which it is located.

The power isolation switch for each analyzer installed inside the shelter shall be supplied by Vendor.

There shall be main power isolator switch mounted outside the shelter suitable for the area classification.

Shelter shall be so designed and constructed to allow free ventilation such that equipment contained within them can be certified the same as the area classification.

## 2.2 Construction

2.2.1 The shelter shall be constructed using materials capable of satisfying all the functional requirements and shall not create any safety hazards.

2.2.2 The design and construction of the shelter shall be self-supporting type and shall be sized to house required analyzers, their sample conditioning system and other accessories. Shelters shall also be provided with suitable transportation arrangement.

2.2.3 The base structure of the shelter shall be constructed using suitable size T beams, channels, and angles, welded properly and adequately. All structural members shall be sized to ensure structural rigidity and to prevent deformation during dragging, lifting, loading and unloading operations of the shelter.

2.2.4 The floor shall be fabricated from anti slip and non- corrosive Aluminium plates as a minimum, strong enough to withstand load of all equipments and at least 1 O-maintenance personal. It shall also be unaffected during transportation and various other obvious forces and shall be sealed to prevent any loss of ventilation pressure.

2.2.5 External sidewalls shall be ribbed interlocking stainless steel sheet of thickness 2mm and internal walls shall be stainless steel sheet of thickness 2mm. The walls of the shelter shall be strong enough to take load of the rack mounted analyzers, related sample conditioning system and associated accessories.

2.2.6 The shelter roof shall be capable of supporting the combined weight of at least 4 men without permanent deformation and shall be sealed properly to prevent loss of ventilation pressure and entry of rain and jet water.


2.2.7 Lifting of the complete shelter along with all analyzers, sample conditioning systems and associated accessories mounted in it shall be assured by means of suitably designed lifting lugs.

2.2.8 The walls and roof shall be insulated by using glass wool of high density and low thermal coefficient, of adequate thickness commensurate with the HVAC design.

2.2.9 The shelter shall be provided with a main door and an emergency door opposite to main door. Both the doors shall be opening outwards, provided with wire reinforced safety glass window, automatic spring door closer opening by simple push, fitted with panic bar for use in case of emergency. The main door shall be provided with outside pad lock holes. Warning light shall be provided at both the Main door and the emergency door indicating the Hydro carbon presence within the shelter.

2.2.10 Extension roof (overhang) made of stainless steel sheet shall be provided all along the walls of the shelter and over the sampling system for protection of the sampling system and



	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0	
			Rev	
		SHEET 15 OF 34		

maintenance personnel from the direct weather conditions. The extension roof shall be overhung at least 1000 mm outside the analyzer shelter.

- 2.2.11 A nameplate with the analyzer shelter number shall be fixed near the main door and emergency door. Tag numbers of the analyzers shall be fixed near the main door. Tag Numbers of each analyzer and sampling system shall be fixed near the respective items. All inlet & outlet tube/ pipes shall be provided with tag number & proper identification numbers engraved in the stainless steel plate. All electrical wires/ leads shall be identified inside the junction *box* equipment by proper plastic ferrules. All cables shall be identified with stainless steel plate engraved tag nos. / identification numbers.
- 2.2.12 Provision shall be made for keeping all fast loop devices, distribution devices outside the shelter. A suitable restriction orifice shall be provided in each sample line to limit the sample flow not exceeding thrice the normal flow in the event of tube rupture/opening of the tube down the line.
- 2.2.13 All pipes which introduce flammable gases inside shelter shall have readily accessible shut off valves.


### 2.3 Safety considerations

- 2.3.1 Analyser shelter shall be provided with pressurisation/purging with fresh air with air changes as per specs to make it safe for installation, operation and maintenance of analysers.
- 2.3.2 All junction boxes and electrical equipments shall be explosion proof as per area classification.
- 2.3.3 All analysers installed shall be suitable for working as per inside area classification even without fresh air purging / pressurisation.
- 2.3.4 The equipments which are not suitable for inside area shall be de-energised in case of ventilation failure and gas detection.
- 2.3.5 Warning panels, alarm annunciator, and repeat contacts to control room shall be provided for safety related parameters.
- 2.3.6 Gas detection, fire detection and oxygen deficiency detection shall be provided as per specs.
- 2.3.7 A PLC shall be provided to execute safety logics. PLC shall have redundant CPU. PLC shall be mounted in Ex-proof enclosure. PLC fault shall be annunciated.

### 2.4 Warning Panels

- 2.4.1 The following safety related local alarms / indicators shall be generated and displayed:
- Ventilation failure
  - Flammable gas detected (> 20%)
  - Fire detected
  - Oxygen deficiency
  - Gas detection Instrument fault
  - Manual emergency (panic)



	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0	
			Rev	
		SHEET 16 OF 34		

2.4.2 These alarms shall be supported at the following locations:

- Inside shelter on annunciator panel
- Near shelter doors on warning panels
- Potential free repeat contacts shall be provided for connection to Purchaser's

## 2.5 Hazardous Area Classification

- Hazardous area classification shall be as indicated in the job specification ~or outside the shelter. Hazardous area for inside the analyser shelter shall be considered as IEC Zone-I Gas Group IIC , temp. class T3 considering pressurization failure condition. All equipments inside the analyser shelter shall be suitable for operation in area classification under pressurization failure condition.
- Non explosion protected equipments will be de-energised in case of pressurisation failure and gas detection.
- Restart of such equipments shall not be possible without appropriate authorization.

## 2.6 HVAC System for Analyser Shelter

### VENTILATION AND AIR CONDITIONING

#### GENERAL

- The purpose of ventilation and air conditioning system is to provide
- A safe operating environment for equipments and personnel
- The required climatic conditions for optimal equipment performance
- A sustainable climate for the comfort of personnel in line with local regulations and/or practice
- To dilute flammable or toxic gases and/or vapors that may accidentally escape from equipment inside the analyzer house to a non-hazardous level around any potential means of ignition
- To keep house pressurized to prevent possible entry of flammable or toxic gases from the outside atmosphere into the house
- Vendor shall supply the **complete redundant air conditioning, venting, heating and/or house pressurization system.** The system shall be capable to maintain the inside house conditions as mentioned below:
  - ☐ Temperature  $24^{\circ}\text{C} \pm 2^{\circ}\text{C}$
  - ☐ Pressure 5 – 10 mmwc
  - ☐ Humidity 50% RH  $\pm 5\%$

Suitable temperature and pressure indicators shall be provided inside the house by Vendor. Pressure switch shall be provided to initiate an alarm on loss of house pressure.

Each analyzer house shall have common fresh air intake via a stack mounted on the analyzer house roof. These stacks shall be provided with a rain hood and a mesh to prevent entry of birds etc. also adds tie bars for support of stack. The air shall be drawn from a non-hazardous area and the air intake location shall be at least 1 meter outside the hazardous area. The design of the intake duct and the diameter and length shall be sized by Vendor so as to limit the air velocity inside the ducting to a maximum of 8m/second. The intake stack shall have filters 5 microns down to 99% efficiency, fire dampers and louvers.

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0
			Rev
		SHEET 17 OF 34	

All duct penetrations through fire rated walls shall include fire and gas dampers manufactured and installed in accordance with the requirements of UL 555 and NFPA Standard 90A.

The dampers Shall have a two hour fire rating and shall spring close tight when released by a fusible link or by a Fire and Gas signal. The direction of the air flow within each house shall ensure air movement throughout, and around all equipment installed inside, irrespective of wind direction and strength.

The inlet ducting shall be fabricated from hot dipped galvanized steel to BS729, the size of the ducting shall be such that air velocities inside will not create noise level which exceed 70dB(A).

The flow of air from the HVAC unit shall be sufficient to dilute escaping gas or vapors, resulting from the failure or rupture of any sample or service line, to less than 20% of LEL around any potential sources of ignition and to maintain house pressure 5mmH<sub>2</sub>O above the atmospheric pressure to prevent entry of hazardous gas.

Vendor shall ensure for each analyzer house the ventilation rate at least 10 volume changes per hour or at least 20m<sup>3</sup> of air per installed analyzer per hour, whichever is greater, to dilute any flammable gas or vapor to a non-hazardous level.

Two pressurization fans each rated at 100% of the design duty with automatic changeover shall be provided with each analyzer house. The fan motors shall be suitable for use in Zone 1 area. The fan shall be non-sparking type. The ducting to the fan inlet shall be protected from the ingress of rain water or significant blowback by wind, and shall be complete with a wire mesh screen to prevent the entry of birds, vermin or particulate matter. Neither wind speed nor direction shall have any effect on the ventilation.

Analyzer house shall be air conditioned by air handling units. The unit shall comprise of fan section, pre-filter (EU3) direct expansion cooling coil and refrigeration compressor and associated air cooled condenser. This equipment, including any controls, shall be suitable for use in a Zone 1 area.

Air shall enter the analyzer house at ceiling level from ducting via openings with adjustable flow diverters to facilitate a proper direction and flow of air throughout the analyzer house. The ventilation air shall escape from the house through vertical ducts at two opposite corners of the house, via louvers with adjustable openings.

The ducts should be installed on the outside of the short walls and connected to the interior of the analyzer house by openings in these walls which are flushed at floor and ceiling level to allow escape of gases and vapors both heavier and lighter than air.


There shall be separate power supply for the ventilating fans and shall have tripping circuit to trip the motors in case of fire.

Each fan support and casing construction shall be of adequate rigidity to prevent resonance and vibration. The fan bearing support shall be the part of fan casting.

Low flow switch shall be provided with each fan to detect air flow to the house. The switch shall be set to indicate flow failure when flow falls below 60% of design flow. A time delay of 1 min. to be provided to avoid spurious operations due to short term disturbances. Low flow alarm shall initiate visible (lamp on annunciator) and audible alarm and makes change over to the other system.

During start up of the house, both the HVACs shall run for the predefined period.

Reset buttons for both the HVAC units shall be provided on safeguarding panel. This switch shall be used to reset the latched HVAC unit alarm. The alarm latching is required to avoid the changeover to

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0
			Rev
		SHEET 18 OF 34	

the same HVAC unit until it is attended to.

- 2.6.1 Vendor shall design, engineer, procure, manufacture, inspect & test at works, shop-paint, pack & forward, transport, supply install, test and commission the HVAC System for Analyser Shelter complete with all auxiliaries required for efficient & satisfactory operation. Vendor shall carry out Performance Guarantee (PG) test at site to prove the Guaranteed Parameters. The specifications for HVAC system shall be as detailed in 2.6.2 for Analyser Shelters located in hazardous area and 2.6.3 for Analyser Shelters located in safe area.

## 2.6.2 HVAC System for Analyser Shelter Hazardous Area

- 2.6.2.1 Analyser Shelters shall be air conditioned and pressurized to prevent the entry of flammable gases & vapours and combustible dusts.

- 2.6.2.2 Air Conditioning and pressurization shall be achieved by providing packaged type HVAC units as per manufacturer's standard practice.


- 2.6.2.3 Pressurisation system shall be provided for analyser shelter with 2 nos of HVAC system (one working unit and one standby unit) each of same capacity without any common / sharing components. Fresh air shall be taken from safe area. Fresh air intake arrangement comprising of fresh air blower with drive & back draft dampers, cleanable type filter (95%, 5 micron) and bird screen etc. shall be provided. Relief dampers shall be used to exhaust room air at 5 mm WG over pressure. Shelter internal positive pressure shall be maintained at 2.5 mm WG minimum. Fresh air stack with rain cap shall be of carbon steel, welded in construction of minimum 2 mm thick. Fresh air shall be taken from nearest safe area through fresh air stack in a guy wire style or through horizontal/ vertical duct. The Ducts shall be completely leak proof while passing through hazardous area. Loss of pressurization shall initiate an audio-visual alarm. Manual HVAC selector switch to alternate between the HVAC shall be provided in the shelter. Special anti-corrosive coating shall be provided for coolant tubes to withstand harsh refinery environment."

- 2.6.2.4 Fresh air make up requirements shall be calculated by the vendor based on the requirements as specified in Clause 8.3 of NFPA 496, (Latest Edition), i.e. where a release of flammable gas or vapour within an enclosure can occur either in normal operation or under abnormal conditions, protection shall be provided by diluting with air to maintain the concentration of flammable gas, vapour, or mixture to less than 25% of its lower flammable limit of any individual flammable gas or vapour entering the enclosure. However minimum 5 air changes shall be provided as per IEC 61285 for ventilation purpose. Inside temperature rise shall be limited to 5° C above ambient, by fresh air from pressurisation system, in case of failure of AC system.

- 2.6.2.5 Vendor shall confirm that all analysers installed inside Analyser Shelters are suitable for continuous operation in this temperature (Max. ambient +5°C). In case any analyzer being supplied is not suitable for this temperature limit, vendor shall provide high temp pre alarm inside shelter. A separate potential free contact of this alarm shall be provided in alarm J.B. for connection to control room also. The power to analyzer shall be cut off in case of high temperature.

- 2.6.2.6 Vendor shall submit heat load calculation for review during post order engineering. Heat load on account of fresh air shall be considered while calculating the capacity of air conditioners.

- 2.6.2.7 All equipment shall be suitable for operation in their respective area classification. For Analyser shelters located in classified area (Zone - 2, Gr. IINIBIIIC), HVAC unit is required to be

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0
			Rev
		SHEET 19 OF 34	

explosion-proof in construction. All flameproof equipments manufactured locally (within India), the testing shall be carried out by any of the approved testing houses – CMRI/ERTL etc. The item shall, in addition, bear the valid certification from *PECB/CCE* and also the manufacturer shall hold a valid BIS license. All equipments manufactured abroad shall be certified by any approving authority like BASEEFA, FM, UL, PTB, LCIE etc. In addition certification by Indian Authorities *PECB/ CCE*, Nagpur, is mandatory.

- 2.6.2.8 Chemical Filters shall be provided in the fresh air intake to protect the electronic equipment installed inside the analyser shelters against corrosive gases like H<sub>2</sub>S, SO<sub>2</sub>, NO<sub>x</sub> etc. as per specification clause 2.7.

### 2.6.3 HVAC System for Analyser Shelter Safe Area

- 2.6.3.1 Analyser shelters are to be air conditioned and pressurised to prevent the entry of dust.

- 2.6.3.2 Air Conditioning and pressurization shall be achieved by providing packaged type HVAC units as per manufacturer's standard practice.

- 2.6.3.3 Pressurisation system shall be provided for analyser shelter with 2 nos of HVAC system (one working unit and one standby unit) each of same capacity without any common / sharing components. Fresh air intake arrangement comprising of fresh air blower with drive & back draft dampers, cleanable type filters (95%, 5 micron) and bird screen etc shall be provided. Minimum 5 air changes shall be provided as per IEC 61285 for ventilation purpose. Inside temperature rise shall be limited to 5° C above ambient, by fresh air from pressurization system, in case of failure of AC system. Relief dampers shall be used to exhaust room air at 5 mm WG over pressure. Shelter internal positive pressure shall be maintained at 2.5 mm WG minimum. Loss of pressurisation shall initiate an audio-visual alarm. Manual HVAC selector switch to alternate between the HVAC shall be provided in the shelter. Special anti-corrosive coating shall be provided for coolant tubes to withstand harsh refinery environment."

- 2.6.3.4 Vendor shall confirm that all analysers installed inside Aoalyser Shelters are suitable for continuous operation in this temperature (Max. ambient +5°C). In case any analyzer being supplied is not suitable for this temperature limit, vendor shall provide high temp pre alarm inside shelter. A separate potential free contact of this alarm shall be provided in alarm J.B. for connection to control room also.  
The power to analyzer shall be cut off in case of high temperature.

- 2.6.3.5 Vendor shall submit heat load calculation for review during post order engineering. Heat load on account of fresh air shall be considered.


- 2.6.3.6 Chemical Filters shall be provided in the fresh air intake to protect the electronic equipment installed inside the analyser shelters against corrosive gases like H<sub>2</sub>S, SO<sub>2</sub>, NO<sub>x</sub> etc. as per specification clause 2.7.

- 2.6.3.7 Vendor shall submit heat load calculation for review during post order engineering. Heat load on account of fresh air shall be considered while calculating the capacity of air conditioners.

### 2.6.4 Inside Conditions to be maintained

Following inside conditions are to be maintained and guaranteed by vendor throughout the year:

Dry bulb temperature                      26°C ± 1°C

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0
			Rev
		SHEET 20 OF 34	

Relative humidity 35% to 70%

## 2.6.5 Outdoor Design Conditions

Outdoor design conditions, as mentioned elsewhere, shall be considered for heat load calculation.

## 2.6.6 Spares

Spares for commissioning and start up as required shall be provided by vendor without any additional time & cost implication.

## 2.7 Chemical Filters

2.7.1 The design, selection, manufacture and supply of chemical air filters for the duty specified shall be in vendor's scope

2.7.2 Chemical air filters are required to be installed in fresh air circuit.

2.7.3 Selection Data for Chemical Filters

The following conditions shall be considered as a minimum for outside ambient air:

GAS	OUTSIDE (:g/m <sup>3</sup> )		INSIDE (PPM by Vol.)
	Yearly Average	Max. (8 hr. average)	
S O <sub>2</sub> / SO <sub>3</sub>	100	13000	< 0.010
NO <sub>x</sub>	100	9500	< 0.05
H <sub>2</sub> S	TRACES	13900	< 0.003
* Cl <sub>2</sub>	TRACES	2900	< 0.001
* NH <sub>3</sub>	TRACES	TRACES	< 0.5
SPM	400	15000	< 200 :g/m <sup>3</sup>
RSPM	250	-	< 100 :g/m <sup>3</sup> (< 10 :)

\* Normally not associated with Refinery emission.


## 2.7.4 Technical Specifications for Chemical Filters

2.7.4.1 Chemical air filter unit shall be selected to provide inside conditions as given above considering the outside ambient concentrations given under Max. (8 hrs. average) column.

2.7.4.2 Chemical air filter shall be selected for the chemical media life of minimum 2 years. The outside gas concentration given above shall be considered while evaluating the life. Chemical Filter supplier to furnish the calculations and nomographs etc. in support of the chemical media life, at post order stage.

2.7.4.3 Chemical air filter unit shall be skid-mounted cubicle for horizontal installation.

2.7.4.4 Three stage chemical filter shall be provided – *one/two* modules containing Puracarb or equivalent media and other metal modules containing chemisorbant or equivalent media.

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0
			Rev
		SHEET 21 OF 34	

2.7.4.5 Filter packs suitable for removal of specified gases shall be housed in an adequately rigid & reinforced sheet metal enclosure, with flanged inlet & outlet connections, inspection cover/manhole.

2.7.4.6 The pre-filters at inlet & fine filters at outlet shall be capable of removing dust particles of 10 microns with 90% efficiency & of 1+ microns with minimum 90% efficiency respectively.

2.7.4.7 Unit shall be suitable for outdoor installation & continuous operation. It shall be painted as per painting specifications of the Bidding document.

2.7.4.8 It should have adequate provision for easy removal & servicing of filter packs.

2.7.4.9 Unit shall be provided with indication of differential pressure across the filters.

## 2.8 Power Supply

2.8.1 Unless otherwise specified, the following power supplies shall be provided for each shelter at one point near the shelter by owner. Further distribution step down etc. as per requirement shall be done by the vendor:

- i) 415V, 50Hz, 3 phase with neutral for the HVAC system.
- ii) 110VAC 50Hz Single phase for analyser, alarm system, horn and other related accessories.  
230V 50Hz Single phase for lighting (internal and external) system of the shelter and heat tracing shall be developed by vendor.

2.8.2 The supply voltage fluctuation of  $\pm 10\%$  and supply frequency fluctuation of  $\pm 3\text{Hz}$  from the specified value, shall not affect the system performance.

2.8.3 The size and number of incomers shall depend on load and distance and shall be finalized during detail engineering. Vendor shall provide necessary terminal sizes and suitable cable glands.

2.8.4 Main switches for all three-power supplies shall be mounted outside the analyser shelter, which shall be weather proof to IP66 and explosion proof suitable for the specified hazardous area classification. The power supply cables will be terminated after the main switches inside the shelter in different junction boxes with terminals and switch fuse unit for power distribution to the relevant equipments/items. Individual switches shall be provided for each instrument for independent de-energisation of the items. 'Power Supply on' indication shall be provided on the main power supply line to each analyser on PDB.


2.8.5 Two power sockets of 110V 50Hz and 230V 50Hz supply for electrical tools or test equipments shall be provided at two opposite corners of each shelter.

## 2.9 Other Utilities

Owner shall provide following utilities at one point near each shelter. Further distribution shall be done by vendor as per the requirement.

2.9.1 Steam

- a) Pressure: 2.5 - 5.5 kg/cm<sup>2</sup>g

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0	
			Rev	
		SHEET 22 OF 34		

b) Temperature: Saturated

c) Line size connection: 1" NB NPT (M) with valve.

#### 2.9.2 Instrument Air

a) Pressure: 4 .0– 6.0 kg/cm'g

b) Dew Point: - 40°C at atmospheric pressure

c) Line size connection: 1.0" NB NPT (M) with valve

#### 2.9.3 Cooling water

a) Pressure: 3.5 - 5.0 kg/cm'g

b) Temperature: 33°C

c) Connection size: 1.0" NBNPT (M) with valve

#### 2.9.4 Nitrogen

a) Temperature: Ambient

b) Pressure: 5 - 8 kg/cm'g

c) Connection size: 1.0" NBNPT (M) with valve

Vendor shall furnish the list of utilities required with expected consumption.

### 2.10 Lighting

2.10.1 Power supply for lighting inside and outside the shelter shall be 230 V 50 Hz.

2.10.2 Internal lighting shall be provided by fluorescent tube lamps to provide in illumination of 300-400 lux at all places on the floor.

2.10.3 External lighting shall be under overhangs to provide illumination sufficient for maintenance / repair work.


2.10.4 Lighting fixtures inside and outside the shelter shall be suitable for the hazardous area classification specified.

2.10.5 Lighting switch shall be provided outside the shelter near to the main door.

### 2.11 Terminal Housing

2.11.1 The terminal housing shall be suitable for the area classification indicated in the purchaser's data sheets. Unless otherwise specified, the enclosure shall comply with the following



	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0
			Rev
		SHEET 23 OF 34	

requirements as a minimum:

Weather proof housing: IP-65 as per IEC-60529/IS-13947

Flameproof housing: Flameproof/Explosion proof i.e., Ex (d) as per IEC 60079 / IS2148 for explosion proof construction

Flameproof housing shall also be made weather proof and shall be provided with metallic enclosure.

- 2.11.2 All cables shall terminate on the terminal blocks in all vendor-supplied equipments, Separate terminal blocks shall be provided for power and signal cables. Unless otherwise specified, terminals shall be suitable for terminating following conductor sizes, as a minimum:

Signal cables : 1.5 /2.5 sq. mm

Power cables : 6 sq. mm

Separate terminal box shall be provided in case instrument terminals available as standard are not suitable to accommodate the specified conductor sizes.

## 2.12 Tubing / Piping / Wiring

Tubing and piping runs shall be installed such that they will not interfere in the maintenance or removal of any analyzer or equipment in the house or shelter nor encroach on space allotted for future instruments. All valves and instruments shall be readily accessible.

Traps shall be provided and installed by Vendor outside the house or shelter for all steam traced inlet sample lines and steam users. Each steam user shall have its own trap.

All users of instrument air shall have block valves at the take off point. All sample inlet and outlet points shall have isolation valve.

All piping and tubing shall be adequately supported. All tubing shall be protected by running it in trays or channels.

All tubing shall be annealed SS-316, 1/2 inch OD by 0.049" wall thickness or 1/4 inch OD by 0.035 wall thickness as appropriate. Fittings shall be Flare less SS-316.

Other materials for tubing and/or fittings may be considered where required by process conditions.


- 2.12.1 All safety valve outlets shall be terminated in a common header of 2" NB schedule 80S Stainless Steel 304 pipe and single outlet shall be provided out side the shelter with one non return valve and lock open type I" ball valve. Similarly all vents to atmosphere shall be terminated in a similar 2" NB Schedule 80S Stainless Steel 304 pipe and single outlet shall be provided . If commom header is not there then with non-return valve and Lock open type I" ball valve.

- 2.12.2 All atmospheric gas outlet line shall be equipped with protection from climatic condition.

- 2.12.3 All tubing work shall be done by using 1/2." OD or 118"OD SS tube aod Swagelok/ Parker/ Hamlet flare less, double compression type fittings.

- 2.12.4 All wiring/ tubing and all other erection work shall be done in accordance to API RP 551-5



	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0
			Rev
		SHEET 24 OF 34	

2.12.5 All cable entries/outlets in the junction boxes/ distribution boxes etc and to the analyzer shall be provided with double compression type certified flameproof cables glands suitable for the indicated hazardous area. The material of the same shall be Nickel-plated brass.

2.12.6 All cabling/wiring works inside the shelter shall be in accordance with the international Standard / industry practice for similar application. However the cables shall be armoured as a minimum.

2.12.7 Dimensions and layout of each shelter shall be provided by contractor for Owner / PMC review before taking up for fabrication.

### 2.13 Hook up of Analyser Shelter

2.13.1 End Connections shall be provided for all interconnections (fast loop return, sample return, utilities, flare, vent, drain etc.) as specified in purchaser's data sheet for their hook up.

2.13.2 In case end connection for hook up of vendor's standard supply is different than that specified in the purchaser's data sheet, vendor should include the required hook up material in their scope of supply.

2.13.3 Unless otherwise specified, end connection details shall be as below:

a) Threaded end connections shall be NPT as per ANSI/ASME B 1. 20.1.

b) Flanged end connections shall be as per ANSI/ASME B 16.5

c) Grooves of ring type joint flanges shall be octagonal as per ANSI 16.20.

d) Flange face finish shall be as per clauses 6.4.4.1, 6.4.4.2 and 6.4.4.3 of ANSI/ASME B 16.5. The face finish as specified in the data sheets, shall be as follows:

125 AARH : 125 to 200 AARH

63 AARH : 32 to 63 AARH

2.14 Foundation:

2.14.1 The analyzer shelter shall be installed on 200 mm high concrete pedestal provided on paved area in the plant by owner. The pedestal shall be extending 1 meter all around the footprint of analyzer shelter.


2.14.2 Analyser shelter shall be supplied with base channel of min. 150 mm height which will be bolted to the pedestal.

2.14.3 Vendor shall arrange all equipments outside the shelter including HVAC in such a manner that they are accommodated on the pedestal.

2.14.4 All civil works necessary to install the shelter on pedestal and any residual civil work to provide additional foundation for any accessory shall be in Vendor scope.

### 2.15 Painting

2.15.1 Non SS parts of the analyzer shelter shall be treated and painted as follows:

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0
			Rev
		SHEET 25 OF 34	

- a) All surfaces including structures shall be sand blasted and grinded smooth and free of scale, rust etc.
- b) Chemical treatment shall be done to remove rust, oil, entrapped impurities and other foreign materials.
- c) Exterior and inside colour of shelter shall be finalised during detailed engineering.

### 3.0 NAMEPLATE

3.1 Each analyser shelter shall have a stainless steel nameplate attached firmly to it at a visible place near the main and Emergency doors, furnishing the following information:

- a) Tag number as per purchaser's data sheet.
- b) Manufacturer's serial number (If any).
- c) Manufacturer's name/trade mark.
- d) Area classification in which the shelter can be used.
- e) Size of shelter.

Vendor shall fit a nameplate with the analyzer house number (e.g. AH-01) to both doors on each analyzer house.

Vendor shall also fit an appropriate warning boards like following:

- Analyser house protected by artificial ventilation
- Warning - doors shall be kept closed
- Warning - risk of H<sub>2</sub>S
- Warning - flammable material shall only be introduced into the analyser house if specifically permitted and recorded.

Vendor shall clearly identify all services with name plates, (for steam this shall also indicate maximum pressure and temperature), at entries to analyzers both internally and externally and entries to sample conditioning systems.


Vendor shall clearly identify all sample flow and return lines, carrier gas and calibration gases with name plates, at entries to analyzers both internally and externally and entries to sample conditioning systems.

All nameplates, labels and signs shall be in dual language, Hindi and English. In addition any signs for extreme caution, such as the risk of Hydrogen Sulphide shall also be in Bangla.

All parts inside and outside of the analyzer house, inside sample conditioning system, HVAC, safe guarding PLC shall have a nameplate indicating the label of that part for identification. The parts in Sample conditioning system shall also be printed with their set point or normal values in the second line of the label.

### 4.0 INSPECTION AND TESTING

- 4.1 Unless otherwise specified, purchaser reserves the right to test and inspect all the items at the vendor's works.
- 4.2 Vendor shall submit the following test certificates and test reports for purchaser's review:

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0	
			Rev	
		SHEET 26 OF 34		

- a) Material test certificate as per clause 3.1B of EN 10204 for flanges, fittings and sheet steel.
- b) Certificate of radiography/ X-ray for header welded joints. Dye penetration test certificate shall be provided for joints where radiography/ X-ray is not possible.
- c) Dimensional verification certificate as per clause 4.3 of this specification.
- d) Hydrostatic testing of all headers.
- e) Leakage and continuity testing.
- f) Power Distribution and wiring check
- g) Functional check for HVAC
- h) Type test certificates

Vendor shall carry out a complete inspection of all analyzer houses, to ensure all analyzers, analyzer sample systems, pipe and tube work, utilities, drain and vent systems, heating and ventilating system plus all analyzers which are field mounted are in manufacturer's perfect working order. The analyzer house Vendor shall permit inspection by the client at any time during the actual construction of any part or parts of the project.

Vendor shall make following facilities available for test :

- Sufficient qualified labour to carry out the test.
- Air or nitrogen at required pressure for the full duration of the test.
- Air bubbler, maximum working pressure 10kg/cm<sup>2</sup>(g).
- A gas/air leak detector
- Measuring equipment for supplies and outputs (multi-meter).
- Special measuring tools/equipment for components installed.
- Power supply units as applicable.
- Three copies of the as built drawings.
- Test and calibration gas/liquid samples for each analyzer.


Inspection and full functional testing shall then be carried out at Vendor's premises of all analyzer houses and systems and all field mounted analyzers, with the analyzer house Vendor's responsible analyzer specialist and the Client. This will include a full calibration test of each analyzer.

The analyzer house Vendor shall then ensure safe transportation of each analyzer house, complete with analyzers, sample systems and contents, plus all field mounted analyzers and their equipment, to the site, where they shall be installed by client under Vendor's supervision.

All field equipments, including field mounted analyzers sample systems and associated analytical equipment that is not mounted in each house shall be installed by Client under Vendor's supervision.

Analyzer house Vendor's responsible analyzer specialist shall then carry out a complete inspection to ensure all analyzers, their systems and all utilities are in manufacturer's perfect working order before each analyzer system and all utilities are commissioned by the analyzer house specialist. This will include a full calibration test of each analyzer.

The sample transport and return lines shall be disconnected from the preconditioning panel and sample conditioning cabinet and then flushed out with demineralised water. The system shall then be dried using clean air or nitrogen.

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0	
			Rev	
		SHEET 27 OF 34		

Analyzer house Vendor shall carry out pressure test and inspect the sample transport and sample conditioning systems before the system is offered for inspection by the client.

During the leak test, all inlets and outlets shall be capped off, with the exception of those which are provided with a valve. The isolating valve shall be closed for these connections. The analyzer shall not be included in the leak test and shall be disconnected at the inlet and outlet connection. All other valves and reducers shall be fully opened. The maximum pressure applied shall not exceed 10 kg/cm<sup>2</sup>(g). Each system shall be pressurized for at least five minutes while the bubbler is carefully observed.

Systems or parts with a design pressure upto 9kg/cm<sup>2</sup>(g) shall be isolated from the system having higher design pressure and shall be opened to atmosphere during the pressure test. Systems or parts of systems with a design pressure higher than 9kg/cm<sup>2</sup>(g) shall be pressurized at 1.5 times the design pressure via a tight shut-off valve and a high-quality pressure gauge.

### 4.3 Dimensional Verification

- 4.3.1 End connection dimensional details shall be verified for all instruments and their accessories in accordance with approved drawings. In any case, the variation shall not exceed  $\pm 2.0\text{mm}$ .

### 4.4 Hydrostatic Testing

All headers shall undergo hydrostatic testing at 1.5 times the header design pressure with water at ambient temperature. There shall not be any visible leakage during the testing.

### 4.5 Continuity Testing


- a) All power cables shall be megger tested at minimum 600V. The insulation shall be as per IS-1554 Part I.
- b) All signal cables / wires shall be checked for continuity, termination and identification using multi-meter.

### 4.6 Leakage Testing

All tubing and piping shall undergo leakage testing when pressurised with nitrogen at 100 psig. No bubbles shall appear when testing with soap solution.

### 4.7 Witness Inspection

- 4.7.1 Vendor shall offer all analyser shelters for pre-dispatch inspection at their works. Following tests/checks shall be carried out, as a minimum.
- a) Physical dimensional verification and workmanship as per clause 4.3 of this specification.
  - b) Leakage testing of tubes and headers with nitrogen as per clause 4.5 and 4.6 of this specification.
  - c) Power distribution and wiring scheme check
  - d) Insulation resistance work

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0	
			Rev	
		SHEET 28 OF 34		

e) Functional check of HVAC

f) Review of all certificates and test reports as indicated In clause 4.2 of this


4.7.2 In the event the witness inspection is not carried out by purchaser, the tests shall anyway be completed by the vendor and documents for the same shall be submitted to purchaser for scrutiny.

## 5.0 UTILITY SERVICES

Vendor shall provide a suitable distribution system as required. All service lines must have a minimum distance of 25mm clear between neighboring flanges. Steam and condensate lines shall have an allowance for insulation

Vendor shall provide a suitable distribution system for carrier gas, calibration gas, instrument air, etc as required for each analyzer. A means shall be provided to initiate an alarm on low pressure/volume in the header or cylinders.

All piping and tubing from headers, analyzers, cabinet drains, vents, steam users and steam tracing inside the shelter shall be brought to the outside so that, at the jobsite, all connections can be made outside the shelters.

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0
			Rev
		SHEET 29 OF 34	

## 6.0 SAFEGAURDING SYSTEM

Each analyzer house shall be protected by a safeguarding system against hazardous situations. Vendor shall supply safe guarding PLC, fire & gas detector, alarm initiating devices, annunciator etc. fully wired with respective junction box or PLC.

Vendor shall develop the “Cause & Effect Diagram”, “Functional Logic Diagram” and Input-output list for safe guarding PLC and submit the same to the client for approval. After client’s approval Vendor shall develop the logic and load into the PLC. The logic and Input-output configuration shall be uniform for the all analyzer houses supplied by Vendor.

The proposed interconnectivity among the systems like Safe guarding PLC, Annunciator, GC, AMS system, plant FGS, plant DCS, AMS PLC, etc. shall be provided. The vendor shall prepare the final interconnection diagram during detail engineering stage and submit to the client for review and/or approval.

### **AIR INTAKE**

The presence of flammable or toxic gas at the point of fresh air intake of the ventilation system shall be monitored by Gas detectors. The Gas detectors shall be fitted in such a way that the prevailing flow profiles and air speed inside the ducting do not adversely affect either representative sampling or the accuracy of detection. The detector should easily accessible for maintenance.

### **INSIDE ANALYZER HOUSE**


Flammable gas detectors shall be installed in the direct vicinity of the controlled outlet opening of the ventilation system inside the house. Toxic gas detectors shall be located at positions where leakage into the analyzer house is most like to occur in case of failure or mal-operation. Hydrogen gas detectors shall be installed if Hydrogen is used as carrier gas for Gas Chromatographs. Optical Smoke detector shall be installed inside the house to detect smoke/fire. Oxygen detector shall be installed inside house to alarm on oxygen deficiency. Flashing lights – RED & GREEN shall be installed inside the house. Flashing RED light shall indicate “unsafe” condition inside the house. Steady GREEN light shall indicated “healthy (safe)” condition of the house. The lights shall be installed in such a way that the person can see through the glass window mounted on the.

### **OUTSIDE ANALYZER HOUSE**

A Manual Call Point (MCP) shall be provided outside the analyzer house near main entrance. Actuation of MCP shall trip the analyzer house. RED & GREEN lights shall be over the roof of the house. RED light shall indicate trip condition of the house and GREEN light shall indicate healthy condition of house. These lights shall server the purpose of indication of house condition from remote. Air horn shall be installed outside the analyzer house. The horn shall blow whenever any alarm or trip is initiated by any of the device inside or outside the house. The horn shall have minimum sound amplitude of 100dBA.

### **ANNUNCIATOR**

Indication lamps for each gas or fire detection, HVAC run/fault, house purging, house pressure, power available, etc. shall be provided on annunciator panel outside the analyzer house near main entrance. Alarm acknowledge, reset and lamp test push buttons shall be provided on the annunciator. All signals annunciator shall be wired to Safe guarding PLC. The annunciator enclosure shall be suitably certified for the area classification.

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0
			Rev
		SHEET 30 OF 34	

### **SAFE GAURDING PLC**

Safe guarding PLC shall be supplied by analyzer house vendor and shall be installed in a purged enclosure inside the analyzer house along with all necessary wiring, power supply, barriers, relay, MCBs, etc.

The safe guarding system shall be independent of the main process ESD system.

The Fire & Gas System(supplied by other) of main plant will receive inputs from the fire and gas detectors of analyzer house and send output to safe guarding PLC for annunciation, beacon, alarm or trip.

In the event of an analyzer house power being isolated by the safe guarding system the power shall be restarted only by pressing the reset switch located outside the analyzer house.

- Safe guarding system for each analyzer house shall perform following actions, in the event of ventilation failure, loss of over-pressure, flammable or toxic gas detection, O2 deficiency, etc.
- Initiate an appropriate audio and visual alarm
- Isolate power to the wall sockets
- Isolate power to analyzers not certified for use in Zone1 hazardous area, isolate data highway for any analyzers connected to the Analyzer Management System and isolate any non- Intrinsically safe signals.
- In the event of fire detection or actuation of MCP outside the house, the safe guarding system shall carry out the above actions and the following:
  - Isolate power to the analyzer house
  - Isolate all sources of flammable material – sample, carrier gas, etc.
  - Isolate the ventilation fans
  - Close the fire damper at air inlet stack

Vendor shall ensure that all equipments to be isolated above with the exception of the ventilation fans, cannot be re-energized until the ventilation system is operating, the house is repressured and at least five fresh air changes have taken place. All internal panel wiring shall be within plastic trunking. There shall be separate trunking for signal types including IS and Non-IS and for Electrical supplies, with sufficient segregation to eliminate interference. The trunking shall be sized with at least 40% spare capacity.

Between two rows of terminal there shall be plastic trunk (75mm x 75mm) minimum to receive field wiring for the panel.

## **7.0 ELECTRICAL UTILITIES**

### **POWER**


Following power to the analyzer house shall be supplied by client at single point on analyzer house:

220VAC  $\pm$  3%, 50 Hz  $\pm$  0.5Hz UPS power for Analyzers and Safe guarding PLC  
 240VAC, 50Hz Non-UPS power for lighting, maintenance socket, heater in Sample conditioning system, Sample pump, etc.

415VAC, 50Hz, 3-Phase for HVAC motors, sample pump motors, etc. Further distribution to individual device or equipment shall be supplied pre-wired by Vendor.

A manual power disconnect switch for each voltage feeder with padlock option shall be installed on the outside wall of each analyzer house / shelter.

All power distribution boards mounted on the analyzer wall shall be suitable for use in Zone1 area and classified EExd IIC T6, these shall be supplied by vendor.

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0
			Rev
		SHEET 31 OF 34	

Vendor shall calculate the expected load, for each supply voltage, with a 30% allowance for future expansion; these calculations shall be supplied to the client. All distribution boards shall have 30% spare capacity for future expansion.

The protection of power circuits shall be provided in both live and neutral lines and shall be either switches/fuses or MCBs. It shall be possible to "lock off" an isolated circuit. Cables entering distribution boards shall be terminated at suitably sized and rated terminals.

Bus bars and fuse blocks / switch blocks / MCBs shall be used for power distribution and shall be installed in such a way that any equipment can be disconnected from or connected to the system without interrupting power supplies to other equipments. Provision shall be made to provide a minimum of 30% spare for future requirement. Power supply wiring shall not be jumped from one instrument / device to the other.

Vendor shall provide wall sockets installed along the internal walls. These shall be provided with adequate protection for a Zone 1 area. The supply to wall sockets shall be protected in both live and neutral lines by residual current breakers and either switches/fuses or MCBs. In the event of ventilation failure or 20% LEL gas detected power to the sockets and equipment not certified for Zone 1 IIC T6 use shall be isolated. The sockets shall be provided for both 240VAC UPS and 240VAC, utility supply.

Power to all electrical equipments inside the house which are not suitably protected for a zone 1 hazardous area shall be isolated by Safe guarding system if a ventilation failure occurs.

## CABLE

Electrical Power and Instrumentation Signal/Communication cables shall enter and leave analyzer house via separate cable transits mounted in the analyzer house walls.

Cable glands shall be used on all junction boxes or equipment entries. Glands shall be suitable for cable types and hazardous area classification.

Cable connections from chromatograph analyzers to its programmer or its computer shall not be cut. The cable shall be extended through the analyzer shelter intact, coiled, and marked by the Supplier so that connections can be made to the proper remote control section or computer.

All internal cabling shall be run on perforated galvanized cable tray. Adequate separation of signals level and voltage shall be maintained to ensure signal integrity.

The minimum size of power and lighting circuit cables shall be 2.5mm<sup>2</sup> and also for all fire and gas detector cable size shall be 2.5mm<sup>2</sup> and other instrument signal wiring shall be 1.0mm<sup>2</sup> minimum.

Physical segregation of wiring for each signal type and power supply shall be maintained. Single core cables within panels shall be color coded for different signal types and power. Vendor shall supply details of his color coding system.

## JUNCTION BOX

Vendor shall provide NEMA 4X (IP65) terminal boxes on the outside of each house and shall be certified for Zone 1 hazardous area. Separate junction boxes shall be provided for Analog signals, Digital Signals, Fire & Gas signals and Communication signals. Vendor shall provide leads inside the shelter from these junction boxes to each analyzer, fire & gas detector or safe guarding PLC.



 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0	
			Rev	
		SHEET 32 OF 34		

Further cabling from these junction boxes to Plant DCS, ESD or Fire & Gas detection system shall be carried out by Client.

The multi-core cables shall enter the junction box via bottom gland plate and all other cables shall enter via side gland plates. There shall be no top entries.

All terminal blocks shall be of the screw type, with barriers and marking strips. All wires shall have cross ferrules at each end by means of a small plastic sleeve (permanently stamped). Each terminal block shall have a minimum of 20 percent spares.

Wiring between terminals shall be continuous runs and shall not be spliced. With the exception of solid jumpers, not more than two wires shall be connected to one terminal.

The wiring shall be segregated as AC wiring, intrinsically safe DC wiring, and non-intrinsically safe DC wiring, communication wiring and power wiring.

## LIGHTING

Vendor shall supply suitable and adequate lighting for each house, both internally and externally, to supply illumination level minimum of 400 Lux. All fittings shall be suitable for use in a Zone 1 area, certified EExd IIC.

Failure of any one light fitting shall not mean that any part of the house shall fall below an acceptable illumination level. Vendor shall provide minimum one light with battery backup for one hour with each house.

Both internal and external lights shall be controlled from switches placed externally at both entrance doors. Switches shall be certified for Zone 1 use.

## EARTHING

Provision shall be made for three (3) independent earth connections to the safe guarding panel - plant earth, instrument earth and intrinsically safe (IS) earth.

The Plant earth - All removable doors and covers, gland plates, instrument cases, etc, shall be connected to the plant earth. Earth studs, size M10, shall be provided inside the panel, located at the bottom of the panel. All protective earths shall be connected to these studs.

Instrument Earth - an electrically isolated copper instrument earthing busbar shall be located at the bottom of the panel. Both ends shall have an earthing lug capable of accepting a 16mm<sup>2</sup> copper earth wire. The busbar shall be positioned below terminal blocks to allow easy access for the connection of earth wires. Cable screens and electronic loops requiring earthing shall be directly connected to the earth busbar and loop-connection of screens shall not be allowed. A minimum of 30% spare connecting points shall be provided.

Intrinsically Safe Earth - An electrically isolated copper IS instrument earth busbar shall be located at the side of the panel. Both ends shall have an earthing lug capable of accepting a 16mm<sup>2</sup> copper earth wire. This earth bar shall be used for intrinsically safe circuits. A minimum of 30% spare connecting points shall be provided.

Apart from the above earthing, Vendor shall supply a non-insulated "plant" earth bar within the analyzer house above floor level. All metal enclosures for electrical equipment, including analyzers and auxiliary equipment shall be bonded to this earth bar. The minimum size of earth conductor shall be 6mm<sup>2</sup>. Provision shall be made for site connection of two 70mm<sup>2</sup> earth conductors to the earth bar. Earth continuity shall be ensured throughout the analyzer houses including all doors and framework.

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0
			Rev
		SHEET 33 OF 34	

## 8.0 DOCUMENTATION

Vendor shall submit to the client following design and engineering documents as minimum:

- Schedule of Vendor documents and drawing
- General arrangement in detail with all assemblies or items within the assembly including overall dimensions and location, gross weight, transporting support, lifting arrangement, earthing details, face to face dimensions, etc.
- Exploded/cross sectional View – Drawing indicating assembly details, description of component and material description and part no. against which the spares can be ordered.
- Analyzer house and panel layout drawings - clearly showing overall size, cut out details, list of instruments showing label engravings, paint finish and color, frame dimensions, etc.
- Schematic Drawing – Drawing shall indicate the electrical arrangement of all components shown in a de-energized state.
- Interconnection diagram - Block diagrams will show interconnecting cables among Instruments, analyzers, electrical equipment, junction box, safe guarding plc, annunciator, sample conditioning system, etc. indicating cables not in Vendor's scope of supply.
- Internal wiring diagram for all instrument and electrical termination details including Junction box, safe guarding plc, analyzers, etc. terminations.
- Instruments layout drawing – indicating location of each instrument with tag no. with elevation, tubing or cable layout, instrument air line layout, etc.
- Functional logic diagram – for sequence of operation and interlock logic of safe guarding plc.
- Instrumentation data sheet for each instrument installed in the house including Fire and gas detectors.
- Instrument & Electrical Cable schedule – which will list all cables with type, size, length and location.
- Installation, commissioning, operation and maintenance manual for all equipments installed in the house including, HVAC, PLC, Annunciator, Analyzers, fire and gas detectors, instrumentation items, electrical items, etc.
- Instrument loop diagrams – indicating location and termination details of each instrument with safe guarding plc or analyzer
- Sample hook up drawing – from sample take off to sample conditioning system to analyzer and return to sample line. This will indicate vent and drain lines.
- Detailed bill of materials for all items / parts with their make, model and ordering information.
- Commissioning spare list

## 9.0 PACKING AND SHIPPING

Each instrument and all moving parts shall be securely packed and properly packaged, boxed, or crated to prevent damage to instruments and parts while handling, during shipment, delivery, and warehousing.


All glass shall be covered with cardboard or wooden protectors and the complete instrument wrapped or packed in a container of suitable design to withstand normal shipping, handling, and indoor storage.

All openings (including tubing and pipefitting) shall be covered, plugged, or capped to prevent entrance of foreign materials and contaminants during transit and storage.

All framed openings of the shelter shall be weather sealed for shipping.

Field mounted analyzers, auxiliary equipment or other heavy items shall be provided with additional bracing to prevent them breaking loose during shipment. All supports which will be in contact with equipment in the analyzer houses shall be suitably protected.

## 10.0 SERVICE AND SUPPORT

	GENERAL SPECIFICATION FOR ANALYSER SHELTER	GSTD-001	0
			Rev
		SHEET 34 OF 34	

Vendor shall accept full system responsibility for all supplied hardware, operating and application software, and provide the necessary training, and site support for the construction, staging, testing, installation and pre-commissioning phases per this specification until successful hand over to the contractor.

- Vendor's responsibility shall include, but is not limited to, the following items:
- System engineering support
- System hardware and operating system software
- Software for interfacing all foreign devices
- System documentation
- Recommended spare parts
- Factory acceptance testing
- Packing and shipping per the accompanying requisition
- Warranty
- Failure of this Specification, Attachments, and/or drawings to state or show materials essential to make the equipment specified complete and operable shall not relieve Vendor from the responsibilities for furnishing such materials.

The Client's review of Vendor's drawings does not relieve Vendor from the responsibility of furnishing equipment that will function as intended by this Specification.

Vendor must take full responsibility for all supplied equipment and adhere to the requirements of this specification.

## 11.0 SPARES

Vendor shall submit full bill of material including all items with respective manufactures part No. Commissioning spares shall be in Vendor's scope of supply.

Bill of Material shall include following

- Analysers (Chromatograph Spares)
- Sample Conditioning System Spares
- Safe Guarding PLC & it's spares
- JB spare Details
- Fire & gas Detector spares
- Instrumentation items installed inside/outside Analyzer House.
- Electrical Spares including HVAC motors, pumps, tube lights, MCBs ,emergency light, etc.
- Mechanical Spares Details
- Calibration or carrier Gas cylinder details

All above spares details will include complete ordering information for future procurement.

## 12.0 SHIPPING

All threaded and flanged openings shan be suitably covered to prevent entry of foreign material.

Glass windows shall be covered with thermo-coal sheet of appropriate thickness to avoid damage during transport.

Shipping breaks shall be provided in all equipment, which are supplied in installed condition inside the analyser shelter. Equipment, which is likely to damage during shipment, shall be packed separately for shipment.

 पी डी आई एल <b>PDIL</b>	<b>PROJECTS &amp; DEVELOPMENT INDIA LTD</b>	<b>GSTD-0002</b>	<b>0</b>	
			Rev	
		<b>SHEET 1 OF 14</b>		

# REQUIREMENTS FOR ANALYSER SYSTEM

FOR

## ANALYSER SHELTER

0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

 पी डी आई एल <b>PDIL</b>	<b>REQUIREMENTS FOR ANALYSER SYSTEM</b>	<b>GSTD-002</b>	<b>0</b>	
			Rev	
		<b>SHEET 2 OF 14</b>		

## **ANALYSER SYSTEM SPECIFICATIONS**

### **1. GENERAL**

- 1.1 This specification defines the minimum requirements of Analyser System / systems designed for reliable and effective analysis of various process streams.
- 1.2 All analysers alongwith their associated equipments shall be installed by the contractor inside the analyser shelters.
- 1.3 All analyser shelters shall be ventilated, pressurized and air-conditioned. However, all analysers and other associated equipments shall be so designed and selected that these will continue to operate even in case of ventilation / pressurization failure.
- 1.4 Contractor shall provide all installation material including consumables to install the analysers, sample conditioning systems, sample transfer lines, vent lines and all other accessories. All instruments shall be completely accessible to permit adjustments, calibration and maintenance.
- 1.5 The components to be furnished for each sample system will depend upon the sample stream conditions. The contractor shall select and provide all the necessary components for each of these systems accordingly.

### **2. SAMPLING SYSTEM**

- 2.1 The sampling system shall consist of necessary components, including sample probes, sample filters, pressure reducers, safety relief valves, pressure and temperature gauges, moisture separators, flow regulators, flowmeters, isolation valves etc. necessary to prepare the sample for proper analysis.
- 2.2 All components shall be sized and coupled so as to keep the sample volume to a minimum.
- 2.3 Calibration zero and span gas connections shall be provided for each analyser.
- 2.4 The sampling system shall have various sub-assemblies as required. The minimum requirements of each sub- assembly shall be as given below.

#### **2.5 Sample Probe Assembly**

- a. Sampling probe shall be designed to extract true representative sample from the process line. The design shall prevent particulates from entering into the sample system.
- b. The design of probe assembly shall facilitate on line removal of the probe without shutting off the process. Suitable mounting adapters shall be provided with the probe.

	REQUIREMENTS FOR ANALYSER SYSTEM	GSTD-002	0	
			Rev	
		SHEET 3 OF 14		

- c. Probes shall be of 316SS material as a minimum or better as required by process stream.
- d. The length of tubing between the sample probe and the sample stream pressure reducing station shall be kept minimum by close coupling various components in between.

## 2.6 Sample Stream Pressure reducing stations:

- a. Contractor shall design and provide sample stream pressure reducing station to minimize sample transfer time maintaining the integrity of the sample. Sample stream pressure reducing stations shall consist of pressure regulators, relief valves ,pressure gauges, temperature gauges etc as required.
- b. These stations will be located at the sample process connection to minimize transport time lag from the sample point to the analyser.

## 2.7 Sample Transfer Line

- a. The sample transfer lines shall transport the fluid sample from the sample stream pressure reducing stations to sample conditioning system located at the analyser house/shelter.
- b. Contractor shall provide heat tracing for sample line wherever necessary, in order to maintain the sample integrity.
- c. The routing of sample transfer lines shall be done in such away that the total length between the sampling point and the analyser sample conditioning system is minimum. Short radius bends shall be avoided to avoid excessive pressure drop.

## 2.8 Sample Conditioning System:

- a. Sample conditioning system shall be provided by the contractor at the analyser shelter
- b. Multi stream analyser system shall have a separate sample handling subassembly for each stream.
- c. Sample conditioning system shall include, but not limited to, moisture separators, filters, rotameters, pressure gauges, flow switches, solenoid valves etc.as necessary for proper analysis of each sample stream. Isolating valves shall be provided as required.
- d. Stream selecting valves shall be located as close as possible to the analyser to minimize connecting tubing-length and to minimize the possibility of cross contamination of samples.
- e. Stream selecting valves shall be double block and bleed and shall fail closed so as to block the sample from the analyser on loss of motive power.
- f. Block valves shall be provided on all process sample lines.
- g. Rotameters for measuring all sample flows shall be included.

	REQUIREMENTS FOR ANALYSER SYSTEM	GSTD-002	0	
			Rev	
		SHEET 4 OF 14		

- h. Special precautions may be necessary where catalyst fines and coking material, and other difficult stream conditions are present.
- i. Wherever it is necessary to maintain the handling system at elevated temperature to properly condition the sample ,it shall be closed in a thermally insulated, thermostatically controller heated enclosure. Enclosure heating shall be with steam heater unless specified otherwise. Sample stream flow adjustments and analyser shutoff valves shall be operable from the front of the enclosure without opening the enclosure door. Sample stream flow, pressure and temperature indication shall be visible from the front of the enclosure.
- j. Sample tubing between the sample conditioning system and the analyser shall be kept as short as possible.

## 2.9 Sample Stream Bypass/ Fastloop:

- a. Sample stream bypass/fastloop shall be provided for the sample streams to meet the required sample transport time.
- b. Flowmeters shall be provided by contractor for sample bypass/fastloop flow.

space, within or otherwise hazardous area, in which under normal operating conditions a non-hazardous atmosphere exists.

- 4.3 The interior temperature shall be maintained at  $26\pm 2^\circ\text{C}$  maintained. Contractor shall provide necessary air conditioning, heating, pressurization and ventilation.
- 4.4 Contractor shall propose a layout of analysers and their sample conditioning system such that the length of tubing in between the sample conditioning system and the analyser shall be located in such away that it is completely accessible to permit adjustments, calibration and maintenance.

## 5. ANALYSER:

- 5.1 The analyser shall be furnished with all the necessary equipment to properly analyse the sample.
- 5.2 Material of construction for the components in contact with the sample stream shall be SS316 except where the stream composition requires other material.
- 5.3. The detector cells shall be of a type that will provide adequate separation of components, minimize analysis time, minimize maintenance time and meet the performance requirements of this specification.
- 5.4. The analyser system temperature shall be controlled by an accurate (V1EC) electric heating system to ensure the proper sample separation and minimize the analysis time.

	REQUIREMENTS FOR ANALYSER SYSTEM	GSTD-002	0	
			Rev	
		SHEET 5 OF 14		

5.5. A shutdown switch shall be provided to protect the analyser from the loss of carrier gas or loss of fuel gas.

5.6 Solenoid operated multi function valves for sample inlet and column switching shall be provided.

## 6. PROGRAMME / CONTROLLER

6.1 The programmer / controller shall be microprocessor based and shall be furnished with all the equipments necessary to properly control the analysis cycle, the automatic zero adjustment circuit, the calibration of the analyser and programmer systems and the transition of data to a DCS or digital computer and any require peripheral equipment.

6.2 Visual read out using a digital indicator shall be provided to identify each component being analysed and each step in the program as well as displaying the latest readings.

6.3 Peak peaker and long term memory circuit boards shall be provided for each component of the interest.

6.4. All program data tables shall be capable of field modification without user knowledge of higher level programming. A key lock switch or field alter able password shall be provided to limit access to system software by unauthorized personnel.

6.5. The application program in the analyser shall be retained for a minimum of six months without external power by the use of EEPROM or Battery back-Up. An EEPROM program cartridge interface shall be provided for program loading.

6.6. Maintenance diagnostics shall be included in the software system to allow rapid trouble shooting in the event of system mal-function. Alarms in the English language shall be provided to notify the operator in the event of the mal-function. Allow carrier flow alarm shall be included.

6.7. The stream number shall be printed-out on each analysis report.

## 7. ELECTRIC WIRING- SIGNAL CONTROL AND POWER:

7.1. Contractor's scope of supply and work shall include all cabling and wiring inside the analyser shelter.

7.2. Contractor shall provide an explosion proof (Exd) power distribution box for power supply to various analyzers. This box shall be certified by a statutory body for use in hazardous area. The box shall have copper bus bars for distribution of power supply to various consumers.

7.3. Power supply to individual consumer shall be by dual pole, dual element circuit breakers. These circuit breakers shall be in explosion proof (Exd) construction certified by a statutory body for use in hazardous area and shall be mounted near the equipment served and shall have engraved plastic tag plates.



	REQUIREMENTS FOR ANALYSER SYSTEM	GSTD-002	0	
			Rev	
		SHEET 6 OF 14		

- 7.4. All cabling and wiring shall conform to API-RP-550. Signal and power cabling / wiring shall be segregated and run in separate raceways with separation distances as recommended per API-RP-550
- 7.5. All cables shall be armoured, flame. Retardant PVC insulated, 600 Volt grade, stranded copper conductor. Signal cables shall be twisted pair shielded.
- 7.6 . Conductor size for power cables shall be 2.5 sq.mm (min.) and for signal cable it shall be 1.5 sq.mm.
- 7.7. Colour coding for power supply wiring shall be red for phase, black for neutral and green for earth.
- 7.8. Contractor shall provide junction boxes for signal and control cables separately which shall serve as interfaces for cables going to remote control room. These junction boxes shall be explosion proof (Exd) certified by statutory body for use in hazardous area.
- 7.9 Wire termination shall be done using self insulating crimping lugs.
- 7.10. All cables, wires shall be provided with identification ferrule (one piece ferrule / cylindrical ferrules for proper identification.
- 7.11 Terminal strips shall be provided with identifying terminal numbers, as required. Terminals shall be screw and strap compression type.
- 7.12 20% spare terminals, cable entries with cable glands, relays and other components wired up to terminals shall be provided..

## 8. COMPRESSED GAS CYLINDERS AND THEIR HANDLING:

- 8.1 Each analyser shall be provided with the following compressed gas steel cylinders.
- Carrier gas and fuel gas (wherever required) with dual manifold cylinders configuration.
  - Calibration gas sample bottles.
- 8.2 Fuel gas and Carrier gas cylinders and associated manifolds shall be located on a concrete pad outside the analyser building. The gas cylinder manifold shall be arranged so that one cylinder may be replaced while the analyser remain in operation on the other cylinder.

Cylinders shall be sized 1A (225 mm diameter x 1300 mm long) and shall be supplied with auxiliaries such as fittings and two stage regulators.

- 8.3 Calibration gas cylinders shall be located outside the analyser shelter. Contractor shall include a drawing showing the layout of cylinders.

	REQUIREMENTS FOR ANALYSER SYSTEM	GSTD-002	0	
			Rev	
		SHEET 7 OF 14		

- 8.4. Racks shall be provided to support cylinders, piping, valves and pressure regulators associated with high pressure gas cylinder manifold system. Each cylinder in the system shall be secured to the rack by a separate chain or clamp.
- 8.5. A pressure relief valve, vented to a safe location outside the building shall be installed on the low pressure side of the pressure reducing regulator of each cylinder. Vent piping shall be installed in a manner to prevent the entry of bugs or moisture into the outlet of the event. This vent shall be in addition to the analyser vent.
- 8.6. All pressure regulators shall be two stage type. A sign identifying the type of gas applied to a manifold shall be placed above each cylinder rack.
- 8.7. The location and separation of hydrogen manifold from other flammable gas manifolds shall be in accordance with NFP A50A-1973 section 52 and 61.
- 8.8. All tubing between the cylinders to the analysers shall be complete and easily removable from each and either end .
- 8.9. Contractor's quote shall include fuel, carrier and calibration gas cylinders as necessary, as a minimum, for:
- i) the field testing, commissioning and final acceptance
  - ii) One year from the date of acceptance.
- 8.10. The calibration gases shall be of high purity, at least better than the specified accuracy and precision values for analysers. It is preferable to prepare calibration gases by Gravimetric method.
- 8.11. The concentration of calibration gases must remain constant for a period of at least one year .
- 8.12. The material of construction of cylinders shall be suitable for maintaining stability of the calibration gas mixture for the specified time. Contract or may quote for the staggered' deliveries wherever calibration mixture is not stable.
- 8.13. The contract or must submit the following certificates from any recognized certifying agency / laboratory;
- i) Accuracy / Precision of the calibration gas.
  - ii) Stability of sample for at least one year.
- 8.14. Contractor shall forward all the details including the source of supply, certifying agency, cylinder size and volume, sample pressure, dew point, regulator type and make etc.

In addition contract or must furnish calculations for number of cylinders quoted of each type. For calibration gas cylinders, consider calibration once in every 8 hours.

	REQUIREMENTS FOR ANALYSER SYSTEM	GSTD-002	0	
			Rev	
		SHEET 8 OF 14		

## 9.0 SAFETY REQUIREMENTS:

### 9.1. Hazardous Area Protection:

- a The analyser shelter shall be an unclassified area. Positive pressure and ventilation from a clean air source shall be provided to achieve this classification.
- b It is intended to operate the analysers even during the ventilation failure, hence it is required that all analysers shall be suitable for hazardous area.
- c All the electrical fittings provided in the analyser shelter shall be explosion proof type. However, a safety system shall be provided by the contractor to switch off power supply to all electrical equipments and accessories not suitable for hazardous area in case of ventilation failure. To do this it shall be ensured that all analysers continue to work safely even under these conditions.
- d All junction boxes, power distribution cabinets, LEL detectors and their panel and other safety devices shall be suitable for the hazardous area certified by a statutory body.

### 9.2. Grounding:

- a All electrical equipment in the analyser house / shelter and outside shall be grounded properly.
- b Cylinder racks, sample conditioning enclosures, analyser racks, shall also be grounded directly to the AC ground bus.
- c All necessary grounding bus requirement for Equipment grounding and signal shields shall be provided by the contract or in the analyser shelter .Contractor shall also provide all earthing arrangements inside the analyser shelter.

### 9.3. Combustible Gas Detection System (LEL Detectors):

- a Contractor's scope includes of supply and installation of combustible gas detectors with associated monitoring system for the analyser shelter .
- b Combustible gas detectors shall monitor all inlet air in take points. The detectors shall be calibrated to give alarm and high alarm at 20% and 40% respectively of. The LEL of the

component with the lowest LEL in the area. On the occurrence of high alarm the ventilation system shall be shut-off. Contractor shall provide potential free DPDT contacts rated at 230 V AC 5 Amp for connection to ventilation system.

- c Shutoff of ventilation system shall be based on 2 out of 3 voting, which means that only if two detectors out of the three provided indicate a high LEL, trip shall provided.

	REQUIREMENTS FOR ANALYSER SYSTEM	GSTD-002	0	
			Rev	
		SHEET 9 OF 14		

- d Additionally, combustible gas detectors shall monitor the analyser shelter interior and exhaust air. These detectors shall give alarm and high alarm as mentioned above, however no shut off of ventilation system shall be required.
- e Contractor shall calculate total requirement of combustible gas detectors alongwith their location.
- f The monitors for LEL detectors shall be provided with malfunction, warning and danger lights and a 0 to 100% indicator.
- g Contractor shall provide grouped high alarm and high-high alarm SPOT contacts rated for 230 V AC 5 Amp for repeat alarms in remote control room.
- h The monitors for LEL detection system shall be installed in a panel which shall be pressurized as per NFPA 496 type 'Z' purge.

#### 9.4 Fire / Smoke detection

- a Contractor's scope shall include supply and integration of fire detectors / smoke detectors (Ionisation type) within the analyser shelter. The no .of shelters shall be decided by the contractor based on the shelter size and coverage of area with in the shelter.
- b The monitors for the fire detection shall be installed in a pressurized / purged panel as per NFPA 496 type Z purge. This may be shared with LEL monitor panel.
- C The signals from the fires system monitor shall be provided for :
  - One contact for alarm on the warning panel.
  - One contact each for repeat alarm in the control room DCS and fire panel of Electrical section.

#### 9.5. Oxygen gas monitoring

- a Contractor shall provide a maximum of two nos .of oxygen gas monitoring system for sensing deficiency of oxygen within the shelter.
- b In case the monitors show low concentration of oxygen within the analyser shelter, an alarm shall be initiated on the warning panel. The repeat alarm shall also be provided for  
  
DCS in the Main control room.
- c Oxygen monitors should be located in purged panel as per NFPA 496 type Z purge. These may be located in the same panel where LEL detectors are installed.

#### 9.6 Warning Panels:

	<b>REQUIREMENTS FOR ANALYSER SYSTEM</b>	GSTD-002	0
			Rev
		SHEET 10 OF 14	

- a Contractor shall provide warning panels for audio visual alarming of hazardous conditions inside the analyser shelter. One such panel shall be installed by contract or on each of the external walls of the analyser shelter where entrance doors are provided.
- b The warning panel shall provide the following audio-visual alarms:
  - i Presence of combustible gases inside the analyser house / shelter.
  - ii Loss of analyser house / shelter pressurization
  - iii Ventilation system failure
  - iv Fire / smoke within the shelter
  - v Oxygen deficient within the shelter
- c For alarming of analyser shelter pressurization failure contractor shall provide an explosion proof pressures switch for sensing analyser shelter inside pressure.
- d These warning panels shall be of explosion proof (Exd) construction certified by a statutory body for use in hazardous area.

## 10.0 FACTORY TESTING AND ACCEPTANCE:

- 10.1. The analyser systems shall be thoroughly checked and tested prior to shipment to assure correct design, construction and proper operation.
- 10.2. The Owner / Consultant reserves the right to be involved and satisfy himself a teach and every stage of inspection and testing.
- 10.3. During the final testing vendor shall test and demonstrate to the Owner / Consultant, the functional integrity of all analysers, sampling systems and all other hardware. Repeatability test shall be performed on all analysers for a test period of 24 hours. No material or equipment shall be transported until all required tests are successfully completed and certified' Ready for shipment 'by the Owner / Consultant. Softwares, if involved, shall also be tested.
- 10.4. Contractor shall submit schedule of factory testing and inspection.
- 10.5. After placement of order vendor shall submit his factory testing and customer acceptance procedure for Owner's / Consultant approval. This document shall contain the information related to each test e.g. purpose of test, definition, test procedure, results expected and acceptance.
- 10.6. Owner / Consultant has every right to add or delete any test in vendor's test procedure and acceptance criteria. The system shall be tested and accepted as per the approved testing procedures and acceptance criteria. The cost of performing all tests shall be borne by the vendor.

	REQUIREMENTS FOR ANALYSER SYSTEM	GSTD-002	0	
			Rev	
		SHEET 11 OF 14		

10.7. Contractor shall notify the Owner / Consultant atleast three weeks prior to final system testing at vendor's works. In the event that representatives of Owner / Consultant arrive and the system is not ready for testing, the contractor shall be liable for back charging for any extra time and expenses incurred by the Owner.

10.8. It shall be contractor's responsibility to modify and / or replace any hardware, equipment or analyser if the specified functions are not completely achieved satisfactorily during factory testing and acceptance.

#### **11.0 INSTALLATION, TESTING AND COMMISSIONING:**

11.1. Contractor shall provide the services of his installation team which would install the equipment in the analyser house / shelter and in the field, lay the tubing from sample probe to analyser house / shelter, lay the interconnecting cabling tubing inside the analyser house / shelter, perform system check outs, test and commission the entire system.

11.2. All technical personnel assigned to the site by the vendor shall be fully conversant with the system supplied and shall have capability to bring the system on-line quickly and efficiently with a minimum of interference with other concurrent construction and commissioning activities.

11.3. Contractor's responsibility at site shall include all activities necessary to be performed to complete the job including;

- a Receipt of all analysers and related hardware, and checking of completeness of supply. In case of shelters, verification of all analysers and accessories duly installed, tested and wired
- b Installation of all analysers, and other associated equipment including all safety equipment like LEL detectors, annunciators, panels etc., all auxiliaries like power supply distribution boxes, all interconnecting tubing / piping etc. so as to complete the job in case of analyser room (not shelter).
- c Installation of sample probes, pressure reducing stations, sample conditioning systems, interconnecting tubing, heat tracing etc.
- d All analyser sample stream bypass, vent and drain tubing/piping.
- e Termination of all field cables or cables to control room, ferruling, tagging of interconnecting cables in analyser house/shelter.
- f Interconnection cabling inside the analyser house/shelter
- g All civil works like grouting, fixing etc and patch up work where vendor is likely to remove the plaster and shall make holes in the walls, floor or ceiling.
- h Checking of interconnections, hardware configuration, overall system functioning. Leakage rate test. Liaison with vendor's home office.
- k Field testing.

	REQUIREMENTS FOR ANALYSER SYSTEM	GSTD-002	0	
			Rev	
		SHEET 12 OF 14		

l Commissioning of the complete analyser system .

m Final acceptance testing .

#### 11.4 **System Check-outs:**

- a Checking of all interconnections , configuration and overall system functioning.
- b Any discrepancy found during checking shall be brought to the notice of Engineer-in-Charge.
- c All the check-outs shall be performed in the presence of Owner/ PMC authorized representative. All readings shall be recorded on a suitable format and shall be submitted for approval.
- d After system checking is completed, contractor shall connect back any terminal or tubing or connection removed for loop checking.
- e All the equipment shall be checked thoroughly after its receipt at site. The tests, as a minimum, shall include;
  - i Visual and mechanical testing
  - ii Complete system configuration loading
  - iii Calibration of all analysers, and other related equipment.
  - iv Demonstration of all system functions.
  - v Demonstration of all system diagnostics.
  - vi Checking of correct change of redundant devices.
  - vii Demonstration of analyser accuracies, linearities, repeatabilities, response time etc.
  - viii Demonstration of proper operation of system at specified voltage supply specifications.
  - ix A leakage test shall be conducted on entire system. Maximum permissible leakage rates shall not exceed 5%perhour of specified designed pressure.

#### 12.0 **TRAINING:**

Contractor shall be responsible to train the Owner / Consultant personnel in the field for maintenance of hardware and software. Theoutline of each course including the course contents and the duration shall be forwarded by the vendor alongwith the offer.

#### 13.0 **DOCUMENTATION:**

	REQUIREMENTS FOR ANALYSER SYSTEM	GSTD-002	0	
			Rev	
		SHEET 13 OF 14		

Contractor shall furnish all the manuals, including for maintenance and operation, necessary to test, operate and maintain etc the analysers and other related equipment, hardware and software.

#### **14.0 ENGINEERING DRAWINGS:**

14.1 . Contractor shall provide a complete set of drawings covering each part of supply for Owner / Consultant record. The contract or is required to include Owner's project number on each of his drawing.

14.2 . All field modifications shall be carefully recorded by the contractor's installation and commissioning personnel and changes shall be incorporated into the final drawings.

#### **15.0 FINAL ACCEPTANCE TEST:**

The Owner. Will take over the system from the contractor after the final acceptance test, which is defined as successful uninterrupted operation of the integrated system for three weeks with desired accuracy and repeatability. Contractor's personnel shall be present during the test. Any malfunctioning of the system components shall be replaced / repaired as required. Once the system failure is detected, the acceptance test shall start all over again from the beginning.

#### **16.0 TESTING AND CALIBRATION EQUIPMENT:**

Contractor shall make available all consumables including calibration gas cylinders, instruments and equipments necessary for testing, calibration, maintenance etc. as defined by the 'scope of work' .All instruments and equipments used for the above purpose shall be of standard make with accuracy better than the accuracy expected from the calibrated / tested equipments and shall be certified by National Physical Laboratory or other equivalent agencies.

#### **17.0 SPARE PARTS:**

Contractor shall quote separately for spare parts required for a two year period of operation for the complete analyser system and the associated auxiliaries offered. Contractor shall enclose a list of spare parts quoted along with the offer.

#### **18.0 MAINTENANCE CONTRACT:**

Contractor shall quote separately for maintenance contract after warranty period for two years based on per day rate for each category of personnel required. The personnel deployed shall have thorough knowledge of the system and at least two years of experience as maintenance of similar system.

#### **19.0 PACKING AND SHIPPING INSTRUCTIONS:**

19.1. All materials used for packing, wrapping, sealers, moisture resistant barriers and corrosion preventers shall be recognized brands and shall conform to the best standards in the areas for the articles which are being packaged.




	REQUIREMENTS FOR ANALYSER SYSTEM	GSTD-002	0	
			Rev	
		SHEET 14 OF 14		

- 19.2. Workmanship shall be in accordance with best commercial practice with the requirement of applicable specifications. There shall be no defects; imperfections or omissions which would tend to impair the protection of the package as a whole.
- 19.3. The package shall be suitable for storing in tropicalised climate as per specified ambient conditions.
- 19.4 . Shipment shall be thoroughly checked for completeness before final packing and shipment. Contractor shall be fully responsible for any delay in installation or commissioning schedule because of incomplete supply of equipment.

	PROJECTS & DEVELOPMENT INDIA LTD	GSTD-0003	0	
			Rev	
		SHEET 1 OF 23		


## GENERAL SPECIFICATION FOR STACK ANALYSERS(IF applicable)

0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	GENERAL SPECIFICATION FOR  STACK ANALYSERS	GSTD-0003	0	
			Rev	
		SHEET 2 OF 23		


#### Abbreviations:

AARH	Arithmetic Average Root Height
CCE	Chief Controller of Explosives
CIMFR	Central Institute of Mines and Fuel Research
ERTL	Electronics Regional Testing Laboratory
DGMS	Director General of Mine safety
CRCA	Cold Rolled Cold Annealed
DC	Direct Current
DCS	Distributed Control System
HVAC	Heating Ventilation and Air conditioning
IR	Infrared
LCD	Liquid Crystal Display
LED	Light Emitting Diodes
MAWP	Maximum Allowable Working Pressure
MOC	Material of Construction
PTFE	Poly Tetra Fluoro Ethylene
NPT	National Pipe Thread
RAM	Random Access Memory
RTU	Remote Transmission Unit
SS	Stainless Steel
UV	Ultraviolet

	GENERAL SPECIFICATION FOR  STACK ANALYSERS	GSTD-0003	0	
			Rev	
		SHEET 3 OF 23		

## CONTENTS

- 1.0 GENERAL
- 2.0 DESIGN AND CONSTRUCTION
- 3.0 NAME PLATE
- 4.0 INSPECTION AND TESTING
- 5.0 SHIPPING
- 6.0 REJECTION

	GENERAL SPECIFICATION FOR  STACK ANALYSERS	GSTD-0003	0	
			Rev	
		SHEET 4 OF 23		

## 1.0 GENERAL

### 1.1 Scope

1.1.1 This specification, together with the data sheets, covers the requirements for the complete design, materials, nameplate marking, and inspection, testing and shipping of stack gas analysers.

1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the purchaser's enquiry:

ANSI/ASME American National Standards Institute/ American Society of Mechanical Engineers.

B 1.20.1 Pipe Threads. General Purpose (Inch)

B 16.5 Steel Pipe Flanges and Flanged Fittings. NPS ½ through NPS 24.

B 16.20 Metallic Gaskets for Pipe Fittings, Ring Joints, Spiral and Gasketed.

API American Petroleum Institute

Manual on Installation of Refining Instruments and Control System

RP 551 Process Measurement Instrumentation

RP 552 Transmission System

RP 554 Process Instrumentation and Control

RP 555 Process Analysers

ASTM 693 Standard Practice for cleaning methods and cleanliness levels for material and equipment used in oxygen-enriched environment.

EN 50020 Electrical Apparatus for potentially explosive atmospheres-Intrinsic safety 'i'

EN 10204 Inspection Documents for Metallic Products.

IEC-60079 Electrical Apparatus for Explosive Gas Atmosphere.

IEC-60529 Degree of Protection Provided by Enclosures. (IP Code)

IEC-61000-4 Electromagnetic Compatibility for Industrial Process Measurement and Control Equipment.


IEC-61285 Industrial Process Control Safety of Analyzer Houses

IEEE 515.

IS-13947 Specification for Low Voltage Switchgear and Control gears.

IS-2148 Electrical Apparatus for Explosive Gas Atmosphere-Flameproof enclosures 'd'.

NFPA 496 National Fire Protection Association

	GENERAL SPECIFICATION FOR  STACK ANALYSERS	GSTD-0003	0	
			Rev	
		SHEET 5 OF 23		

1.1.3 In the event of any conflict between this standard specifications, job specification/data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

- a) Statutory Regulations
- b) Data Sheets
- c) Standard Specification
- d) Codes and Standards

1.1.4 In addition to meeting the purchaser's specification in totality, vendor's extent of responsibility shall include the following:


- a) Purchaser's data sheet indicates the type of analyser and the minimum sample conditioning system requirements. Vendor shall be responsible for the selection of proper analyser and design of the sample conditioning system to analyse the component of interest within the stated performance requirements.
- b) Carry out complete application engineering of the stack gas analyser so as to achieve the desired analysis within stated performance requirements.
- c) Provide all hardware and software, as necessary, to meet the functional requirements specified in the purchaser's specifications.
- d) Provide complete data to purchaser for successfully proving serial communication with purchaser's host system i.e. DCS when specified in the job specification.
- e) Purchaser's data sheets indicate the minimum requirements of material of construction for the analyser and its sample conditioning system. Alternate superior material of construction shall also be acceptable provided vendor assumes complete responsibility for the parts of the analyser system which have the alternate material of construction for their compatibility with the analysis stream and surrounding atmosphere as specified in purchaser's data sheet.

## 1.1.2 Bids


1.2.1 Vendor's quotation shall be strictly as per the bidding instruction to vendor attached with the material requisition.

1.2.2 Whenever a detailed technical offer is required, vendor's quotation shall include the following:

- a) Compliance to the specifications.
- b) A detailed specification sheet for each analyser, which shall provide information regarding type, materials of construction, performance specification and accessories of analyser. The material specification and units of measurement for various parts in vendor's specification sheets shall be to the same standards as those indicated in purchaser's data sheets.
- c) A detailed drawing showing various components of sample conditioning system and their piping/tubing hook-up arrangement including sample return, vent, utilities connection and requirement of heat tracing (i.e. electrical or steam tracing), as necessary.

	<b>GENERAL SPECIFICATION FOR STACK ANALYSERS</b>	GSTD-0003	0
			Rev
		SHEET 6 OF 23	

- d) Sample transportation time calculations for the specified distance between sample point and analyser indicating sample flow rate and the recommended size of the sampling tube.
- e) Calibration gas cylinder calculations considering six months of continuous operation with once in a fortnight calibration. The calculation sheet shall indicate the rate of gas consumption and specification of gases including composition, concentration, accuracy and shelf life of calibration blend.
- f) Proven references for each offered model of analyser inline with clause 1.2.3 of this specification.
- g) A copy of approval for intrinsically safe/flameproof enclosure, whenever specified, from local statutory authority, as applicable, such as Chief Controller of Explosives (CCE), Nagpur or Director general of Mines Safety (DGMS) in India, along with:
- Test certificate from recognised house CMRI/ERTL etc. for flameproof enclosure as per relevant Indian Standard for all Indian manufactured equipments.
  - Certificate of conformity from agencies like CSA, BASEEFA, PTB, LCIE, FM, UL etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.
- h) Utility requirements and their consumption i.e. instrument air, cooling water, steam etc. along with their process conditions like flow, pressure and temperature.
- i) Power consumption for each analyser and its accessories.
- j) HVAC requirements i.e. heat load, humidity particulate/chemical filtration etc.
- k) Deviations on technical requirements shall not be entertained. In case vendor has any valid technical reason, they must include a list of deviations tag number wise, summing up all the deviations from the purchaser's data sheets and other technical specifications along with the technical reasons for each of these deviations.
- l) Catalogues giving detailed technical specifications, model decoding details and other related information for each type of analyser and accessories covered in the bid.
- 1.2.3 All items, as offered, shall be field proven and should have been operating satisfactorily individually for a period of minimum 4000 hours on the bid due date for the analysis as specified in the purchaser's data sheet. Items with proto-type design or items not meeting provenness criteria specified above shall not be offered.
- 1.2.4 All documentation submitted by the vendor including their quotation, catalogues, drawings, installation, operation and maintenance manuals, etc shall be in English language only.
- 1.2.5 Vendor shall also quote for the following: -
- Complete calibration kit consisting of calibration gas cylinders, pressure regulators, gauges, cylinder gas piping manifolds and driers, (as required) etc. as a minimum, for
  - each analyser. In case of dual range analyser, separate calibration standards shall be provided for each range. For the purpose of calculating requirement of zero and span calibration samples/gases, consider calibration time of 30 minutes every fortnight for each analyser for a period of six (6) months of continuous operation.

	GENERAL SPECIFICATION FOR  STACK ANALYSERS	GSTD-0003	0	
			Rev	
		SHEET 7 OF 23		

- c) Consumable spares for the duration of six months with list of items as per vendor recommendations for each analyser system, unless otherwise specified in job specification.
- d) Start up and commissioning spare parts for each analyser/analyser system as per vendor recommendations. However this list of spare parts must include 5% or minimum one of each type of following spare parts:
- Solenoid valve
    - Pressure regulator
    - Filters
    - Temperature controller
  - IR/UV Source (lamp)
    - Peristaltic pump
    - Set of fuses
    - Set of o-rings
    - Tubing and tube fittings (sizes smaller than 6 mm or 1/4").


Additional spare parts, if required, during start-up and commissioning, even though not listed in the list of start-up and commissioning spares mentioned above, shall be supplied by the vendor without any implication.

- d) Any special instrument or tool needed for testing, calibration and maintenance of the analyser such as spanner set (for tubes smaller than 6 mm or 1/4"), non-magnetic tools, bubble rotameter etc.
- e) Training at vendor works and at site as specified in job specifications.
- f) Two years operational and maintenance spares for each analyser and its accessories as per vendor recommendations, which shall include spare parts like electronic modules, temperature controller, power supply module, flow meter, solenoid valve, pressure regulator, local indicator, tubes, fan assembly, sample cell, detector assembly, UV/IR source/lamps, set of o-rings, set of fuses etc.

### 1.3 Drawing and Data

- 1.3.1 Detailed drawing, data, catalogues and manuals required from the vendor are indicated by the purchaser in the vendor data requirement sheets attached with the enquiry. The required number of reproducible, prints, and soft copies shall be despatched to the address mentioned, adhering to the time limits indicated.
- 1.3.2 Final documentation consisting of design data, installation, operation and maintenance manual etc., submitted by the vendor after placement of purchase order shall include the following, as a minimum;
- a) Specification sheet for each analyser and its accessories.
- b) Certified drawings for each analyser and its accessories, tag number wise, which shall provide the following information:



	GENERAL SPECIFICATION FOR  STACK ANALYSERS	GSTD-0003	0	
			Rev	
		SHEET 8 OF 23		

- i) Overall dimensions in millimetres.
  - ii) Sampling system details identifying each component with make and model number, process connection, utility connection, calibration sample/gas connection, heat tracing requirements, sample vent and fast loop details etc. The flow, pressure and temperature at interface and other appropriate location must be shown in the sampling system drawing.
  - iii) Detailed interconnection drawing of each analyser identifying each component with terminal number, cable type, and cable size and cable entry details. The interface details shall be clearly identified in the drawing.
  - iv) Grounding details.
  - v) Power supply distribution details.
- c) Programming/configuration data for each analyser, as applicable.
  - d) Serial interface specification including its configuration data (addresses) for host communication.
  - e) Power consumptions and utility requirements.
  - f) Calibration curves and calibration data for each analyser.
  - g) Zero and span calibration gas specification including composition, shelf life time and accuracy.
  - h) Copy of type test certificates.
  - i) Copy of the test certificates of all the tests indicated in clause 4.0 of this specification.
  - j) Installation procedure for each analyser and their accessories.
  - k) Calibration and maintenance procedures including replacement of its parts/internals wherever applicable.

## 1.4 Definitions

1.4.1 The following definitions shall apply for analysers and their accessories:


a) Transportation time

Transportation time is the time interval between a step change in the process fluid composition in the process line and the initial analyser response (excluding analyser response time).

b) Response Time

The time interval between the initial response of the analyser and the time required for the analyser output to reach a value of 90% of the final output value for a step change in sample quality.

c) Time Constant

	GENERAL SPECIFICATION FOR  STACK ANALYSERS	GSTD-0003	0	
			Rev	
		SHEET 9 OF 23		

The analyser response to reach a value of 63% of the final output value for a step change in sample quality is called the analyser time constant.

d) Repeatability

Repeatability of a measurement is the band of values within which an analyser repeats its measurement when the same sample is applied to it. The short termed repeatability is generally determined by multiple readings of a sample during calibration and is usually true random error over short period of time if external influences like pressure and temperature etc remain constant.

It is also defined as the difference between two successive analyser results that would be exceeded in the long run in only one (1) case in twenty (20) when a single analyser system is operated on a flowing sample of uniform quality.

e) Sensitivity

The sensitivity of an analyser is a measure of an analyser's ability to detect a least change in concentration of a measured component that is not masked by the background noise.

f) Accuracy

Accuracy of a measurement is the measure of how close the measured value is to the true value of the sample. For all type of analysers, accuracy is primarily a function of the accuracy of the standards used for calibration.

g) Analyser Rack

An open analyser mounting structure with/without canopy used for mounting analysers, sample handling system and their accessories individually or together in combination.

h) Analyser Cabinet


Small housing, in which analysers are installed individually or grouped together. Maintenance is performed from outside the cabinet with door (s) open.

## 2.0 DESIGN AND CONSTRUCTION

### 2.1 Analyser Requirements

2.1.1 The type of analyser and its measuring principle is specified in the purchaser's data sheet. Accessories and equipments as required to make online analysis complete are also specified in the data sheet. In general, the scope shall include the following:


- a) Sample probe and sampling system, as applicable
- b) Analyzer complete with all hardware and software consisting of detector, transmitter and associated equipments.
- c) Fast loop and Sample return system, as applicable
- d) Calibration and maintenance equipment.
- e) Gas cylinders for zero and span calibration.

	<b>GENERAL SPECIFICATION FOR</b>  <b>STACK ANALYSERS</b>	GSTD-0003	0
			Rev
		SHEET 10 OF 23	

Unless otherwise specified the scope shall also include supply of all interconnecting tubing, piping, fittings, heat tracing equipment etc., excluding sample return piping from analyser battery limit to sample return header.

In-situ analysers when specified may not include sampling system.

- 2.1.2 Analysers and its related equipments directly connected to process line and In-situ analysers shall be capable of withstanding line pressure/vacuum and temperature conditions specified in the purchaser's data sheet.
- 2.1.3 The analyser design and design of sample handling system shall be such that components or any sub-assembly that requires removal, shall be possible without any need to disassemble any other component. Such components shall include items like stream selector valves, (when applicable) filters, pressure regulators, flow-indicator, detector, electronic modules etc.
- 2.1.4 Analyser shall be microprocessor based with state-of-the-art technology and shall be capable of being configured from analyser front panel locally using built-in keyboard. When specified, it shall also be possible to configure the analyser from remote through a separate terminal.
  - 2.1.4.1 The programmer/ controller shall be microprocessor based and shall be furnished with all the equipments necessary to properly control the analysis cycle, the automatic zero adjustment circuit, the calibration of the analyser and programmer systems and the transition of data to ADSU or DCS and any require peripheral equipment.
  - 2.1.4.2 Visual readout using a digital indicator shall be provided to identify each component being analysed and each step in the program as well as displaying the latest readings.
  - 2.1.4.3 Peak peaker and long term memory circuit boards shall be provided for each component of the interest.
  - 2.1.4.4 All program data tables shall be capable of field modification without user knowledge of higher level programming. A key lock switch or field alterable password shall be provided to limit access to system software by unauthorized personnel.
- 2.1.5 The configuration related data of the analyser including set range shall be stored in a nonvolatile memory such that this data remains unaffected by power fluctuations or power off condition. In case vendor's standard product stores configuration data in battery backed RAM, analyser shall have facility to provide battery drain alarm as diagnostic maintenance message.
- 2.1.6 The span of the analyser shall be field adjustable from the analyser front without opening the analyser enclosure. In case, separate device is required to make such a change, the same shall be included by vendor in their scope of supply.
- 2.1.7 Analyser shall run diagnostic subroutines on continuous basis and shall be able to provide diagnostic alarms related to analyser optics, detector and electronics, as and when any failure/malfunction is detected.
- 2.1.8 Analyser shall have an integral output meter with digital readout in engineering units.
- 2.1.9 All interconnecting wiring shall be colour coded / numbered and terminal blocks be clearly identified.
- 2.1.10 The analyser shall be capable of providing the following outputs:
  - a) Isolated 4-20 mA DC current output for each analysed component. Smart or field bus output shall be provided when specifically indicated in the purchaser's data sheet.

	GENERAL SPECIFICATION FOR  STACK ANALYSERS	GSTD-0003	0	
			Rev	
		SHEET 11 OF 23		

- b) RS485 serial output with MODBUS (RTU) protocol, whenever serial output is specifically indicated in the purchaser's data sheet. The serial output signal shall contain analyser data of component of interest and diagnostic alarms, as a minimum.
- c) SPDT contact outputs for various diagnostic alarms (as applicable) such as:
  - i) High or low set point alarm as measurement
  - ii) Analyser failure
  - iii) Low sample flow
  - iv) Temperature control failure

Any other alarm contact, either specifically indicated in purchaser's data sheet or available as standard with the analyser, shall also be provided.

Unless specified otherwise, all contacts shall be normally closed type (contact open in alarm) and shall be rated for 110V AC 5 Amperes.

#### 2.1.11 Statutory Regulatory Compliance

The design of analysers shall be in compliance to EPA, TUV or any other recognized regulations applicable in the country of origin. These analysers shall also meet the regulations of local pollution control boundary regulatory authorities applicable at the place of installation.

2.1.12 The design of analyser system shall be in compliance with the electromagnetic compatibility requirements as per IEC-61000-4-X.

#### 2.1.13 Material of Construction

2.1.13.1 Unless otherwise specified, the material of construction of all components wetted by the sample shall be SS 316, as a minimum. Vendor must ensure the compatibility of material of each component with the process fluid.

2.1.13.2 Material of all soft parts like diaphragms and o-rings shall be of PTFE. Other vendor standard materials can also be acceptable provided these are compatible with the specified process conditions.

2.1.13.3 The material of construction of all non-wetted parts shall be as per manufacturer's standard. However, non-metallic materials for casings, enclosures and instrument covers shall be avoided.

#### 2.1.14 Power Supply

2.1.14.1 Unless indicated otherwise, the analyser including the sample handling system shall operate at 110V 50Hz power supply.

2.1.14.2 The analyser performance shall be within the specified limits when the supply voltage varies by  $\pm 10\%$  of specified value and supply frequency varies by  $\pm 3$  Hz of specified value.

2.1.14.3 Electrical tracing when specified, shall operate at 230V 50 Hz supply. 230V 50Hz power supply shall also be used for analyser cabinet/panel lighting and air conditioning unit, when specified.

#### 2.1.15 End Connection

	<b>GENERAL SPECIFICATION FOR STACK ANALYSERS</b>	GSTD-0003	0
			Rev
		SHEET 12 OF 23	

2.1.15.1 Unless otherwise specified, the following shall govern;

- a) Threaded connections shall be NPT to ANSI/ASME B 1.20.1.
- b) Flanged connection shall be as per ANSI/ASME B16.5.
- c) Flange face finish shall be serrated concentric to clauses 6.4.4.1, 6.4.4.2, and 6.4.4.3 of ANSI/ASME B 16.5. The face finish shall be as follows:

125 AARH : 125 to 250 AARH  
63 AARH : 32 to 63 AARH

- d) Ring type joint flanges shall have octagonal grooves as per ANSI/ASTM B16.20.

2.1.15.2 End connection of sizes 6 mm or below shall be suitably protected against damage.

2.1.15.3 All end connections shall be clearly identified by attaching labels or stainless steel plate of suitable size.

#### 2.1.16 Enclosure Type

2.1.16.1 Analyzer enclosure and related accessories shall be suitable for the electrical area classification indicated in purchaser's data sheets. Unless otherwise specified, the enclosures shall comply with the following standards:

Weather proof housing : IP 65 as per IEC-60529 / IS-13947  
Flame proof housing : Flame proof Ex (d) as per IEC-60079 / IS-2148  
Purged Enclosure : NFPA 496

Flameproof and purged equipment shall also be made weatherproof.

2.1.16.2 In addition to meeting weatherproof requirements specified in clause 2.1.15.1 of this specification, intrinsically safe analysers shall meet the requirements specified in EN 50020 and shall be certified for the area classification specified in the purchaser's data sheet.


2.1.16.3 Analyser where air/nitrogen purge is provided, purge shall be as per NFPA 496 Type X. Analyser power shall cut off in case of purge failure. Purge failure alarm shall be provided for purchaser use.

2.1.16.4 Separate cable entries shall be available in the analyser/enclosure for power and signal cable.

Unless otherwise specified, following shall apply:

- a) Cable entry and terminal size for power cable shall be ¾" NPT(F) cable entry other than ¾" NPT (F) shall be provided when specified.
- b) Cable entry for Serial cable/signal cables (Signal output) shall be ½" NPT (F).
- c) Cable entry for multi-pair signal cables (Multiple output) shall be 1½" NPT (F).

Reducer fitting may be provided when the analyzer standard cable enters are different than those specified.

	<b>GENERAL SPECIFICATION FOR</b>  <b>STACK ANALYSERS</b>	GSTD-0003	0
			Rev
		SHEET 13 OF 23	

2.1.16.5 All enclosure entries including sample, utilities, cables etc. shall be clearly identified by attaching label or stainless steel plate of suitable size.

## 2.2 Sample Handling System

2.2.1 The sample handling system shall consist of primary sample conditioning near sample take off point, sample transportation line, secondary sample conditioning near the analyser, sample return, sample/analyser vent and sample drain/recovering system, as applicable.

The primary sample-conditioning unit shall be a fabricated assembly and shall be mounted on a stainless steel plate suitable for surface mounting.

Secondary sample conditioning shall also be a fabricated assembly and shall be mounted either on a stainless steel plate or within an enclosed cabinet/box with a viewing window.

2.2.2 Stream sampling shall be continuous and analyser shall be located as near as possible to the sample take-off point. Where the analyser is located away from the sample take-off point, vendor shall design the sample fast loop (bypass loop) as part of sampling system. Design shall ensure that the sample drawn is true representative of the stream to be analysed.

2.2.3 In general, sampling systems shall be designed and constructed in accordance with API-RP-555. The design of sample handling system shall consider the following factors, as a minimum:

- a) The pressure/vacuum-temperature conditions required for the analyser.
- b) Interfering components in the process sample.
- c) Normal and abnormal sample compositions.
- d) Fouling sample conditions e.g. polymer formation or presence of solids etc.
- e) Transportation time requirements.
- f) Utilities available and their process conditions.


2.2.4 Unless otherwise specified, material of all components wetted by sample shall be suitable for the process fluid and sample process conditions specified in the purchaser's data sheet. The material of construction for all wetted parts shall be, 316 SS, as a minimum.

2.2.5 Sampling system shall include all elements as necessitated by the process conditions indicated in the purchaser's data sheets, to make the sample suitable for the analysis. This shall include but not limited to filters (coarse and fine), pressure regulators, relief valves, flow indicators, flow controllers, temperature indicators, scrubbers, heaters, coolers, dryers, sample pumps, aspirators etc.

Each sampling system element shall be capable of being removed without disassembling the entire system.


2.2.6 Sample probe shall be provided by the vendor to obtain representative sample from the stack. The sample probe shall be inserted in the stack through an isolation valve (ball or gate valve), which shall be part of vendor's scope of supply. The probe design shall ensure the following:

- a) On-line removal and insertion of the probe with non-fly-off design.
- b) Unless otherwise specified, end connection for installation in the line shall be 4" flanged with type and rating as specified in purchaser's data sheet. The line isolation valve shall also be of the same size and rating as probe end connection.

	GENERAL SPECIFICATION FOR  STACK ANALYSERS	GSTD-0003	0	
			Rev	
		SHEET 14 OF 23		

- c) The probe diameter shall be such that it can be easily inserted or removed through the line isolation valve when in fully open condition.
- d) The length of the probe shall be selected considering its insertion upto the middle third of the stack. For the purpose of calculating probe length, consider nozzle length as 200 mm.
- 2.2.7 Sampling system shall include a sample block valve on all process sample line. The block valve shall be provided meeting the following requirements:
- a) The block valve shall be located immediately after the sample probe.
- b) Where purchaser's data sheets do not indicate the requirement of sample probe, the block valve shall be provided in the sample line as a part of primary sample conditioning unit.
- c) The size of the sample block valve shall be as per the sample line size while the rating shall be as specified in the purchaser's data sheet.
- 2.2.8 The size of the sample tubing shall be decided by the vendor considering:
- a) The distance between sample take off and analyser specified in purchaser's data sheet.
- b) The specified sample transportation time.
- c) Pressure at the sample take off point.
- Where no transportation time is specified in the purchaser's data sheets, vendor shall consider the sample transportation time as 60 seconds.
- 2.2.9 Where sample is required to be transported in hot condition, sample shall be drawn using prefabricated heated tubes. The heated medium shall be either steam or electric power as specified in purchaser's data sheet.
- Heating shall be controlled such that the sample temperature is maintained typically around +20°C above the sample dew point.
- 2.2.10 When fast loop is specified or recommended by vendor, vendor shall provide flow meter for sample bypass flow. Sample return line to process shall be provided with isolation valve and check valve. Vendor shall ensure that return pressure of the sample shall be higher than the pressure of the process return point specified in purchaser's data sheet.
- 2.2.11 Sampling system shall include provision for connecting calibration sample/gases in auto or in manual configuration as specified in purchaser's data sheet. When no specific requirement is indicated, the provision shall be made for manual configuration only.
- 2.2.12 Whenever auto-calibration requirement is specified in the purchaser's data sheet, it shall be possible to initiate auto calibration cycle at preset time interval defined by user either manually via the analyser keyboard or remotely through an external contact.
- The sample handling system shall be designed to include all hardware and/or software to meet this requirement. The analysed component concentration output shall remain at the last good measured value during auto calibration cycle.
- 2.2.13 Unless specified otherwise, analysers with common take off shall have separate sample handling system for each analyser.



	GENERAL SPECIFICATION FOR  STACK ANALYSERS	GSTD-0003	0	
			Rev	
		SHEET 15 OF 23		

2.2.14 Filters shall always be provided in dual configuration. It shall be possible to replace the filter without upsetting the operation of the analyser.

2.2.15 Unless specified otherwise, sample lines used for carrying samples for more than one analyser shall be provided with sample pumps in dual configuration. It shall be possible to remove or insert the pump without upsetting the sampling system.

2.2.16 A suitable restriction orifice shall be provided in each sample line to limit the sample flow exceeding thrice the normal flow in the event of tube rupture or opening of tube down the line.

2.2.17 Sample Extraction Techniques:

Sample extraction shall be any one of the following unless otherwise specified in the Data sheet.

2.2.17.1 Dilution Technique.

- a) Instrument air shall be provide by the purchaser and the specification shall be as specified elsewhere. Vendor shall consider the minimum pressure condition for the system design.
- b) Vendor scope shall include all items/elements like dilution probe, pneumatic control module, instrument air pressure/flow controller, pressure gauge, etc. as necessary for proper system design. Additional dew point suppression of instrument air (Beyond that is specified) shall be taken care of by vendor.
- c) Vendor shall select the dilution ratio depending upon their system design. Calculations for the same shall be furnished by vendor.
- d) For dilution type technique, vendor must select the range of analyzers based on the dilution ratio selected.
- e) Vendor shall be fully responsible to select the dilution probe with critical orifice. The material of orifice shall be 'QUARTZ' as a minimum. Vendor's scope shall include supply of one spare orifice along with each sample probe clearly marking the dilution Ratio.

2.2.17.2 Hot Extraction Technique.


Vendor shall select heated sample lines (Prefabricated tubes with tracer and insulation) with electrical tracing. The temperature of the sample line shall be controlled at a temperature so as to avoid condensation in the sample lines. The temperature control unit shall also form part of vendor's scope of supply. The sample lines shall be prefabricated tubes with electrical traces fully insulated with overall sheath of low smoke grade PVC. All such tubes should have undergone services life performance test as per IEEE 515. The electrical tracing line with temperature controller shall be suitable for the specified area classification.

2.2.18 The sample handling system shall be designed to,

Avoid plugging of sample probe and sample line even in case of;

- Failure of electrical tracing
- Failure of instrument air
- Excessive solid particles during start up or process upset condition.



	GENERAL SPECIFICATION FOR  STACK ANALYSERS	GSTD-0003	0	
			Rev	
		SHEET 16 OF 23		

Vendor shall clearly study each of these scenario and provide automatic sample shut off and blow back facility in line with the requirements of the specified application.

2.2.19 The routing of sample transfer lines shall be done in such a way that the total length between the sampling point and the analyser sample conditioning system is minimum. Short radius bends shall be avoided to avoid excessive pressure drop.

2.2.20 Where sample pumps are used, moisture sensor shall be provided in sample handling system to cut off pumps in case of high moisture level.

2.2.21 Analyser rack and cabinet

a) Whenever specified in the purchaser's data sheet, the analyser shall be supplied in pre-assembled, pre-tubed and pre-wired condition complete with sample handling system. The primary sample-conditioning unit i.e. conditioning at sample tap-off point, shall be supplied separately.

b) When open rack mounted installation is specified in purchaser's data sheet, the analyser and sample handling system shall be supplied installed in an open rack with canopy to protect the analyser from direct sunlight and rain. The open rack shall be fabricated using channels/pipes of suitable size. The material of construction shall be stainless steel. The canopy shall also be fabricated out of SS plate of 1.2 mm thick.

c) Whenever closed cubical mounted installation is specifically indicated in the purchaser's data sheets, analyser and sample handling system shall be supplied preinstalled in freestanding closed analyser cabinet. The analyser cabinet shall be suitable for outdoor installation and shall be provided with a key lock. Cabinet shall be fabricated out of 2.0mm SS sheet reinforced with angles of suitable sizes. Fittings and hinges shall be of stainless steel. Anchor bolts required for installation of cabinet shall also be supplied by vendor. A power isolation switch with suitable circuit breaker or fuse shall be provided for the incoming power supply. All items including analyser installed within the cabinet shall be suitable for the maximum possible temperature likely to be attained within the cabinet (i.e. with all items fully powered-on within the cabinet) and area classification specified in the purchaser's data sheet. Heating/cooling of analyser cabinet shall be provided either when purchaser's data sheets specify the requirement of heating and/or cooling or recommended by the analyser manufacturer or found necessary by the manufacturer to meet following requirements:

i) The temperature induced measurement error exceeds  $\pm 1\%$  of full scale in the worst temperature conditions.


ii) The maximum allowable ambient temperature condition of any component within the cabinet exceeds its limits.

Whenever cooling is specified or found necessary, vendor may select one of the following cooling methodology, unless specifically indicated otherwise:

a) Cabinet mounted air conditioner certified for the specified area classification.

b) Vortex cooler with compressed air system and air dryer of suitable size and capacity. No separate instrument air shall be provided by purchaser for vortex cooler.

c) Power supply cable entry and terminal size shall be as defined during detail

	GENERAL SPECIFICATION FOR  STACK ANALYSERS	GSTD-0003	0	
			Rev	
		SHEET 17 OF 23		

engineering by purchaser

- d) The maximum height of rack/cabinet shall be limited to 2100 mm. Cabinet shall be suitable for side and bottom cable entry.

### 2.3 CARBON MONOXIDE, CARBON DIOXIDE ANALYSERS


- 2.3.1 Unless specified otherwise the CO/CO<sub>2</sub> analysers shall be of Infra Red type
- 2.3.2 IR/UV analyser shall preferably be non-dispersive type.
- 2.3.3 Analyser cell length shall be selected as per specified analyser component range. In case of dual range analysers, the selected cell length shall be suitable for both the ranges.
- 2.3.4 The analyser cell material and window material shall be suitable for the specified service. Unless otherwise specified or required otherwise by pressure-temperature conditions, the oring material shall be Teflon.
- 2.3.5 The analyser design shall be such that it is insensitive to source fluctuations or cell window degradation/partial cloudiness.
- 2.3.6 The analyser shall have built-in indicator with digital display.
- 2.3.7 Unless otherwise specified, analyser shall meet the following performance requirements:

Repeatability	:	± 1% of full scale or better
Zero drift	:	± 1% full span/week.
Speed of response	:	less than 90 seconds for 90% of final reading.
Linearity	:	± 1% of full scale or better.

### 2.4 SO<sub>x</sub> ANALYSER

- 2.4.1 Unless specified otherwise the analyser measurement principle shall be based on UV Fluorescence. The UV source lamp shall be highly energizing, monochromatic with minimum source life of 5 years.
- 2.4.2 Analyser cell length shall be selected as per specified analyser component range. In case of dual range analysers, the selected cell length shall be suitable for both the ranges. The analyser cell material and window material shall be suitable for the specified service.
- 2.4.3 Unless otherwise specified or required otherwise by pressure-temperature conditions, the oring material shall be Teflon.
- 2.4.4 The analyser design shall be such that it is insensitive to source fluctuations or cell window degradation/partial cloudiness.
- 2.4.5 Special filters shall be offered to minimize the interference of background components, which are of least interest in process stream.
- 2.4.6 Where IR type analysers are specified, the same shall meet the specification as per clause 2.3 above.
- 2.4.7 Unless otherwise specified, analysers shall meet the following performance requirements:

Zero/span Drift	:	± 1% of full span/week
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	<b>GENERAL SPECIFICATION FOR STACK ANALYSERS</b>	GSTD-0003	0
			Rev
		SHEET 18 OF 23	

Repeatability	:	± 0.5% full scale or better.
Response time overall	:	less than 90 seconds for 90% of final reading.
Linearity	:	± 1% of full scale or better.

#### 2.4.8 Analyzer for incinerator stack for sulphur plant (SRU)

The analyzer system design and analyzer selected for incinerator stack are suitable for the sample containing high sulphur contents. The sample handling system shall be designed for such eventuality which is likely to occur during start up or under plant upset condition.

Any one of the following techniques shall be considered meeting other requirements:

- a) Dilution technique with sample handling system designed considering the worst conditions of sulphur.
- b) Hot extraction technique with heated analysers.

### 2.5 NOx Analysers

2.5.1 Unless otherwise specified the NOx analyser measurement principle shall be Chemiluminescence type.

2.5.2 The analyser shall be complete with ozonator, mode selection chamber for NO, NO-NO<sub>2</sub>, reaction chamber and detection unit.

2.5.3 Special filters shall be offered to minimise the interference of background components, which are of least interest in process stream.

2.5.4 The analyser shall have built in indicator with digital display for measurement & instrument opacity parameters indications.

2.5.5 Unless otherwise specified the analyser shall meet the following performance requirements

Zero/span Drift	:	± 1% of full span/week
Repeatability	:	± 0.5% full scale or better.
Response time overall	:	less than 90 seconds for 90% of final reading.
Linearity	:	± 1% of full scale or better.

### 2.6 HC Analyser


2.6.1 Unless specified otherwise the analyser measurement principle shall be based on the Flame Ionisation Detection (FID) for HC Analysers.

2.6.2 Probe length shall be provided such that 30% insertion in heater stack and shall be calculated based on the nozzle projection and shall be based on the Stack ID given.

2.6.3 Probe & Filter material shall be selected to suit the stack process condition.

2.6.4 Unless otherwise specified the analyser shall meet the following performance requirements.

Zero/span Drift	:	± 1% of full span/week
Repeatability	:	± 1% full scale or better.
Response time overall	:	less than 30 seconds.

	GENERAL SPECIFICATION FOR  STACK ANALYSERS	GSTD-0003	0	
			Rev	
		SHEET 19 OF 23		

Linearity :  $\pm 1\%$  of full scale or better.

## 2.7 Analyser Data storage Unit

2.7.1 The central analyser data storage unit (ADSU) shall be provided for the storage of data and diagnostic alarms of analysers and analyser shelter/ analyser room as applicable.

2.7.2 Unless specified otherwise a common ADSU shall be provided for all the stack analysers and related analyser shelters/rooms:

2.7.2.1 Processor/Hard ware for data acquisition and communication including network switches, fibre optic cables etc.

2.7.2.2 Shelter analyser console located at each shelter.

2.7.2.3 Common stack analyser system console located at control room.

### 2.7.3 ADSU Data Acquisition System:

2.7.3.1 The Data acquisition & Communication Hard Ware of ADSU shall be located in shelter.

2.7.3.2 Each stack Analyser shall be connected to the ADSU through serial link in multi drop configuration. The serial link shall be MODBUS RTU protocol. Necessary hardware required at analyser side for protocol conversion shall be provided by vendor.

2.7.3.3 In addition to the analyser serial link, the above shall also accept all alarms from shelter equipments/items such as Detector alarms, power failure alarm, purge failure alarm etc.

2.7.3.4 Any alarm inputs from analyser sample handling system and calibration commands etc. shall also be provided at ADSU.

2.7.3.5 The ADSU data acquisition system shall be connected to shelter analyser and common stack analyser system console at control room.

2.7.3.6 The ADSU system cabinet shall be free standing cabinet and shall be located at each shelter.

The construction shall be similar to analyser cabinets as per clause with minimum dimension of 600W X 600D X 2100H.


### 2.7.4 Shelter Analyser Console:

2.7.4.1 Shelter Analyser console located at each analyser shelter shall be provided for complete analyser measurement and diagnostic data and other shelter measurement data for monitoring, calibration and maintenance.

### 2.7.5 Common Stack Analyser console:

2.7.5.1 The common stack analyser system console at control room shall store the complete analysis data of analysers and present this in a predefined format. The console shall be common for one or more stack analyser system in the plant and shall receive data from each ADSU data acquisition subsystem at shelter/Analyser room. The data from each shelter/ analyser room shall be provided independently and no multi dropping at field shall be considered.

2.7.5.2 The console shall be provided with stack analyser system software and shall have the following features.

	<b>GENERAL SPECIFICATION FOR STACK ANALYSERS</b>	GSTD-0003	0
			Rev
		SHEET 20 OF 23	

- a) Display of all analysis data stack wise, component wise and exception wise.
- b) Alarm display & printing.
- c) Report generation as per statutory requirements such as USEPA, TUV etc.
- d) Freely formatted report generation.
- e) Report generation as per local pollution control board requirements
- f) Data storage and data compaction facilities.
- g) System alarms, display & printing.
- h) Predictive maintenance packages, if any.
- i) Hourly shiftily, daily, weekly, monthly reports shelter wise.
- j) Command for auto calibration for each analyser.
- k) System shall store the analysis data and reports upto 1 year period.

2.7.5.3 The report generation as per statutory requirements shall have the following reports as minimum.


- a) Data of each analyser with sample interval of 1 sec., 1 minute.
- b) Performance report, period as defined by statutory regulation authority. 30 days, quarterly, biannual, and annual as minimum.
- c) Magnitude of excess emission for each analyser.
- d) Specific identification of periods of excess emissions , start up, shut down or other periods, cause of malfunction and corrective action.
- e) Report of malfunctions or operative maintenance of each analyser along with period.
- f) Summary report in case of excess emission period less than 1 % of time of reporting period, in predefined formats.

2.7.5.4 The software provided for common stack analysers shall be certified compliance to USEPA or TUV or any other statutory regulations.

2.7.6 The consoles at shelter and at control room shall access data independently from analysers. In case of failure of one console the other console shall continue to receive data. Upon resumption of failed console, the stored data from other console shall be transferred by command.

2.7.7 Each console shall have the following minimum configuration.

- a) Consoles shall be PC based, Pentium latest processor with retentive memory of 512K RAM, 80GB Hard disk with 19" TFT monitor
- b) No. of background colours and foreground colours for the monitor will be seven, as a minimum. These colours shall be used to distinguish parameters such as control, information, process and alarms etc.
- c) No. of display characters is 80 character X 40 lines and No. of character type is min 96 ASCII characters with character construction of 5X7 dots and pattern of 7X8 dots.
- d) Length of tag no is nine alpha numeric characters.
- e) Length of description is fifteen alpha numeric characters.
- f) Monitor data display update rate shall not be more than two (2) seconds.
- g) Dynamic graphics shall be provided with control.

	GENERAL SPECIFICATION FOR  STACK ANALYSERS	GSTD-0003	0	
			Rev	
		SHEET 21 OF 23		

- h) Windowing facility is required with 4 No. of windows/Display.
- i) Zooming facility is required.
- j) The real time clock of each operator console shall be crystal controlled one which shall be independent of line frequency.
- k) A minimum of two cursor control devices must be available with monitor of console. For example cursor control could be used for monitoring the data and engineering of the complete system.
- l) Key board shall preferably be touch sensitive membrane type. Each key board entry shall be registered with an audio beep. However, if press type keyboard is provided it shall be ensured that the key board is not susceptible to dust and moisture.
- m) The self diagnostic message for a subsystem failure shall appear on the analyser console irrespective of display selected. The choice of the detailed self diagnostic displays shall be made by a key lock switch.
- n) The offered printer shall be HP laser jet colour printer.

2.7.8 The communication between ADSU at analyser shelter and the common stack analyser console at control room shall be through fibre optic cable with necessary converters and the same shall be provided by vendor.

2.7.8.1 All fiber optical cables shall be routed through hard HDPE conduits and shall be totally enclosed within using HDPE matching fittings. The HDPE conduits shall be as per IS-4984 or equivalent IEC standard. The outer Colour of the conduit shall be orange with black fittings throughout the run. Individual fiber optic cable shall have minimum one pair of spare fiber. All fiber optical cables shall be rodent resistant and armored type only.


### 3.0 NAMEPLATE

3.1 Each analyser and its accessory shall have a stainless steel nameplate firmly attached to it at a visible place, furnishing the following information as applicable:

- a) Tag number as per purchaser's data sheets.
- b) Manufacturer's serial number and model number.
- c) Manufacturer's name/trade mark.
- d) Component being analysed and its range.
- e) Area classification in which the equipment can be used.
- f) Power supply requirements.
- g) Analyser Outputs

### 4.0 INSPECTION AND TESTING

4.1 Unless otherwise specified, purchaser reserves the right to test and inspect all the items at the vendor's works in line with the inspection test plan for process stream analysers. Vendor shall

	GENERAL SPECIFICATION FOR  STACK ANALYSERS	GSTD-0003	0	
			Rev	
		SHEET 22 OF 23		

provide necessary facilities, utilities, competent manpower and consumables required for carrying out the inspection.

4.2 Vendor shall submit the following test certificates and test reports for purchaser's review for each of the analyser:

- a) Dimensional verification certificate for each analyser.
- b) Material test report as per clause 2.2 of EN10204 for all wetted parts.
- c) Manufacturer's test reports as per clause 3.1B of EN 10204 for various bought out components.
- d) Leak test report for complete analyser system including sample handling system using Nitrogen or instrument air at 1.5 times the maximum working pressure.
- e) Calibration report for each analyser as per clause 4.3 of this specification.
- f) Repeatability test for each analyser as per clause 4.4 of this specification.
- g) Power supply variation check.
- h) Test certificates for zero, span, carrier and fuel gases as applicable.
- i) Certificates from statutory body for flameproof/intrinsic safety and weatherproof enclosures as applicable.

#### 4.3 Analyser Calibration

4.3.1 Analyser along with sample handling system shall be calibrated using zero and span calibration gas samples in the following sequence:

- a) Check/adjust zero by connecting zero gas and span by connecting span gas.
- b) Check again zero by connecting zero gas after (a) above. Also repeat span gas check.
- c) If either or both zero and span are adjusted in step (b), repeat (b) again to verify the calibration until no further adjustments are made in zero and span.

#### 4.4 Repeatability Testing

4.4.1 Repeatability of the analyser shall be checked by connecting either span gas (if it is approximately 70% of analyser span) or any other gas sample on continuous basis for the following time period.

- a) 24 hours by manufacturer and report to be submitted for review.
- b) 8 hours during witness inspection.

#### 4.5 Witness Inspection

4.5.1 All the analysers shall be offered for pre-dispatch inspection by the purchaser at vendor works. Following tests/ checks shall be carried out on each analyser as a minimum:

- a) Physical dimensional verification and workmanship.

	GENERAL SPECIFICATION FOR  STACK ANALYSERS	GSTD-0003	0	
			Rev	
		SHEET 23 OF 23		

- b) Bill of material check for each analyser system including sample handling system.
- c) Leakage testing of complete system using nitrogen or instrument air.
- d) Calibration check as per clause 4.3 above.
- e) Repeatability check as per clause 4.4.
- f) Power supply variation check. Analyser must function satisfactorily on specified variation of power supply voltage.
- g) Review of all test certificates and test reports indicated in clause 4.2 above.

4.5.2 In the event when the witness inspection is not carried out by purchaser, the tests shall any way be completed by the vendor and documents for same shall be submitted to purchaser for scrutiny.

## 5.0 SHIPPING

- 5.1 All threaded and flanged openings shall be suitably covered to prevent entry of foreign material.
- 5.2 Each major part shall be sealed in thick plastic bag. Suitable moisture absorbent shall be provided for electronic components.

## 6.0 REJECTION

- 6.1 Vendor shall prepare their offer strictly as per clause 1.2 of this specification and shall attach only those documents, which are specifically indicated in the material requisition.
- 6.2 Any offer not conforming to the above requirements, shall be summarily rejected.




 पी डी आई एल <b>PDIL</b>	<b>PROJECTS &amp; DEVELOPMENT INDIA LTD</b>	<b>GSTD-0004</b>	<b>0</b>	
			Rev	
		<b>SHEET 1 OF 14</b>		

# GENERAL SPECIFICATION

## FOR


## ANALYSER SYSTEM

0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	GENERAL SPECIFICATION FOR ANALYSER SYSTEM	GSTD-0004	0	
			Rev	
		SHEET 2 OF 14		

## CONTENTS

SL. NO.	TITLE	SHEET NO.
1.0	GENERAL	3
2.0	SAMPLE HANDLING SYSTEM	3
3.0	PIPING & TUBING	5
4.0	ANALYSER	5
5.0	PROGRAMMER/ CONTROLLER	5
6.0	ELECTRIC WIRING- SIGNAL, CONTROL & POWER	6
7.0	COMPRESSED GAS CYLINDERS & THEIR HANDLING	6
8.0	SAFETY REQUIREMENTS	8
9.0	FACTORY TESTING & ACCEPTANCE	9
10.0	INSTALLATION, TESTING & COMMISSIONING	10
11.0	TRAINING	11
12.0	DOCUMENTATION	11
13.0	ENGINEERING DRAWINGS	11
14.0	FINAL ACCEPTANCE TEST	12
15.0	TESTING & CALIBRATION EQUIPMENT	12
16.0	SPARE PARTS	12
17.0	MAINTENANCE CONTRACT	12
18.0	PACKING & SHIPPING INSTRUCTIONS	12


 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR ANALYSER SYSTEM	GSTD-0004	0	
			Rev	
		SHEET 3 OF 14		

## 1.0 GENERAL

- 1.1 This specification defines the minimum requirements of Analyser System/systems designed for reliable and effective analysis of various process streams.
- 1.2 All analysers along with their associated equipments shall be installed by the vendor inside the analyser shelter.
- 1.3 All analyser shelter shall be ventilated, pressurized and air-conditioned. However, all analysers and other associated equipments shall be so designed and selected that these will continue to operate even in case of ventilation/ pressurization failure.
- 1.4 Vendor shall provide all installation material including consumables to install the analysers, sample conditioning systems, sample transfer lines, vent lines and all other accessories. All instruments shall be completely accessible to permit adjustments, calibration and maintenance.
- 1.5 The components to be furnished for each sample system will depend upon the sample stream conditions. The vendor shall select and provide all the necessary components for each of these systems accordingly.

## 2.0 SAMPLE HANDLING SYSTEM

- 2.1 The sampling system shall consist of necessary components, including sample probes, sample filters, pressure reducers, safety relief valves, pressure and temperature gauges, moisture separators, flow regulators, flow meters, isolation valves etc. necessary to prepare the sample for proper analysis.
- 2.2 All components shall be sized and coupled so as to keep the sample volume to a minimum.
- 2.3 Calibration zero and span gas connections shall be provided for each analyser.
- 2.4 The sampling system shall have various sub-assemblies as required. The minimum requirements of each sub-assembly shall be as given below.
- 2.5 Sample Probe Assembly
  - a) Sampling probe shall be designed to extract true representative sample from the process line. The design shall prevent particulates from entering into the sample system.
  - b) The design of probe assembly shall facilitate on line removal of the probe without shutting off the process. Suitable mounting adapters shall be provided with the probe.
  - c) Probes shall be of Inconel 600 material unless specified otherwise.
  - d) The length of tubing between the sample probe and the sample stream pressure reducing station shall be kept minimum by close coupling various components in between
- 2.6. Sample Stream Pressure reducing stations:
  - a) Vendor shall design and provide sample stream pressure reducing stations to minimize sample transfer time maintaining the integrity of the sample. Sample stream pressure reducing stations shall consist of pressure regulators, relief valves, pressure gauges, temperature gauges etc as required.

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR ANALYSER SYSTEM	GSTD-0004	0	
			Rev	
		SHEET 4 OF 14		


- b) These stations will be located at the sample process connection to minimize transport time lag from the sample point to the analyser.

## 2.7. Sample Transfer Line

- a) The sample transfer line shall transport the fluid sample from the sample stream pressure reducing stations to sample conditioning system located at the analyser shelter.
- b) Vendor shall provide heat tracing for sample line wherever necessary, in order to maintain the sample integrity.
- c) The routing of sample transfer lines shall be done in such a way that the total length between the sampling point and the analyser sample conditioning system is minimum. Short radius bends shall be avoided to avoid excessive pressure drop.

## 2.8. Sample Conditioning System:

- a) Sample conditioning system shall be provided by the vendor at the analyser house/shelter.
- b) Multi-stream analyser system shall have a separate sample handling sub assembly for each stream.
- c) Sample conditioning system shall include, but not limited to, moisture separators, filters, rotameters, pressure gauges, flow switches, solenoid valves etc. as necessary for proper analysis of each sample stream. Isolating valves shall be provided as required.
- d) Stream selecting valves shall be located as close as possible to the analyser to minimize connecting tubing length and to minimize the possibility of cross contamination of samples.
- e) Stream selecting valves shall be double block and bleed and shall fail closed so as to block the sample from the analyser on loss of motive power.
- f) Block valves shall be provided on all process sample lines.
- g) Rotameters for measuring all sample flows shall be included.
- h) Special precautions may be necessary where catalyst fines and coking material, and other difficult stream conditions are present.
- i) Wherever it is necessary to maintain the handling system at elevated temperature to properly condition the sample, it shall be enclosed in a thermally insulated, thermostatically controller heated enclosure. Enclosure heating shall be with steam heater unless specified otherwise. Sample stream flow adjustments and analyser shutoff valves shall be operable from the front of the enclosure without opening the enclosure door. Sample stream flow, pressure and temperature indication shall be visible from the front of the enclosure.
- j) Sample tubing between the sample conditioning system and the analyser shall be kept as short as possible.

	GENERAL SPECIFICATION FOR ANALYSER SYSTEM	GSTD-0004	0	
			Rev	
		SHEET 5 OF 14		

2.9. Sample Stream Bypass/Fast loop:

- a) Sample stream bypass/fast loop shall be provided for the sample streams to meet the required sample transport time.
- b) Flow meters shall be provided by vendor for sample bypass/fast loop flow.

2.10. Analyser Vent:


- a) Analysers shall be vented to atmosphere individually or through a common vent system.
- b) In case common vent header is provided, the pipe diameter shall be big enough to prevent build up of back pressure.
- c) The venting of the analyser shall be done to atmosphere at a minimum height of 3 meters above the highest walkway of the structure over the analyser shelter away from any working area or any ventilation system.
- d) The vent lines or header shall be provided with low point drains.

**3.0 PIPING AND TUBING:**

- 3.1. All tubing runs shall be either horizontal or vertical, with 90° tubing bends of stainless steel tubing. The tubing shall be run and arranged such that quick visual tracing is possible. All valves, gauges and flowmeters must be visible and accessible.
- 3.2. Sample and vent tubing, piping, fittings, valves, traps, rotameters and other components shall be of SS 316 material, unless otherwise specified.
- 3.3. All tube fitting used shall be of SS 316 and shall be non-flare type of `Swagelok/Parker/Hamlet make.
- 3.4. Sample tubing from the field shall terminate at a bulk head union plate using tube to tube bulk head fittings located at the top of the cabinet, in case sample conditioning system is enclosed in a cabinet.
- 3.5. Sampling line shall be arranged to be free draining without any pockets.
- 3.6. Vendor shall provide suitable connections for periodic flushing of sample tubing, with Nitrogen and steam, between sampling point and analyser inlet filter. Flushing connections shall be provided at both ends of each sample line.

**4.0 ANALYSER**

- 4.1 The analyser shall be furnished with all the necessary equipment to properly analyse the sample.
- 4.2 Material of construction for the components in contact with the sample stream shall be SS 316 except where the stream composition requires other material.
- 4.3 The detector cells shall be of a type that will provide adequate separation of components, minimize analysis time, minimize maintenance time and meet the performance requirements of this specification.
- 4.4 The analyser system temperature shall be controlled by an accurate electric heating system to ensure the proper sample separation and minimize the analysis time.

	GENERAL SPECIFICATION FOR ANALYSER SYSTEM	GSTD-0004	0	
			Rev	
		SHEET 6 OF 14		

4.5 A shutdown switch shall be provided to protect the analyser from the loss of carrier gas or loss of fuel gas.

4.6 Solenoid operated multi function valves for sample inlet and column switching shall be provided.

## 5.0 PROGRAMMER/CONTROLLER

5.1. The programmer / controller shall be microprocessor based and shall be furnished with all the equipments necessary to properly control the analysis cycle, the automatic zero adjustment circuit, the calibration of the analyser and programmer systems and the transition of data to a DCS or digital computer and any require peripheral equipment.

5.2. Visual readout using a digital indicator shall be provided to identify each component being analysed and each step in the program as well as displaying the latest readings.

5.3. Peak peaker and long term memory circuit boards shall be provided for each component of the interest.

5.4. All program data tables shall be capable of field modification without user knowledge of higher level programming. A key lock switch or field alterable password shall be provided to limit access to system software by unauthorized personnel.

5.5. The application program in the analyser shall be retained for a minimum of six months with out external power by the use of EEPROM or Battery back-up. An EEPROM programme cartridge interface shall be provided for program loading.

5.6. Maintenance diagnostics shall be included in the software system to allow rapid trouble shooting in the event of system mal-function. Alarms in the English language shall be provided to notify the operator in the event of the mal-function. A low carrier flow alarm shall be included.

5.7. The stream number shall be printed-out on each analysis report.

## 6.0 ELECTRIC WIRING - SIGNAL CONTROL AND POWER:


6.1. Vendor's scope of supply and work shall include all cabling and wiring inside the analyser shelter.

6.2. Vendor shall provide an explosion proof (Exd) power distribution box for power supply to various analysers. This box shall be certified by a statutory body for use in specified hazardous area. The box shall have copper bus bars for distribution of power supply to various consumers.

6.3. Power supply to individual consumer shall be by dual pole, dual element circuit breakers. These circuit breakers shall be in explosion proof (Exd) construction certified by a statutory body for use in hazardous area and shall be mounted near the equipment served and shall have engraved plastic tag plates.

6.4. All cabling and wiring shall conform to API-RP-550. Signal and power cabling/wiring shall be segregated and run in separate raceways with separation distances as recommended per API-RP-550.


6.5. All cables shall be armoured, flame retardant PVC insulated, 600 Volt grade, stranded copper conductor. Signal cables shall be twisted pair shielded.

	GENERAL SPECIFICATION FOR ANALYSER SYSTEM	GSTD-0004	0	
			Rev	
		SHEET 7 OF 14		

- 6.6. Conductor size for power cables shall be 2.5 sq. mm (min.) and for signal cables it shall be 1.5 sq. mm.
- 6.7. Colour coding for power supply wiring shall be red for phase, black for neutral and green for earth.
- 6.8. Vendor shall provide junction boxes for signal and control cables separately which shall serve as interfaces for cables going to remote control room. These junction boxes shall be explosion proof (Exd) certified by statutory body for use in specified hazardous area.
- 6.9. Wire termination shall be done using self insulating crimping lugs.
- 6.10. All cables, wires shall be provided with identification ferrule (one piece ferrule/ cylindrical ferrules\_ for proper identification.
- 6.11. Terminal strips shall be provided with identifying terminal numbers, as required. Terminals shall be screw less clamp type.
- 6.12. 20% spare terminals, cable entries with cable glands, relays and other components wired up to terminals shall be provided.

## **7.0 COMPRESSED GAS CYLINDERS AND THEIR HANDLING:**

- 7.1. Each analyser shall be provided with the following compressed gas steel cylinders.
  - a) Carrier gas and fuel gas (wherever required) with dual manifold cylinders configuration.
  - b) Calibration gas sample bottles.
- 7.2. Fuel gas and Carrier gas cylinders and associated manifolds shall be located on a concrete pad outside the analyser building. The gas cylinder manifold shall be arranged so that one cylinder may be replaced while the analyser remains in operation on the other cylinder. Cylinders shall be sized 1A (225mm diameter x 1300mm long) and shall be supplied with auxiliaries such as fittings and two stage regulators.
- 7.3. Calibration gas cylinders shall be located outside the analyser shelter. Vendor shall include a drawing showing the layout of cylinders.
- 7.4. Racks shall be provided to support cylinders, piping, valves and pressure regulators associated with high pressure gas cylinder manifold system. Each cylinder in the system shall be secured to the rack by a separate chain or clamp.
- 7.5. A pressure relief valve, vented to a safe location outside the building shall be installed on the low pressure side of the pressure reducing regulator of each cylinder. Vent piping shall be installed in a manner to prevent the entry of bugs or moisture into the outlet of the vent. This vent shall be in addition to the analyser vent.
- 7.6. All pressure regulators shall be two stage type. A sign identifying the type of gas applied to a manifold shall be placed above each cylinder rack.
- 7.7. The location and separation of hydrogen manifold from other flammable gas manifolds shall be in accordance with NFPA 50A-1973 section 52 and 61.

	GENERAL SPECIFICATION FOR ANALYSER SYSTEM	GSTD-0004	0	
			Rev	
		SHEET 8 OF 14		

- 7.8. All tubing between the cylinders to the analysers shall be complete and easily removable from each and either end.
- 7.9. Vendor's quote shall include fuel, carrier and calibration gas cylinders as necessary, as a minimum, for:
- The field testing, commissioning and final acceptance
  - Six months from the date of acceptance.
- 7.10. The calibration gases shall be of high purity, at least better than the specified accuracy and precision values for analysers. It is preferable to prepare calibration gases by Gravimetric method.
- 7.11. The concentration of calibration gases must remain constant for a period of at least one year.
- 7.12. The material of construction of cylinders shall be suitable for maintaining stability of the calibration gas mixture for the specified time. Vendor may quote for the staggered deliveries wherever calibration mixture is not stable.
- 7.13. The vendor must submit the following certificates from any recognised certifying agency/laboratory;
- Accuracy/Precision of the calibration gas.
  - Stability of sample for at least one year.
- 7.14. Vendor shall forward all the details including the source of supply, certifying agency, cylinder size and volume, sample pressure, dew point, regulator type and make etc.

In addition, vendor must furnish calculations for number of cylinders quoted of each type. For calibration gas cylinders, consider calibration frequency as once in every fortnight.


## 8.0 SAFETY REQUIREMENTS:

### 8.1. Hazardous Area Protection:

- The analyser shelter shall be in hazardous classified area. Positive pressure and ventilation from a clean air source shall be provided to achieve this classification.
- It is intended to operate the analysers even during the ventilation failure, hence it required that all analysers shall be suitable for hazardous area.
- All the electrical fittings provided in the analyser shelter shall be explosion proof type. However, a safety system shall be provided by the vendor to switch off power supply to all electrical equipments and accessories not suitable for hazardous area in case of ventilation failure. To do this it shall be ensured that all analysers continue to work safely even under these conditions.
- All junction boxes, power distribution cabinets, LEL detectors and their panel and other safety devices shall be suitable for the hazardous area certified by a statutory body.

### 8.2. Grounding:



	GENERAL SPECIFICATION FOR ANALYSER SYSTEM	GSTD-0004	0	
			Rev	
		SHEET 9 OF 14		


- a) All electrical equipment in the analyser shelter and outside shall be grounded properly.
- b) Cylinder racks, sample conditioning enclosures, analyser racks, shall also be grounded directly to the AC ground bus.
- c) All necessary grounding bus requirement for Equipment grounding and signal shields shall be provided by the vendor in the analyser shelter. Vendor shall also provide all earthing arrangements inside the analyser shelter.

#### 8.3. Combustible Gas Detection System (LEL Detectors):

- a) Vendor's scope includes of supply and installation of combustible gas detectors with associated monitoring system for the analyser shelter.
- b) Combustible gas detectors shall monitor all inlet air intake points. The detectors shall be calibrated to give alarm and high alarm at 20% and 40% respectively of the LEL of the component with the lowest LEL in the area. On the occurrence of high alarm the ventilation system shall be shut-off. Vendor shall provide potential free DPDT contacts rated at 230 VAC 5 Amp for connection to ventilation system.
- c) Shutoff of ventilation system shall be based on 2 out of 3 voting, which means that only if two detectors out of the three provided indicate a high LEL, trip shall provided.
- d) Additionally, combustible gas detectors shall monitor the analyser house/shelter interior and exhaust air. These detectors shall give alarm and high alarm as mentioned above, however no shutoff of ventilation system shall be required.
- e) Vendor shall calculate total requirement of combustible gas detectors along with their location.
- f) The monitors for LEL detectors shall be provided with malfunction, warning and danger lights and 0 to 100% indicator.
- g) Vendor shall provide grouped high alarm and high - high alarm SPDT contacts rated for 230 V AC 5 Amp for repeat alarms in remote control room.
- h) The monitors for LEL detection system shall be installed in a panel which shall be pressurized as per NFPA 496 type 'X' purge.

#### 8.4. Fire/Smoke detection

- a) Vendor's scope shall include supply and integration of fire detectors/smoke detectors (Ionisation type) within the analyser shelter. The no. of shelters shall be decided by the vendor based on the shelter size and coverage of area within the shelter.
- b) The monitors for the fire detection shall be installed in a pressurised/ purged panel as per NFPA 496 type X purge. This may be shared with LEL monitor panel.
- c) The signals from the fire system monitor shall be provided for:
  - One contact for alarm on the warning panel.
  - One contact each for repeat alarm in the control room DCS and fire panel of Electrical section.

	GENERAL SPECIFICATION FOR ANALYSER SYSTEM	GSTD-0004	0
			Rev
		SHEET 10 OF 14	

#### 8.5. Oxygen gas monitoring

- a) Vendor shall provide a maximum of two nos. of oxygen gas monitoring system for sensing deficiency of oxygen within the shelter.
- b) In case the monitors show low concentration of oxygen within the analyser shelter, an alarm shall be initiated on the warning panel. The repeat alarm shall also be provided for DCS in the Main control room.
- c) Oxygen monitors should be located in purged panel as per NFPA 496 type X purge. These may be located in the same panel where LEL detectors are installed.


#### 8.6. Warning Panels:

- a) Vendor shall provide warning panels for audio visual alarming of hazardous conditions inside the analyser shelter. One such panel shall be installed by vendor on each of the external walls of the analyser shelter where entrance doors are provided.
- b) The warning panel shall provide the following audio - visual alarms:
  - i) Presence of combustible gases inside the analyser shelter.
  - ii) Loss of analyser shelter pressurisation
  - iii) Ventilation system failure
  - iv) Fire/smoke within the shelter
  - v) Oxygen deficient within the shelter
- c) For alarming of analyser shelter pressurisation failure vendor shall provide an explosion proof pressure switch for sensing analyser shelter inside pressure.
- d) These warning panels shall be of explosion proof (Exd) construction certified by a statutory body for use in hazardous area.

8.7 Minimum two no beacon assembly and 1 no. hooter suitable for specified hazardous area shall be provided on the shelter to warn the operator of presence of hazardous area inside the shelter.

### 9.0 FACTORY TESTING AND ACCEPTANCE:

- 9.1. The analyser systems shall be thoroughly checked and tested prior to shipment to assure correct design, construction and proper operation.
- 9.2. The Owner/Consultant reserves the right to be involved and satisfy himself at each and every stage of inspection and testing.
- 9.3. During the final testing vendor shall test and demonstrate to the Owner/Consultant, the functional integrity of all analysers, sampling systems and all other hardware. Repeatability test shall be performed on all analysers for a test period of 24 hours. No material or equipment shall be transported until all required tests are successfully completed and certified 'Ready for shipment' by the Purchaser/Consultant. Software's, if involved, shall also be tested.
- 9.4. Vendor shall submit schedule of factory testing and inspection.
- 9.5. After placement of order vendor shall submit his factory testing and customer acceptance procedure for Purchaser / Consultant approval. This document shall contain the information


 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR ANALYSER SYSTEM	GSTD-0004	0	
			Rev	
		SHEET 11 OF 14		

related to each test e.g. purpose of test, definition, test procedure, results expected and acceptance.

- 9.6. Purchaser / Consultant has every right to add or delete any test in vendor's test procedure and acceptance criteria. The system shall be tested and accepted as per the approved testing procedures and acceptance criteria. The cost of performing all tests shall be borne by the vendor.
- 9.7. Vendor shall notify the Purchaser / Consultant at least three weeks prior to final system testing at vendor's works. In the event that representatives of Purchaser / Consultant arrive and the system is not ready for testing, the vendor shall be liable for back charging for any extra time and expenses incurred by the Owner.
- 9.8. It shall be vendor's responsibility to modify and/or replace any hardware, equipment or analyser if the specified functions are not completely achieved satisfactorily during factory testing and acceptance.

#### **10.0 INSTALLATION, TESTING AND COMMISSIONING:**

- 10.1. Vendor shall provide the services of his installation team which would install the equipment in the analyser shelter and in the field, lay the tubing from sample probe to analyser shelter, lay the interconnecting cabling tubing inside the analyser shelter, perform system checkouts, test and commission the entire system.
- 10.2. All technical personnel assigned to the site by the vendor shall be fully conversant with the system supplied and shall have capability to bring the system on-line quickly and efficiently with a minimum of interference with other concurrent construction and commissioning activities.
- 10.3. Vendor's responsibility at site shall include all activities necessary to be performed to complete the job including;
  - a) Receipt of all analysers and related hardware, and checking of completeness of supply. In case of shelters, verification of all analysers and accessories duly installed tubed and wired
  - b) Installation of all analysers, and other associated equipment including all safety equipment like LEL detectors, annunciators, panels etc., all auxiliaries like power supply distribution boxes, all interconnecting tubing/piping etc. so as to complete the job in case of analyser shelter.
  - c) Installation of sample probes, pressure reducing stations, sample conditioning systems, interconnecting tubing, heat tracing etc.
  - d) All analyser sample stream bypass, vent and drain tubing/piping.
  - e) Termination of all field cables or cables to control room, ferruling/ tagging of interconnecting cables in analyser shelter.
  - f) Interconnection cabling inside the analyser shelter
  - g) All civil works like grouting, fixing etc and patch up work where vendor is likely to remove the plaster and shall make holes in the walls, floor or ceiling.

	GENERAL SPECIFICATION FOR ANALYSER SYSTEM	GSTD-0004	0	
			Rev	
		SHEET 12 OF 14		


- h) Checking of interconnections, hardware configuration, overall system functioning.
- i) Leakage rate test.
- j) Liaison with vendor's home office.
- k) Field testing.
- l) Commissioning of the complete analyser system.
- m) Final acceptance testing.

#### 10.4. System Check-outs:

- a) Checking of all interconnections, configuration and overall system functioning.
- b) Any discrepancy found during checking shall be brought to the notice of Engineer-in-Charge.
- c) All the check-outs shall be performed in the presence of Owner/ PMC authorised representative. All headings shall be recorded on a suitable format and shall be submitted for approval.
- d) After system checking is completed, vendor shall connect back any terminal or tubing or connection removed for loop checking.
- e) All the equipment shall be checked thoroughly after its receipt at site. The tests, as a minimum, shall include;
  - i) Visual and mechanical testing
  - ii) Complete system configuration loading
  - iii) Calibration of all analysers, and other related equipment.
  - iv) Demonstration of all system functions.
  - v) Demonstration of all system diagnostics.
  - vi) Checking of correct change of redundant devices.
  - vii) Demonstration of analyser accuracies, linearities, repeatabilities, response time etc.
  - viii) Demonstration of proper operation of system at specified voltage supply specifications.
  - ix) A leakage test shall be conducted on entire system. Maximum permissible leakage rates shall not exceed 5% per hour of specified designed pressure.

#### 11.0 TRAINING:

Vendor shall be responsible to train the Purchaser/Consultant personnel in the field for maintenance of hardware and software. The outline of each course including the course contents and the duration shall be forwarded by the vendor along with the offer.

	GENERAL SPECIFICATION FOR ANALYSER SYSTEM	GSTD-0004	0
			Rev
		SHEET 13 OF 14	

## 12.0 DOCUMENTATION:

Vendor shall furnish all the manuals, including for maintenance and operation, necessary to test, operate and maintain etc the analysers and other related equipment, hardware and software.

## 13.0 ENGINEERING DRAWINGS:

- 13.1. Vendor shall provide a complete set of drawings covering each part of supply for Purchaser/Consultant record. The vendor is required to include Purchaser's project number on each of his drawing.
- 13.2. All field modifications shall be carefully recorded by the vendor's installation and commissioning personnel and changes shall be incorporated into the final drawings.

## 14.0 FINAL ACCEPTANCE TEST:

The Owner will take over the system from the vendor after the final acceptance test, which is defined as successful uninterrupted operation of the integrated system for three weeks with desired accuracy and repeatability. Vendor's personnel shall be present during the test. Any malfunctioning of the system components shall be replaced/repared as required. Once the system failure is detected, the acceptance test shall start all over again from the beginning.

## 15.0 TESTING AND CALIBRATION EQUIPMENT:

Vendor shall make available all consumables including calibration gas cylinders, instruments and equipments necessary for testing, calibration, maintenance etc. as defined by the 'scope of work'. All instruments and equipments used for the above purpose shall be of standard make with accuracy better than the accuracy expected from the calibrated/tested equipments and shall be certified by National Physical Laboratory or other equivalent agencies.

## 16.0 SPARE PARTS:


Vendor shall quote separately for spare parts required for a two year period of operation for the complete analyser system and the associated auxiliaries offered. Vendor shall enclose a list of spare parts quoted along with the offer.

## 17.0 MAINTENANCE CONTRACT:

Vendor shall quote separately for maintenance contract after warranty period for two years as per job requirements. The personnel deployed shall have thorough knowledge of the system and at least two years of experience as maintenance of similar system.

## 18.0 PACKING AND SHIPPING INSTRUCTIONS:

- 18.1. All materials used for packing, wrapping, sealers, moisture resistant barriers and corrosion preventers shall be of recognised brands and shall conform to the best standards in the areas for the articles which are being packaged.
- 18.2. Workmanship shall be in accordance with best commercial practice with the requirement of applicable specifications. There shall be no defects; imperfections or omissions which would tend to impair the protection of the package as a whole.


 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR ANALYSER SYSTEM	GSTD-0004	0	
			Rev	
		SHEET 14 OF 14		

- 18.3. The package shall be suitable for storing in tropicalised climate as per specified ambient conditions.
- 18.4. Shipment shall be thoroughly checked for completeness before final packing and shipment. Vendor shall be fully responsible for any delay in installation or commissioning schedule because of incomplete supply of equipment.

 पी डी आई एल <b>PDIL</b>	<b>PROJECTS &amp; DEVELOPMENT INDIA LTD</b>	<b>GSTD-0005</b>	<b>0</b>	
			Rev	
		<b>SHEET 1 OF 22</b>		

# GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER


0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER	GSTD-0005	0	
			Rev	
		SHEET 2 OF 22		

## CONTENTS

- 1.0 GENERAL
- 2.0 DESIGN AND CONSTRUCTION
- 3.0 NAME PLATE
- 4.0 INSPECTION AND TESTING
- 5.0 SHIPPING
- 6.0 REJECTION



	GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER	GSTD-0005	0	
			Rev	
		SHEET 3 OF 22		

## 1.0 GENERAL

### 1.1 Scope

1.1.1 This specification, together with the data sheets, covers the requirements for the complete design, materials, nameplate marking, inspection, testing and shipping of process stream analysers. This standard specification shall be applicable for all types of process stream analysers irrespective of whether separate specifications are included or not included in this specification.

1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the purchaser's enquiry:

ANSI/ASME American National Standards Institute! American Society of Mechanical Engineers.

B 1.20.1 Pipe Threads. General Purpose (Inch)

B 16.5 Steel Pipe Flanges and Flanged Fittings. NPS 1'2 through NPS24.

B 16.20 Metallic Gaskets for Pipe Fittings, Ring Joints, Spiral wound and Gasketed.

API American Petroleum Institute

Manual on Installation of Refining Instruments and Control System

RP 551 Process Measurement Instrumentation

RP 552 Transmission System

RP 554 Process Instrumentation and Control

RP 555 Process Analysers

ASTM693 Standard Practice for cleaning methods and cleanliness levels for material and equipment used in oxygen-enriched environment.

ASTM 0764-92 Standard Practice for Validation of Process Stream Analysers.

EN 50020 Electrical Apparatus for potentially explosive atmospheres-Intrinsic safety 'i'

EN 10204 Inspection Documents for Metallic Products.

IEC-60079 Electrical Apparatus for Explosive Gas Atmosphere.


IEC-60529 Degree of Protection Provided by Enclosures. (IP Code)

IEC-61000-4 Electromagnetic Compatibility for Industrial Process Measurement and Control Equipment.

IEC-61285 Industrial Process Control Safety of Analyzer Houses.

IS-13947 Specification for Low Voltage Switchgear and Control gears.

IS-2148 Electrical Apparatus for Explosive Gas Atmosphere-Flameproof enclosures 'd'.

	GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER	GSTD-0005	0
			Rev
		SHEET 4 OF 22	

NFPA 496

National Fire Protection Association

1.1.3 In the event of any conflict between this standard specification, job specification/data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

- a) Statutory Regulations
- b) Data Sheets
- c) Standard Specification
- d) Codes and Standards

1.1.4 In addition to meeting the purchaser's specification in totality, vendor's extent of responsibility shall include the following:


- a) Purchaser's data sheet indicates the type of analyser and the minimum sample conditioning system requirements. Vendor shall be responsible for the selection of proper analyser and design of the sample conditioning system to analyse the component/components of interest within the stated performance requirements.
- b) Carry out complete application engineering of the process gas analyser so as to achieve the desired analysis within stated performance requirements.
- c) Provide all hardware and software, as necessary, to meet the functional requirements specified in the purchaser's specifications.
- d) Provide complete data to purchaser for successfully proving serial communication with purchaser's host system i.e. DCS when specified in the job specification.
- e) Purchaser's data sheets indicate the minimum requirements of material of construction for the analyser and its sample conditioning system. Alternate superior material of construction shall also be acceptable provided vendor assumes complete responsibility for all the parts of the analyser system so as to be compatible with the process stream and surrounding atmosphere as specified in purchaser's data sheet.

## 1.2 Bids


1.2.1 Vendor's quotation shall be strictly as per the bidding instruction to vendor attached with the material requisition.

1.2.2 Whenever a detailed technical offer IS required, vendor's quotation shall include the following:

- a) Compliance to the specifications.
- b) A detailed specification sheet for each analyser, which shall provide information regarding type, materials of construction, performance specification and accessories of analyser. The material specification and units of measurement for various parts in vendor's specification sheets shall be to the same standards as those indicated in purchaser's data sheets. All the relevant terminology used in purchaser's data sheets and standard specifications shall be as per ISA RP 31.1.
- c) A detailed drawing showing various components of sample conditioning system and piping/tubing hook-up arrangement including sample return, vent, utilities in connection and requirement of heat tracing (i.e electrical or steam tracing), as necessary.

	GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER	GSTD-0005	0	
			Rev	
		SHEET 5 OF 22		

- d) Sample transportation time calculations for the specified distance between sample point and analyser indicating sample flow rate and the recommended size of the sampling tube.
  - e) Calibration gas cylinder calculations considering six months of continuous operation with once a week calibration. The calculation sheet shall indicate the rate of gas consumption and specification of gases including composition, concentration, accuracy and shelf life of calibration blend.
  - f) Reference gas cylinder calculations considering six months of continuous operation. The calculation sheet shall indicate the rate of gas consumption and specifications of the reference gas.
  - g) Proven references for each offered model inline with clause 1.2.3 of this specification.
  - h) A copy of approval for intrinsically safe/flameproof enclosure, whenever specified, from local statutory authority, as applicable, such as Petroleum and Explosives Safety Organisation/Chief Controller of Explosives (CCE), Nagpur or Director general of Mines Safety (DGMS) in India, along with:
    - i) Test certificate from recognised house CMRI/ERTL etc. for flameproof enclosure as per relevant Indian Standard for all Indian manufactured equipments.
    - ii) Certificate of conformity from agencies like CSA, BASEEFA, PTB, LCIE, FM, UL etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.
  - i) Utility requirements and their consumption i.e. instrument air, cooling water, steam etc. along with their process conditions like flow, pressure and temperature.
  - j) Power consumption for each analyser and its accessories.
  - k) HVAC requirements i.e. heat load, humidity particulate/chemical filtration etc.
  - l) Deviations on technical requirements shall not be entertained. In case vendor has any valid technical reason, they must include a list of deviations tag number wise, summing up all the deviations from the purchaser's data sheets and other technical specifications along with the technical reasons for each of these deviations.
  - m) Catalogues giving detailed technical specifications, model decoding details and other related information for each type of analyser and accessories covered in the bid.
- 1.2.3 All items, as offered, shall be field proven and should have been operating satisfactorily individually for a period of minimum 4000 hours on the bid due date for the similar analysis as specified in the purchaser's data sheet. Items with proto-type design or items not meeting provenness criteria specified above shall not be offered.
- 1.2.4 Whenever specified, vendor must furnish certified values of failure rates, probability of failure on demand and test interval for the safety integrity level analysis.
- 1.2.5 All documentation submitted by the vendor including their quotation, catalogues, drawings, installation, operation and maintenance manuals, etc shall be in English language only.


	GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER	GSTD-0005	0	
			Rev	
		SHEET 6 OF 22		

1.2.6 Vendor shall also quote for the following: -

- a) Complete calibration kit consisting of calibration gas cylinders, pressure regulators, gauges, cylinder gas piping manifolds and driers, (as required) etc. as a minimum, for each analyser. In case of dual range analyser, separate calibration standards shall be provided for each range. For the purpose of calculating requirement of zero and span calibration samples/gases, consider calibration time of 30 minutes every week for each analyser for a period of six (6) months of continuous operation.
- b) Complete reference gas kit consisting of Reference gas cylinders, pressure regulators, gauges, cylinder gas piping manifold and drier etc as a minimum separately for each analyser as applicable. The reference gas cylinders shall be supplied for a period of six (6) months of continuous operation.
- c) Consumable spares for the duration of six months with list of items as per vendor recommendations for each analyser system, unless otherwise specified in job specification.
- d) Start up and commissioning spare parts for each analyser/analyser system as per vendor recommendations. However this list of spare parts must include 5% or minimum one of each type of following spare parts:
  - Solenoid valve
  - Pressure regulator
  - Filters
  - Temperature controller
  - IRIUV Source (lamp)
  - Peristaltic pump
  - Set of fuses
  - Set of o-rings
  - Tubing and tube fittings (sizes smaller than 6 mm or y").

Additional spare parts, if required, during start-up and commissioning, even though not listed in the list of start-up and commissioning spares, shall be supplied by the vendor without any implication.

- e) Any special instrument or tool needed for testing, calibration and maintenance of the analyser such as spanner set (for tubes smaller than 6 mm or y"), non-magnetic tools, bubble rotameter etc.
- f) Training at vendor works and at site as specified in job specifications.
- g) Two years operational and maintenance spares for each analyser and its accessories as per vendor recommendations, which shall include spare parts like electronic modules, temperature controller, power supply module, flow meter, solenoid valve, pressure regulator, local indicator, tubes, fan assembly, sample cell, detector assembly, UV/IR source/lamps, set of o-rings, set of fuses etc.

	GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER	GSTD-0005	0	
			Rev	
		SHEET 7 OF 22		

### 1.3 Drawing and Data


1.3.1 Detailed drawing, data, catalogues and manuals required from the vendor are indicated by the purchaser in the vendor data requirement sheet attached with the enquiry. The required number of reproducible, prints, and soft copies shall be despatched to the address mentioned, adhering to the time limits indicated.

1.3.2 Final documentation consisting of design data, installation, operation and maintenance manual etc., submitted by the vendor after placement of purchase order shall include the following, as a minimum;

- a) Specification sheet for each analyser and its accessories.
- b) Certified drawings for each analyser and its accessories, tag number wise, which shall provide the following information:
  - i) Overall dimensions in millimetres.
  - ii) Sampling system details identifying each component with make and model number, process connection, utility connection, calibration sample/gas connection, heat tracing requirements, sample vent and fast loop details etc.

The flow, pressure and temperature at interface and other appropriate location must be shown in the sampling system drawing.

- iii) Detailed interconnection drawing of each analyser identifying each component with terminal number, cable type, cable size and cable entry details. The interface details shall be clearly identified in the drawing.
- iv) Grounding details.
- v) Power supply distribution details.
- c) Programming/configuration data for each analyser, as applicable.
- d) Serial interface specification including its configurational data (addresses) for host communication.
- e) Power consumptions and utility requirements.
- f) Calibration curves and calibration data for each analyser.
- g) Zero and span calibration gas specification including composition, shelf life time and accuracy.
- h) Copy of type test certificates.
- i) Copy of the test certificates of all the tests indicated In clause 4.0 of this specification
- j) Installation procedure for each analyser and their accessories.
- k) Calibration and maintenance procedures including replacement of its parts/internals wherever applicable.

	GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER	GSTD-0005	0	
			Rev	
		SHEET 8 OF 22		

## 1.4 Definitions

1.4.1 The following definitions shall apply for analysers and their accessories:

a) Transportation time

Transportation time is the time interval between a step change in the process fluid composition in the process line and the initial analyser response (excluding analyser response time).

b) ResponseTime

The time interval between the initial response of the analyser and the time required for the analyser output to reach a value of 90% of the final output value for a step change in sample quality.

c) Time Constant

The analyser response to reach a value of 63% of the final output value for a step change in sample quality is called the analyser time constant.

d) Repeatability

Repeatability of a measurement is the band of values within which an analyser repeats its measurement when the same sample is applied to it. The short termed repeatability is generally determined by multiple readings of a sample during calibration and is usually true random error over short period of time if external influences like pressure and temperature etc remain constant.

It is also defined as the difference between two successive analyser results that would be exceeded in the long run in only one (1) case in twenty (20) when a single analyser system is operated on a flowing sample of uniform quality.

e) Sensitivity

The sensitivity of an analyser is a measure of an analyser's ability to detect a least change in concentration of a measured component that is not masked by the background noise.

f) Accuracy

Accuracy of a measurement is the measure of how close the measured value is to the true value of the sample. For all type of analysers, accuracy is primarily a function of the accuracy of the standards used for calibration.

g) Analyser Rack


An open analyser mounting structure with/without canopy used for mounting analysers, sample handling system and their accessories individually or together in combination.

h) Analyser Cabinet

Small housing in which analysers are installed individually or grouped together. Maintenance is performed from outside the cabinet with door (s) open.

## 2.0 DESIGN AND CONSTRUCTION

### 2.1 Analyser Requirements

	GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER	GSTD-0005	0	
			Rev	
		SHEET 9 OF 22		

2.1.1 The type of analyser and its measuring principle is specified in the purchaser's data sheet. Accessories and equipments as required to make online analysis complete are also specified in the data sheet. In general, the scope shall include the following:

- a) Sample probe and sampling system, as applicable
- b) Analyser complete with all hardware and software consisting of detector, transmitter and associated equipments.
- c) Fast loop and Sample return system, as applicable
- d) Calibration and maintenance equipment.
- e) Gas cylinders for zero and span calibration.

Unless otherwise specified the scope shall also include supply of all interconnecting tubing, piping, fittings, heat tracing equipment etc., excluding sample return piping from analyser battery limit to sample return header.

In-situ analysers when specified may not include items 2. 1.1(a) and (c)

2.1.2 Analysers and its related equipments directly connected to process line and In-situ analysers shall be capable of withstanding line pressure and temperature conditions specified in the purchaser's data sheet.

2.1.3 The analyser design and design of sample handling system shall be such that components or any sub-assembly that requires removal shall be possible without any need to disassemble any other component. Such components shall include items like stream selector valves, filters, pressure regulators, flow-indicator, detector, electronic modules etc.

2.1.4 Analyser shall be microprocessor based with state-of-the-art technology and shall be capable of being configured from analyser front panel locally using built-in keyboard. When specified, it shall also be possible to configure the analyser from remote through a separate terminal.

2.1.5 The configuration related data of the analyser including set range shall be stored in a nonvolatile memory such that this data remains unaffected by power fluctuations or power off condition. In case vendor's standard product stores configuration data in battery backed RAM, analyser shall have facility to provide battery drain alarm as diagnostic maintenance message.


2.1.6 The span of the analyser shall be field adjustable from the analyser front without opening the analyser enclosure. In case, separate device is required to make such a change, the same shall be included, by vendor in their scope of supply.

2.1.7 Analyser shall run diagnostic subroutines on continuous basis and shall be able to provide diagnostic alarms related to analyser optics, detector and electronics, as and when any failure/malfunction is detected.

2.1.8 Analyser shall have an integral output meter with digital readout in engineering units.

2.1.9 All interconnecting wiring shall be colour coded/numbered and terminal blocks be clearly identified.

2.1.10 The analyser shall be capable of providing the following outputs:

	GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER	GSTD-0005	0	
			Rev	
		SHEET 10 OF 22		

- a) Isolated 4-20 mA DC current output for each analysed component. Smart or field bus output shall be provided when specifically indicated in the purchaser's data sheet.
- b) RS485 serial output with MODBUS (RTU) protocol, whenever serial output is specifically indicated in the purchaser's data sheet. The serial output signal shall contain analyser data of component of interest and diagnostic alarms, as a minimum.
- c) SPDT contact outputs for various diagnostic alarms (as applicable) such as:
  - i) High or low set point alarm as measurement
  - ii) analyser failure
  - iii) low sample flow
  - iv) temperature control failure
  - v) purge failure

Any other alarm contact, either specifically indicated in purchaser's data sheet or available as standard with the analyser, shall also be provided.

Unless specified otherwise, all contacts shall be normally closed type (contact open in alarm) and shall be rated for 110VAC 5 Amperes.

2.1.11 The design of analyser system shall be in compliance with the electromagnetic compatibility requirements as per IEC-61000-4-X.

#### 2.1.12 Material of Construction

2.1.12.1 Unless otherwise specified, the material of construction of all components wetted by the sample shall be SS316, as a minimum. Vendor must ensure the compatibility of material of each component with the process fluid.

2.1.12.2 Material of all soft parts like diaphragms and o-rings shall be of PTFE. Other vendor standard materials can also be acceptable provided these are compatible with the specified process condition.

2.1.12.3 The material of construction of all non-wetted parts shall be as per manufacturer's standard.

However non-metallic materials for casings, enclosures and instrument covers shall be avoided.

#### 2.1.13 Power Supply


2.1.13.1 Unless indicated otherwise, the analyser including the sample handling system shall operate at 110V 50Hz power supply.

2.1.13.2 The analyser performance shall be within the specified limits when the supply voltage varies by  $\pm 10\%$  of specified value and supply frequency varies by  $\pm 3$  Hz of specified value.

2.1.13.3 Electrical tracing when specified, shall operate at 230V 50 Hz supply. 230V 50Hz power supply shall also be used for analyser cabinet/panel lighting and air conditioning unit, when specified.

2.1.14.1 Unless otherwise specified, the following shall govern;



	GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER	GSTD-0005	0
			Rev
		SHEET 11 OF 22	

- a) Threaded connections shall be NPT to ANSIASMEB 1.20.1.
- b) Flanged connection shall be as per ANSIASME B16.5.
- c) Flange face finish shall be serrated concentric to clauses 6.4.4.1, 6.4.4.2, and 6.4.4.3 of ANSIASMEB 16.5. The face finish shall be as follows:

125AARH	:	125 to 250 AARH
63AARH	:	32 to 63 AARH

- d) Ring type joint flanges shall have octagonal grooves as per ANSIASTMB16.20.

2.1.14.2 End connection of sizes 6 mm or below shall be suitably protected against damage.

2.1.14.3 All end connections shall be clearly identified by attaching labels or stainless steel plate of suitable size.

#### 2.1.15 Enclosure Type

2.1.15.1 Analyser enclosures and related accessories shall be suitable for the electrical area classification indicated in purchaser's data sheets. Unless otherwise specified, the enclosures shall comply to the following standards:

Weather proof housing : IP 55 as per IEC-60529 / IS-13947

Flame proof housing : Flame proofEx (d) as per IEC-60079 / IS-2148

Purged Enclosure : NFPA 496

Flameproof and purged equipment shall also be made weatherproof.

2.1.15.2 In addition to meeting weatherproof requirements specified in clause 2.1.15.1 of this specification, intrinsically safe analysers shall meet the requirements specified in EN 50020 and shall be certified for the area classification specified in the purchaser's data sheet.


2.1.15.3 Analyser where air/nitrogen purge is provided, purge shall be as per NFPA 496 Type X. Analyser power shall cut off in case of purge failure. Purge failure alarm shall be provided for purchaser use.

2.1.15.4 Separate cable entries shall be available in the analyser/enclosure for power and signal cable. Unless otherwise specified, following shall apply:

- a) Cable entry and terminal size for power cable shall be informed during detail engineering. Explosion proof 3 way junction box with cable glands shall be supplied, if required.
- b) Cable entry for Serial cable/signal cables (Signal output) shall be 1/2" NPT (F).
- c) Cable entry for multi-pair signal cables (Multiple output) shall be 1/4" NPT (F).

2.1.15.5 All enclosure entries including sample, utilities, cables etc. shall be clearly identified by attaching label or stainless steel plate of suitable size.

## 2.2 Sample Handling System

	GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER	GSTD-0005	0	
			Rev	
		SHEET 12 OF 22		

2.2.1 The sample handling system shall consist of primary sample conditioning near sample take off point, sample transportation line, secondary sample conditioning near the analyser, sample return, sample/analyser vent and sample drain/recovering system, as applicable. The primary sample-conditioning unit shall be a fabricated assembly and shall be mounted on a stainless steel plate suitable for surface mounting.

Secondary sample conditioning shall also be a fabricated assembly and shall be either mounted on a stainless steel plate or within an enclosed cabinet/box with a viewing window. In case the temperature is required to be maintained at primary and secondary sample conditioning, both these conditioning units shall be installed in the heated box/cabinet.

2.2.2 Process Stream sampling shall be continuous and analyser shall be located as near as possible to the sample take-off point. Where the analyser is located away from the sample take-off point, vendor shall design the sample fast loop (bypass loop) as part of sampling system. Design shall ensure that the sample drawn is true representative of the process stream to be analysed.

2.2.3 In general, sampling systems shall be designed and constructed in accordance with API-RP555. The design of sample handling system shall consider the following factors, as a minimum:

- a) The pressure-temperature conditions required for the analyser.
- b) Interfering components in the process sample.
- c) Normal and abnormal sample compositions.
- d) Sample return pressure-temperature conditions.
- e) Fouling sample conditions e.g. polymer formation or presence of solids etc.
- f) Transportation time requirements.
- g) Utilities available and their process conditions.


2.2.4 Unless otherwise specified, material of all components wetted by sample shall be suitable for the process fluid and sample process conditions specified in the purchaser's data sheet. The material of construction for all wetted parts shall be, 316 SS, as a minimum.

2.2.5 Sampling system shall include all elements as necessitated by the process conditions indicated in the purchaser's data sheets, to make the sample suitable for the analysis. This shall include but not limited to filters (coarse and fine), pressure regulators, relief valves, flow indicators, flow controllers, temperature indicators, scrubbers, heaters, coolers, dryers, sample pumps, aspirators etc.

Each sampling system element shall be capable of being removed without disassembling the entire system.

2.2.6 Sample probe shall be provided by the vendor to obtain representative sample from the line. The sample probe shall be inserted in the pipe through a line isolation valve (ball or gate valve), which shall be part of vendor's scope of supply. The probe design shall ensure the following:

- a) On-line removal and insertion of the probe with non-fly-off design
- b) Unless otherwise specified, end connection for installation in the line shall be 1 1/2" flanged with type and rating as specified in purchaser's data sheet. The line isolation valve shall also be of the same size and rating as probe end connection.
- c) The probe diameter shall be such that it can be easily inserted or removed through the line isolation valve when in fully open condition.
- d) The length of the probe shall be selected considering its insertion upto the middle of the pipe. For the purpose of calculating probe length, consider nozzle length as 200 mm.

	GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER	GSTD-0005	0	
			Rev	
		SHEET 13 OF 22		

2.2.7 Sampling system shall include a sample block valve on all process sample line. The block valve shall be provided meeting the following requirements:

- a) The block valve shall be located immediately after the sample probe.
- b) Where purchaser's data sheet do not indicate the requirement of sample probe, the block valve shall be provided in the sample line as a part of primary sample conditioning unit.
- c) The size of the sample block valve shall be as per the sample line size while the rating shall be as specified in the purchaser's data sheet.

2.2.8 The size of the sample tubing shall be decided by the vendor considering:

- a) The distance between sample take off and analyser specified in purchaser's data sheet.
- d) The specified sample transportation time.
- e) Pressure at the sample take off point.

Where no transportation time is specified in the purchaser's data sheets, vendor shall consider the sample transportation time as 60 seconds.

2.2.9 Where sample is required to be transported in hot condition, sample shall be drawn using pre-fabricated heated tubes. The heated medium shall be either steam or electric power as specified in purchaser's data sheet.  
Heating shall be controlled such that the sample temperature is maintained typically around +200°C above the sample dew point.

2.2.10 When fast loop is specified or recommended by vendor, vendor shall provide flow meter for sample bypass flow. Sample return line to process shall be provided with isolation valve and check valve. Vendor shall ensure that return pressure of the sample shall be higher than the pressure of the process return point specified in purchaser's data sheet.


2.2.11 Sampling system shall include provision for connecting calibration sample/gases in auto or in manual configuration as specified in purchaser's data sheet. When no specific requirement is indicated, the provision shall be made for manual configuration only.

2.2.12 In case of multi stream analyser, the sample handling system shall utilize double block and bleed configuration to prevent cross-contamination of samples. All stream selection valves shall have bubble tight shut off. The block valves shall be fail-close type while bleed valve shall be fail-open type.

2.2.13 Filters shall always be provided in dual configuration. It shall be possible to replace the filter without upsetting the operation of the analyser.

2.2.14 The sampling system shall be designed to consider plugging of sample lines under following conditions, if applicable:

- a) Failure of heat tracing
- b) Failure of sample pump
- c) Failure of instrument air, particularly when sample dilution technique is adopted for sample.
- d) Upset of short up conditions, if excessive solids/solid particles are expected under these

	GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER	GSTD-0005	0	
			Rev	
		SHEET 14 OF 22		

operating conditions.

- 2.2.15 Unless specified otherwise, sample lines used for carrying samples for more than one analyser shall be provided with sample pumps in dual configuration. It shall be possible to remove or insert the pump without upsetting the sampling system.
- 2.2.16 A suitable restriction orifice shall be provided in each sample line to limit the sample flow exceeding thrice the normal flow in the event of tube rupture or opening of tube down the line.
- 2.2.17 Whenever auto-calibration requirement is specified in the purchaser's data sheet, it shall be possible to initiate auto calibration cycle at preset time interval defined by user either manually via the analyser keyboard or remotely through an external contact.

The sample handling system shall be designed to include all hardware and/or software to meet this requirement. The analysed component concentration output shall remain at the last good measured value during auto calibration cycle.

#### 2.2.18 Analyser rack and cabinet

- a) Whenever specified in the purchaser's data sheet, the analyser shall be supplied in pre-assembled, pre-tubed and pre-wired condition complete with sample handling system. The primary sample conditioning unit i.e. conditioning at sample tap off point shall be supplied separately.
- b) When open rack mounted installation is specified in purchaser's data sheet, the analyser and sample handling system shall be supplied installed in an open rack with canopy to protect the analyser from direct sunlight and rain. The open rack shall be fabricated using channels/pipes of suitable size. The material of construction shall be stainless steel. The canopy shall also be fabricated out of SS plate of 1.2mm thick.
- c) Whenever closed cubical mounted installation is specifically indicated in the purchaser's data sheets, analyser and sample handling system shall be supplied preinstalled in free standing closed analyser cabinet:-The analyser cabinet shall be suitable for outdoor installation and shall be provided with a key lock.


Cabinet shall be fabricated out of 2.0mm SS sheet reinforced with angles of suitable sizes. Fittings and hinges shall be of stainless steel. Anchor bolts required for installation of cabinet shall also be supplied by vendor.

A power isolation switch with suitable circuit breaker or fuse shall be provided for the incoming power supply.

All items including analyser installed within the cabinet shall be suitable for the maximum possible temperature likely to be attained within the cabinet (i.e. with all items fully powered-on within the cabinet) and area classification specified in the purchaser's data sheet.

Heating/cooling of analyser cabinet shall be provided either when purchaser's data sheet specify the requirement of heating and/or cooling or recommended by the analyser manufacturer or found necessary by the manufacturer to meet following requirements:

- i) The temperature induced measurement error exceeds  $\pm 1\%$  of full scale in the worst temperature conditions.

	GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER	GSTD-0005	0	
			Rev	
		SHEET 15 OF 22		

- ii) The maximum allowable ambient temperature condition of any component within the cabinet exceeds its limits.

Whenever cooling is specified or found necessary, vendor may select one of the following cooling methodologies, unless specifically indicated otherwise:

- a) Cabinet mounted air conditioner certified for the specified area classification.
- b) Vortex cooler with compressed air system and air dryer of suitable size and capacity. No separate instrument air shall be provided by purchaser for vortex cooler.
- c) The maximum height of rack/cabinet shall be limited to 2100 mm. Cabinet shall be suitable for side and bottom cable entry.
- d) Power supply cable entry and terminal size shall be as defined during detail engineering by purchaser.


### 2.3 Infra-Red/Ultra-Violet (IRIUV) Analysers

- 2.3.1 IR/UV analyser shall preferably be non-dispersive type.
- 2.3.2 Analyser cell length shall be selected as per specified analyser component range. In case of dual range analysers, the selected cell length shall be suitable for both the ranges.
- 2.3.3 The analyser cell material and window material shall be suitable for the specified process condition. Unless otherwise specified or required otherwise by pressure-temperature conditions, the o-ring material shall be Teflon.
- 2.3.4 The analyser design shall be such that it is insensitive to source fluctuations or degradation or partial cloudiness of cell window.
- 2.3.5 Special filters shall be offered to minimise the interference of background components, which are of least interest in process stream.
- 2.3.6 Unless otherwise specified, analyser shall meet the following performance requirements:

Repeatability :  $\pm 1\%$  of full scale  
 Zero drift :  $\pm 1\%$  full scale per 24 hours.  
 Response Time : 5 seconds for 90% of final reading

### 2.4 Thermal Conductivity Analyser

- 2.4.1 Thermal conductivity analyser shall be suitable for measuring hydrogen/hydrocarbon in binary gas mixture or in a multi component gas mixture.
- 2.4.2 Analyser shall have precise temperature controller which shall be able to maintain temperature within  $\pm 0.1^\circ\text{C}$  to ensure stable detector operation.
- 2.4.3 Analyser cell shall have flowing reference gas or sealed in (non-flowing) reference as per manufacturer's standard product.

	GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER	GSTD-0005	0
			Rev
		SHEET 16 OF 22	

2.4.4 The analyser sensor cell material shall be suitable for the specified process conditions, unless otherwise specified or required by temperature condition, o-ring material shall be PTFE.

#### 2.4.5 Performance specification

Unless otherwise specified, Analyser shall meet the following performance specifications:

Accuracy :  $\pm 1\%$  of FSR  
 Repeatability :  $\pm 1\%$  of FSR in 24 hours  
 Response time : Maximum 20 seconds for 90% response

### 2.5 Moisture Analyser

2.5.1 The requirements of moisture analyser for corrosive as well as non-corrosive for application are specified in this clause. Vendor shall offer the type of analyser as specified in the purchaser's data sheet.

Whenever, the type of analyser is not indicated in the purchaser's data sheet, vendor shall select the type of moisture analyser as per the specified process conditions

2.5.2 Moisture analyzer for non-corrosive application.

2.5.2.1 The probe shall be in-line mounted (i.e. shall be located at the point of measurement) in general and shall not be damaged by severe shock and line abrasion conditions.

2.5.2.2 The pressure and temperature rating of the probe shall be suitable for the process condition specified in the data sheet.

2.5.2.3 When mounted remote, the probe shall be installed in a sample cell. The end connections of sample cell shall be flanged with ANSI rating as specified in the purchaser's data sheets.

2.5.2.4 Unless otherwise specified or found necessary by vendor, no sample handling system shall be required. However, whenever the sample handling system is specified, the design shall ensure the integrity of sample i.e. moisture contents integrity shall be maintained.

2.5.2.5 The probe shall have Aluminum oxide moisture sensor. Alternate type moisture probe shall also be acceptable, if this meets the performance requirements specified in the purchaser's data sheet.

2.5.2.6 Each probe shall be supplied as pre-calibrated and shall be supplied with its own calibration curve. The calibration shall be valid for a period of minimum six (6) months from the date of supply, as a minimum

2.5.2.7 Performance specification.


The moisture probe shall meet the following requirements as a minimum:

Accuracy :  $\pm 2^{\circ}\text{C}$  within a range of  $60^{\circ}\text{C}$  to  $65^{\circ}\text{C}$  (Dew point)  
 $\pm 3^{\circ}\text{C}$  within a range of  $-66^{\circ}\text{C}$  to  $-110^{\circ}\text{C}$

Repeatability :  $\pm 0.5^{\circ}\text{C}$  in range of  $60^{\circ}\text{C}$  to  $65^{\circ}\text{C}$   
 $\pm 1.0^{\circ}\text{C}$  in range of  $-60^{\circ}\text{C}$  to  $-110^{\circ}\text{C}$

Life time : One year

Time Constant: 5 seconds for 63% of steady state value.

	GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER	GSTD-0005	0
			Rev
		SHEET 17 OF 22	

### 2.5.3 Moisture analyser for corrosive application

2.5.3.1 The moisture probe shall be hygroscopic ally sensitized quartz crystal or equivalent suitable for the specified process samples containing unsaturated hydrocarbon, chlorides, oils etc

2.5.3.2 Sample shall be conditioned in a sample handling system which shall include filters, condensate trap, dryer, pressure regulator (with or without heating as required) etc., however the design shall ensure that moisture integrity is maintained by the sample handling system.

2.5.3.3 The system shall incorporate a dried reference gas cycle after each sample gas measurement in order to strip volatile contaminants from the detector during reference gas cycle.

2.5.3.4 In order to ensure accuracy and reliability of the moisture analyser, the system shall incorporate a moisture generator, consisting of temperature controlled water reservoir and a permeation tube. The moisture generator shall generate a known moisture sample against which calibration of the analyser can be verified.

#### 2.5.3.5 Performance Specification

The moisture probe shall meet the following performance requirements, as a minimum:

Accuracy	:	$\pm 5\%$ of reading
Repeatability	:	$\pm 1\%$ of reading
Response time	:	max. 60 seconds for 90 % of steady state value

### 2.5.4 Analyser Monitor/Controller

2.5.4.1 The analyser monitor/controller shall be microprocessor based and shall be programmable type.

2.5.4.2 The monitor/controller shall be remote mounted type with built-in display with keyboard for data display. The cable between analyser and monitor/controller shall be supplied by the vendor.

2.5.4.3 The monitor/controller shall be able to provide sequential display for various parameters and shall be selectable from the display keyboard.

## 2.6 Oxygen Analyser

2.6.1 The type of oxygen analyser shall be offered as specified in the purchaser's data sheet. Where purchaser's data sheet does not specify the type of oxygen analyser, vendor shall select the type meeting all functional and performance requirements indicated in purchaser's data sheets.


2.6.2 The analyser design shall ensure that the analysis is not affected by other sample constituents present in the sample.

### 2.6.3 Paramagnetic Type Oxygen Analyser

2.6.3.1 Unless otherwise specified, the paramagnetic type of oxygen analyser shall have magneto dynamic type measuring cell.

2.6.3.2. The analyser shall either have integral or split transducer unit containing the measuring



	GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER	GSTD-0005	0
			Rev
		SHEET 18 OF 22	

cell and control unit containing the analyser electronics. The control unit facia shall have with LCD/LED display.

2.6.3.3 Whenever the control unit is remote mounted, cable between control unit and measuring Cell shall be supplied by vendor.

2.6.3.4 Whenever paramagnetic type analyser is specified for pressurized or variable pressure application, the offered analyser shall have required pressure compensation to ensure that the measurement is not affected by changes in sample pressure and sample vent pressure.

The analyser design shall be such that the measurement shall not be affected by changes in ambient temperature and sample flow rate.

2.6.3.5 Paramagnetic analyser shall meet the following performance characteristics as a minimum:

Accuracy	:	±1% of full scale.
Repeatability	:	±0.5% of full scale.
Response time	:	6 seconds for 90% response

2.6.4 Electrochemical (Electrolytic) Type Oxygen Analyser.

2.6.4.1 The electrochemical type of oxygen analyser shall have either aqueous or non-aqueous measuring cell and shall meet the following requirement;

- a) The analyser shall be self or auto-calibrating type. The calibration cycle shall be initiated either after a pre-defined time or whenever analyser senses excessive drop/drift in the output.
- b) Analyser shall provide a suitable alarm for excessive drift. This information may be available as part of HART output signal.


2.6.4.2 In case, in those analysers where cell need to be replaced after the depletion of electrolyte, the analyser shall, in addition, meet the following requirements;

- a) The electro-chemical cell shall be easily replaceable.
- b) The analyser shall provide a warning for maintenance i.e. expiration of sensor well in advance (Typically 2 weeks). In addition analyser shall also provide an alarm in case output drops below the minimum reliable calibration level.
- c) One spare cell shall be supplied as part of consumable spare.

2.6.4.3 The analyser shall have integral electronics with built in LCD/LED display. Electrochemical analyser shall meet the following performance characteristics as a minimum:

Accuracy	:	±1% of full scale.
Repeatability	:	±1% of full scale.
Response time	:	Less than 15 seconds for 90% response



	GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER	GSTD-0005	0
			Rev
		SHEET 19 OF 22	

## 2.6.5 Zirconia Type Oxygen Analyser

2.6.5.1 The Zirconia type oxygen analyser shall be either in-situ type or extractive type as specified in the purchaser's data sheet.

2.6.5.2 In case of in, situ type of analyser, vendor shall ensure that the analyser as offered is suitable for the pressure-temperature specified in the data sheet and the measurement shall not be effected by changes in sample pressure and flow rate. In case of variable pressure application, vendor shall ensure that offered analyser has the provision for pressure compensation and/or pressure balancing arrangement.

2.6.5.3 Zirconia type of oxygen analyser shall be provided with auto-calibration facility to take care of zero-drift of cell.

2.6.5.4 The zirconia analyser shall consist of the following sub-assemblies;

### 2.6.5.4.1 Sensor Assembly

- The sensor assembly shall consist of the measuring cell, heater assembly, temperature sensor and connections for reference and calibration gases.
- The measuring cell shall be a zirconia sensor specific for oxygen measurement.
- The sensor shall be suitable for operating sample temperature up to 700°C.

### 2.6.5.4.2 Control Electronics


- The control electronics shall have capability to execute all required controls, indications, temperature control for normal operation and output signals as specified in purchaser's data sheet.
- Sensor temperature shall be maintained through temperature controller. Temperature sensor shall preferably be ISA type K thermocouple.
- Temperature controller shall cut-off power to heater in case of thermocouple burns out.
- Control electronics shall preferably be remote mounted type. Cable between control electronics and sensor assembly shall be supplied by vendor.

### 2.6.5.4.3 Reference Gas Control

Reference gas shall be flow and pressure controlled. Flow shall be controlled by rotameter With needle valve while pressure shall be controlled by self-actuated pressure control valve provided with pressure gauge.

2.6.5.5 Zirconia type oxygen analyzer shall meet the following performance characteristics as a minimum:

Accuracy	:	± 2% of measured value.
Repeatability	:	± 1.0.% of full scale.
Response time	:	Less than 10 seconds for 90% response.

	GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER	GSTD-0005	0
			Rev
		SHEET 20 OF 22	

## 2.7 Calibration Gas and Reference Gas Cylinders

2.7.1 Each analyser shall be supplied with following gases with stainless steel or Aluminum Cylinders:

- a) Reference gas dual cylinder with manifold where required. The reference gas system shall be dedicated one for each analysers, where required along with automatic switchover to standby cylinder when the first cylinder is exhausted.
- b) Certified calibration gases. In case of dual range of measurement, separate calibration gas for each range shall be provided.

2.7.2 Each of the gas cylinders shall be provided with two stage pressure regulator. Manifold shall be provided for reference gas with dual cylinder configuration.

2.7.3 All gas cylinders shall be located near the analyser and shall be supplied with gas cylinder rack with free standing support.

2.7.4 In case the calibration gas deteriorates or depletes with time, vendor may either supply calibration gas cylinders with deferred delivery or supply alternate devices for preparing calibration blend.


## 3.0 NAMEPLATE

3.1 Each analyser and its accessory shall have a stainless steel nameplate firmly attached to it at a visible place, furnishing the following information as applicable:

- a) Tag number as per purchaser's data sheets.
- b) Manufacturer's serial number and model number.
- c) Manufacturer's name/trade mark.
- d) Component being analysed and its range.
- e) Area classification in which the equipment can be used.
- f) Power supply requirements.
- g) Analyser Outputs

## 4.0 INSPECTION AND TESTING

4.1 Unless otherwise specified, purchaser reserves the right to test and inspect all the items at the vendor's works in line with the inspection test plan for process stream analysers. Vendor shall provide necessary facilities, utilities, competent manpower and consumables required for carrying out the inspection.

	GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER	GSTD-0005	0
			Rev
		SHEET 21 OF 22	

4.2 Vendor shall submit the following test certificates and test reports for purchaser's review for each of the analyser:

- a) Dimensional verification certificate for each analyser.
- b) Material test report as per clause 2.2 of EN 10204 for all wetted part
- c) Manufacturer's test reports as per clause 3.1B of EN 10204 for various bought out components.
- d) Leak test report for complete analyser system including sample handling system using Nitrogen or instrument air at 1.5 times the maximum working pressure.
- e) Calibration report for each analyser as per clause 4.3 of this specification.
- f) Repeatability test for each analyser as per clause 4.4 of this specification.
- g) Power supply variation check.
- h) Test certificates for zero, span, carrier and fuel gases as applicable.
- i) Certificates from statutory body for flameproof/intrinsic safety and weatherproof enclosures as applicable.

#### 4.3 Analyser Calibration

4.3.1 Analyser along with sample handling system shall be calibrated using zero and span calibration gas samples in the following sequence:

- a) Check/adjust zero by connecting zero gas and span by connecting span gas.
- b) Check again zero by connecting zero gas after (a) above. Also repeat span gas check.
- c) If either or both zero and span are adjusted in step (b), repeat (b) again to verify the calibration until no further adjustments are made in zero and span.

#### 4.4 Repeatability Testing


4.4.1 Repeatability of the analyser shall be checked by connecting either span gas (if it is approximately 70% of analyser span) or any other gas sample on continuous basis for the following time period.

- a) 24 hours by manufacturer and report to be submitted for review.
- b) 8 hours during witness inspection.

#### 4.5 Witness Inspection

4.5.1 All the analysers shall be offered for pre-dispatch inspection by the purchaser at vendor works. Following tests/ checks shall be carried out on each analyser as a minimum:

- a) Physical dimensional verification and workmanship.
- b) Bill of material check for each analyser system including sample handling system
- c) Leakage testing of complete system using nitrogen or instrument air.
- d) Calibration check as per clause 4.3 above.
- e) Repeatability check as per clause 4.4.
- f) Power supply variation check. Analyser must function satisfactorily on specified

	GENERAL SPECIFICATION FOR PROCESS STREAM ANALYSER	GSTD-0005	0	
			Rev	
		SHEET 22 OF 22		

variation of power supply voltage.

- g) Review of all test certificates and test reports indicated in clause 4.2 above.

4.5.2 In the event when the witness inspection is not carried out by purchaser, the tests shall any way be completed by the vendor and documents for same shall be submitted to purchaser for scrutiny.

## 5.0 SHIPPING

5.1 All threaded and flanged openings shall be suitably covered to prevent entry of foreign material.

5.2 Each major part shall be sealed in thick plastic bag. Suitable moisture absorbent shall be provided for electronic components.

## 6.0 REJECTION

6.1 Vendor shall prepare their offer strictly as per clause 1.2 of this specification and shall attach only those documents, which are specifically indicated in the material requisition.

6.2 Any offer not conforming to the above requirements, shall be summarily rejected.

	PROJECTS & DEVELOPMENT INDIA LTD	GSTD-0006	0	
			Rev	
		SHEET 1 OF 3		

# GENERAL SPECIFICATION FOR CALIBRATION GAS REQUIRMENT & UTILITY CONSUMPTION

0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	GENERAL SPECIFICATION FOR <b>CALIBRATION GAS REQUIREMENT</b>  <b>&amp; UTILITY CONSUMPTION</b>	GSTD-0006	0	
			Rev	
		SHEET 2 OF 3		

S. No.	Tag No	Analyzer Type	ZERO gas cylinder with regulator pressure gauges and relief valve	SPAN gas cylinder with regulator pressure gauges and relief valve	Fuel/Carrier gas cylinder with regulator pressure gauges and relief valve
1.	Note 1	Note 1	*	*	
2.			*	*	
3.			*	*	
4.			*	*	

**Note 1 : Vendor to Provide the Tag and Analyzer type**

- 1) Vendor shall supply calibration sample cylinders for zero and span calibration for each analyser. Quantity of total cylinders for each analyser shall be calculated by vendor with following basis:-
  - a) Calibration gases are required for six months of normal operation.
  - b) These calibration gas cylinders for six-month operation shall be supplied in two sets. One set these cylinders shall be connected to the analyser and another set of cylinders shall be kept in store.
  - c) Calibration gas accuracy shall be adequate to demonstrate the repeatability of the analysers.
  - d) Calibration / Zero gas quantity shall be calculated based on a frequency of one calibration in fortnight interval as a minimum.
  - e) Calibration gas cylinders shall be preferably of SS316 material. Aluminium gas cylinders are also acceptable in place of SS316.

\* - Vendor to offer total no. of cylinders accordingly and Indicate the same in the offer.

☐ DEVIATION

☐ NO DEVIATION

☐ VENDOR SEAL

	GENERAL SPECIFICATION FOR <b>CALIBRATION GAS REQUIREMENT</b>  <b>&amp; UTILITY CONSUMPTION</b>	GSTD-0006	0	
			Rev	
		SHEET 3 OF 3		

## UTILITY COMSUMPTION

### 1.0 Power Consumption:

(A) 415 VAC, 50Hz (For Air-conditioning, panel lighting, electrical heat

S. No.	Item	Maximum Power Consumption		In Rush Current	
		Unit Consumption	Total Consumption	Ampere	Duration
1.	<b>Note 2</b>				
2.	<b>Note 2</b>				

(C) 110 VAC +/- 10 %, 50Hz +/-3%, UPS (for Analyser and its sample handling system)

S. No.	Item	Maximum Power Consumption		In Rush Current	
		Unit Consumption	Total Consumption	Ampere	Duration
1.	<b>Note 2</b>				
2.	<b>Note 2</b>				

### 2 Instrument Air:

S. No.	Item	Normal (Nm3/hr)		Maximum (Nm3/hr)	
1.	<b>Note 2</b>				
2.	<b>Note 2</b>				

**Note:** 1. All utilities shall be made available to vendor at a single point near the cabinet for the Analyser system, further distribution or conversion if required shall be in Vendor scope. Vendor shall ensure the matching connection to the purchaser provided header connections.

**Note 2 : Vendor to Provide the Tag**

	PROJECTS & DEVELOPMENT INDIA LTD	GSTD-0007	
		DOCUMENT NO	
		SHEET 1 OF 23	

# GENERAL SPECIFICATION FOR MASS SPECTROMETER

00	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD



	<b>GENERAL SPECIFICATION FOR MASS SPECTROMETER</b>	<b>GSTD-0007</b>	
		DOCUMENT NO	
		SHEET 2 OF 23	

## INDEX

### **1.0 GENERAL**

- 1.1. Scope
- 1.2. Codes, Standards and Reference Documentation
- 1.3. Attached Documents
- 1.4. Available utilities

### **2.0 SAMPLING SYSTEMS DESIGN CRITERIA**

- 2.1. General requirements
- 2.2 Gaseous samples
- 2.3. Calibration System / Analyzer Validation
- 2.4. Sampling Systems enclosure
- 2.5. Sampling System Calculation
- 2.6. Sampling Systems components' Sub-Vendor List

### **3.0 ANALYZERS DESIGN**

- 3.1. General requirements
- 3.2. Mass spectrometer

### **4.0 AMBIENT CONDITIONS**

### **5.0 TESTS AND INSPECTIONS**

- 5.1. General
- 5.2. Test Description
- 5.3. Test Certificates
- 5.4. Training

### **6.0 TECHNICAL DOCUMENTATION**

- 6.1. General
- 6.2. Title block and heading
- 6.3. Specification, Data Sheets and other documents
- 6.4. Drawings
- 6.5. Scanned documents
- 6.6. Files management
- 6.8. Size of Drawings, Specification and other documents
- 6.9. Vendor invoice
- 6.10. Addressing documentation
- 6.12. Required Drawings & Documents

### **7.0 SPARE PARTS**

### **8.0 PACKING FOR SHIPMENT**

### **9.0 METHOD OF SUPPLY**

- 9.1 General
- 9.2. Documentation
- 9.3. Responsibility
- 9.4. Guarantees

	<b>GENERAL SPECIFICATION FOR MASS SPECTROMETER</b>	<b>GSTD-0007</b>	
		DOCUMENT NO	
		SHEET 3 OF 23	

## 1.0 GENERAL

### 1.1. Scope

This specification, defines the minimum requirements for design, construction and testing of mass-spectrometer analyzer..

### 1.2. Codes, Standards and Reference Documentation

All primary flow elements shall comply with the latest edition of following codes and standard, where applicable:

ASME/ANSIB-1-:20:1-(19837R-199-2-ASMEIANSI B 16.5 (1996/ADD.A 1992)	threads, pipe threads, general purpose (INCH) Pipe flanges and flanged fitting, steel nickel alloy and other special alloy.
API RP555 Ed.2 (Nov. 2001)	Process analyzer.
IEC 60529 (1989)	Classification of degrees of protection provided by enclosures (IP Code)
IEC 79.00 to 79.09, 79.11, 79.15, 79.18	Electrical apparatus for explosive gas atmospheres. Part 0+18.
CENELEC EN 50014 (1993)	Electrical apparatus for potentially explosive atmosphere. General requirements.
CENELEC50016 (1995)	Electrical apparatus for potentially explosive atmosphere. Pressurized apparatus "p".
CENELECEN 50018 (1994)	Electrical apparatus for potentially explosive (with amendment 1 & 2) atmosphere Flame proof enclosure "d".
CENELECEN 50019 (1977)	Electrical apparatus for explosive atmosphere safety apparatus "e".
CENELECEN 50020 (1994)	Electrical apparatus for explosive atmosphere safety "i",

In the event of conflict between the provision of the documents listed above and the requirements of this specification, the more stringent interpretation shall apply unless approved otherwise in writing.

-

### 1.3. Available utilities

#### 1.3.1. Process

For process utilities see General Conditions document.

#### 1.3.2. Power supply

	<b>GENERAL SPECIFICATION FOR MASS SPECTROMETER</b>	<b>GSTD-0007</b>	
		DOCUMENT NO	
		SHEET 4 OF 23	

The power supply system shall be designed in accordance with type of instruments reliability of the mains supply, type of plant and relevant safety requirements to be met in case of mains failure. The electrical power supply for the analyzer systems and associated accessories shall be 110 V AC - 50Hz from uninterruptible power supply (supplied by other). **24 VDC is to be derived by Vendor.**

## 2.0 SAMPLING SYSTEMS DESIGN CRITERIA

This section provides general guidelines to be strictly followed by sampling system Manufacturer unless the application requires different approach for process and/or technical reasons. Sampling system shall be engineered to obtain analyzer maximum performances in terms of accuracy, repeatability and availability. Sampling systems shall be provided by analyzer Manufacturer that shall be fully responsible of sampling system design.

### 2.1. General requirements

The following are general requirements that, together with good engineering practice have to apply by sampling system Manufacturer. Any other implementation considered necessary to assure good system working shall be provided.

#### 2.1.1. Sampling systems materials

As minimum all metal parts in contact with process sample shall be AISI 316. If the application should require different materials (e.g. monel, hastelloy or other), it shall be notified to PDIL/. Copper, silver, mercury and their alloys must be avoided for components in contact with process fluids. No plastic composition, fiber or paper are permitted as piping or valving. All components shall be resistant to process fluids and to the plant atmosphere

#### 2.1.2. Components selection

Sampling system components shall be selected according to PDIL/ OWNER approved sub-vendor list. Components sizing shall reflect sampling line size to avoid time lag and/or delta P increasing due to components size reduction (i.e. for ½" OD lines, the size of valves, flowmeters, etc shall be ½").

The following requirements shall be considered for components selection:

##### a. Compression fittings

Double ferrule compression fittings must be utilized.

##### b. Pressure regulators

Pressure regulators shall be supplied according to the following requirements:

- Type: diaphragm type, single stage as standard (two stages pressure regulator shall be provided for high pressure system)
- Body material: AISI 316
- Connections: 1/4" NPT-F on inlet and outlet.

Pressure regulators shall be provided for all sample lines to regulate the pressure even if the analyzer maximum inlet pressure rating is higher than

	<b>GENERAL SPECIFICATION FOR MASS SPECTROMETER</b>	<b>GSTD-0007</b>	
		DOCUMENT NO	
		SHEET 5 OF 23	

process sample pressure.

c. **Pressure safety valves**

Pressure safety valves shall be supplied according to the following requirements:

- Type: Spring activated
- Body material: AISI316
- Connections: 1/4" or 1/2" NPT-F on inlet and discharge.

Relief valves shall be provided where following indicated to protect conditioning system components and analyzer:

- Downstream pressure regulators
- Downstream pumps / compressors discharge

d. **Pressure gauges**

Pressure shall be supplied according to the following requirements:-

- Element type: bourdon
- Case material: stainless steel
- Dial dimensions: 50 mm or 2-1/2"
- Connection: 1/4" NPTM on bottom.

Pressure gauges shall be provided where following indicated:

- After pressure reduction
- On pumps / compressors suction
- On pumps / compressors discharge
- On samples having pressure above/below atmospheric.

e. **Temperature gauges**

Temperature gauges shall be supplied according to the following requirements:

- Element type: bi-metallic
- Case material: stainless steel
- Dial dimensions: 50 mm or 2-1/2"
- Connection: 1/4" NPTM on bottom.

Temperature gauges shall be provided where following Indicated:

- After cooling
- On samples having temperature above ambient.

f. **Flow meters**

Variable area flowmeters shall be provided. Flowmeters range shall be calculated to obtain the required time lag; flowmeters shall be sized for normal flowrates from 50% to 70% of selected range. Float material shall be selected according to process fluid and service. Meter factor and design Specific Gravity shall be stated on flowmeter nameplate.

	<b>GENERAL SPECIFICATION FOR MASS SPECTROMETER</b>	<b>GSTD-0007</b>	
		DOCUMENT NO	
		SHEET 6 OF 23	

The following shall be considered for flow meters selection:

- Glass tube meters shall be provided for low flow applications where sample does not exceed 2 bar g. and/or 70 °C.

Glass tube meters shall be suitable for at least 1.5 times the maximum operating pressure of the related system and shall be provided with 5 mm thick polycarbonate screens for personnel protection.

- Metal tube flow meters shall be provided for each one of the following conditions:
  - i) high flow applications or
  - ii) low flow applications where:
    - pressure is above 2 bar g.
    - temperature is above 70 °C.

#### g. **Filters**

Filters types shall be selected according to application requirements. Rate of filtering shall be as recommended by analyzer manufacturer. The following common requirements shall be considered:

- |                        |   |
|------------------------|---|
| -Body material:        | -AISI—316 as minimum  |
| - Filter element type: | - application dependent i.e. sinterized, metallic Screen etc.). |
| - Element replacement: | -to be done without removing the filter body from sample line.  |

Several types of filters are available; follow a partial description of the most commonly used.

##### • By-pass filters

By-pass filters shall be provided for the by-pass of fast loop stream and gross filtering of the sample. Filter shall be self cleaning type of appropriate design for the particular sample. The sample to the analyzer shall be the slipstream from this filter. By-passed sample shall be returned to process or to flare / sewer according to application requirements.

##### • Swirlclean filters

Swirlclean filters shall be used as by-pass filters on high particulate high flow samples.

##### • Coalescing filters

Coalescing filters shall be provided to protect the analyzer from incidental/liquid drops where condensable are foreseen. Coalesced liquid shall be delivered to sewer system.

##### • Tee filters

Final guard filter, low volume tee type, shall normally be provided before analyzer sample flowmeter. Filter element shall normally be sinterized steel.

##### • In-line filters

Where required, final guard filter, low volume in-line type, shall normally be provided on analyzer inlet. Filter element shall normally be sinterized steel.

	<b>GENERAL SPECIFICATION FOR MASS SPECTROMETER</b>	<b>GSTD-0007</b>	
		DOCUMENT NO	
		SHEET 7 OF 23	

#### **h. Switching system**

Where two or more streams have to be introduced in the analyzer, Switching system shall be provided.

Switching shall be done by double block and bleed valve system. Valves shall be ball type. Actuators will be activated using solenoid valves in EExd execution.

Switching valves internal volume shall be as smaller as possible according to analyzer sample flow requirements. If not otherwise requested, calibration shall be manual type. Switching system shall be done to provide to the analyzer the following:

- Process line sample(s)
  - Calibration / Validation sample(s) (where required)
- For each stream, switching sequence and stream duty cycle shall be fully programmable

#### **i. Sample cylinders**

If required, two sample cylinders (if not otherwise specified on job individual specification shall be supplied according to the requirements:-

- Seamless type, formed from tubing.
- 500 cc capacity
- Complete of :
  - Carrying handle.
  - Inlet and outlet needle valves.
  - Outage tube where sampled fluid is liquid.
- Factory passivated and cleaned.

#### **j. Quick connectors**

Quick connectors shall be supplied according to the following requirements:

- Double end shut-off type.
- Self sealing.
- Capable to withstand the required design pressure.
- Provided with stem and body protector caps complete of fixing chain.

#### **k. Flexible hoses**

Flexible hoses shall be completely made of stainless steel (tube and overbraid). Particular care shall be paid to avoid excessive bending during connection and disconnection of sample cylinder; hoses length shall be determined accordingly

#### **l. Pumps**

Where a pump is provided, the following requirements shall be considered:

- Pumps shall be diaphragm type. Double diaphragm pumps shall be utilized where high toxic sample (i.e. high H<sub>2</sub>S content) are sampled.

	<b>GENERAL SPECIFICATION FOR MASS SPECTROMETER</b>	<b>GSTD-0007</b>	
		DOCUMENT NO	
		SHEET 8 OF 23	

- Pump material shall be carbon steel as a minimum; cast iron pumps are not acceptable. Teflon lined internals or other suitable materials of construction shall be provided where highly corrosive fluids (i.e, high H<sub>2</sub>S) are sampled.
  - Pump shall be complete with:
    - Recycle valve
    - Overload thermic protection
    - Power switch (to be provided in case pump unit is installed remotely from Analyzer House).
- Pump dimensioning shall be done taking into account as safety design margin of the 50%.

#### 2.1.3. **Sampling systems interconnections**

Sampling systems shall be provided of tubing unions or bulkheads for sample and utilities lines interconnection as stated in analyzer individual specifications. Connections shall normally be suitable for 6 mm OD tubing for gaseous samples and ½" OD tubing for liquid samples.

#### 2.1.4. **Sampling-systems layout**

Particular care shall be taken to assure easy accessibility of components for maintenance purpose and routine operational checks. Layout drawings shall be provided for PDIL/ OWNER review and approval.

#### 2.1.5. **Sampling systems tagging**

Sample system shall have a permanently fixed label giving the associated analyzer tag number and a brief service description of the analyzer. Components and indicators within the sample systems shall have permanently fastened labels describing their function (e.g. FI-xxx sample flow to analyzer). Labels shall be weather resistant (i.e trafalite, stainless steel, etc.). Labels shall be fixed on sample system plate by means of stainless steel screw (glue is not acceptable). Labels and tags shall be in the English language.

#### 2.1.6. **Sampling systems - Electrical execution**

Unless otherwise indicated in the individual analysis instrument datasheets, the field electrical/electronic instruments and equipment will be provided in EEx-I execution according to CENELEC Code. Compliance with IEC/CENELEC codes shall be certified by an internationally recognized institute. Other protection (EEx-d, EEx-p etc) could be used when EEx-i execution is not available or practical. The mechanical protection degree for electrical / electronic instrumentation shall be IP 65 according to IEC 60529. Enclosure for field mounted equipment will be heavy-duty construction; wiring shall be fully protected against physical damage. The electrical connections shall be NPT threaded (Female) unless otherwise stated in the individual analysis instrument data sheets.

#### 2.1.7. **Sampling systems flow diagram drawing**

Manufacturer shall provide dedicated drawing for each sampling system. Each sampling system component shall be tagged. Operative set for relief valves and flow meters shall be indicated on flow diagram. The drawing shall also include list or table (equivalent to the following sample) reporting tag, description, material, manufacturer, model, selected range and operative set (where applicable) for each sampling system component.

	<b>GENERAL SPECIFICATION FOR MASS SPECTROMETER</b>	<b>GSTD-0007</b>	
		DOCUMENT NO	
		SHEET 9 OF 23	

S.No.	Description	Material	Manufacturer	Model	Range	Set
1						
2						
n						

## 2.2. Gaseous samples

When a gaseous process fluid is sampled the following guidelines have to be applied.

### 2.2.1. Sample Preconditioning unit

For a clean and dry sample with process take off point pressure higher than 6 barg. or where sample pressure is greater than analyzer maximum inlet pressure a pressure reducing station (PRS) plate mounted complete with the following shall be provided as a minimum:

- Sample shut-off valve on sample inlet
- In line filter
- Pressure reducer/regulator
- Pressure gauge on regulator outlet
- Relief valve
- Sample shut-off valve on sample outlet

Samples with high particulate content shall be provided with redundant filters at take-off point; if not otherwise indicated manual switch shall be foreseen.

### 2.2.2. Condensable Samples

In case pressure reduction could cause partial condensation or icing, sample vaporizer regulators shall be provided. Double pressure reduction, with or without vaporizer could be considered if necessary due to process conditions. Provision shall be taken to avoid condensation inside sample line; for this purpose it shall be considered the addition of phase separator (complete of automatic drain facility) and/or coalescing filter. Where required, the panel shall be installed inside an heated enclosure (for description refer to para 2.4). Shut-off and calibration valves shall be operable from the outside of the box. Manufacturer shall advise PDIL/ OWNER about the necessity to provide sample line heating. Heating shall normally be by steam.

If sample needs to be maintained at a constant temperature due to condensation and/or polymerization, PDIL/ OWNER shall be informed about the need to provide temperature controlled sampling lines. If sample contains high water concentration, system heating could be avoided and water be removed by cooler/separator or other mechanical device, only if this does not affect measurement reliability (e.g. measured component be solved in water).



	<b>GENERAL SPECIFICATION FOR MASS SPECTROMETER</b>	<b>GSTD-0007</b>	
		DOCUMENT NO	
		SHEET 10 OF 23	

### 2.2.3. Sample conditioning Unit

As minimum sample conditioning unit shall be provided with the following:

- Sample shut-off valve on sample inlet
- Fast loop system composed by:
  - By-pass filter
  - flow meter
  - check valve
  - shut-off valve on fast loop outlet
- Fine filter
- Zero calibration inlet by three way valve
- Span calibration inlet by three way valve
- Analyzer sample flow meter
- Sample shut-off valve on sample outlet

Where required, the sample conditioning unit shall be installed inside an heated enclosure (for description refer to para 2.4). Shut-off and calibration valves shall be operable from the outside of the box. Where high pressure fluctuations in the process are expected a pressure regulator for fine pressure control shall be provided on sample conditioning unit inlet. The regulator shall be placed downstream fine filter and zero and span calibration inlets. For samples with process take off point pressure higher than 80 barg and/or where high pressure fluctuations in the process are expected also a pressure regulator for fine pressure control shall be provided on sample system inlet. The regulator shall be placed downstream fine filter and zero and span calibration inlets. In case of analyzers extremely sensitive to sample pressure variations a fine regulator shall be provided to avoid errors due to pressure variation between process sample and calibration gases.

### 2.3. Calibration System / Analyzer Validation

2.3.1. Analyzer Manufacturer shall specify the type of samples to be supplied for the calibration of the relevant analyzer. Calibration standard gas (zero and span) to be quoted separately. These gas cylinders shall be provided complete with single stage or two stage pressure regulator, shut-off valve, pressure gauge and provision for connection to the analyzer sampling system. Calibration gas cylinder shall be supplied in 47 liter water capacity and will be provided for six months of operation. Sample tubing considered for calibration gas cylinder to mass spectrometer shall be 1/8 inch. Vendor shall advise requirements for zero and span calibration gases and all consumption rates, composition details, and any special quality requirements.

Cylinders shall be supplied with birth certificate (certification of origin) other certification, if any, in compliance to explosive rules for refilling of the cylinders later on.

2.3.2. When required, analyzers shall be provided with permanent validation facilities which shall on demand introduce standard reference sample into the analyzer. The reference sample (if liquid) shall be stored in appropriate container as part of the analyzer sample system. The

	<b>GENERAL SPECIFICATION FOR MASS SPECTROMETER</b>	<b>GSTD-0007</b>	
		DOCUMENT NO	
		SHEET 11 OF 23	

validation sample shall be switched into the analyzer sample conditioning systems downstream of all conditioning system components except for the final flow control valve flow meter and final guard filter. The validation samples shall be switched via double block and bleed valve system. The valves shall be ball type. The air actuators will be switched using solenoid valves. When *Validation* is selected at the analyzer selection switch, validation sample shall be routed to the analyzer and remain in this *mode* until the selector switch is turned to another position. During this period the "Analyzer Data Valid" contact should be opened and only closed again at the end of the validation after a time delay.

#### 2.4. Sampling Systems enclosure

Where necessary, sample preconditioning system and/or final sampling system shall be installed in a suitable enclosure. Enclosure shall be designed in accordance with the following description; in any case Manufacturer shall provide enclosure specification for PDIL/ OWNER review and approval.

- a. Enclosure protection shall be EExd - IIC T3 IP65 execution.
- b. Enclosure walls shall be made of AISI 316 stainless steel sheets with a minimum thickness of 1.5 mm.
- c. Sampling inlets and outlets shall be provided with suitable bulk-head Compression fittings for tubing connection.
- d. Sampling system plate shall be removable from the enclosure.
- e. Enclosure door shall be complete with locking device and handle.
- f. External fixing eyes shall be provided for installation purpose.
- g. All supports, bolts and screws shall be made of stainless steel.

In the event the system should require heating, the followings additional requirements shall be considered for enclosure manufacturing:

- a. Enclosure shall be sandwich type:
  - Externals shall be made of AISI 316 stainless steel sheets with a minimum thickness of 1.5mm
  - Internals shall be made of AISI 316 stainless steel sheets with a thickness of 1 mm.
- b. The insulation shall be provided on all sides of the enclosure including the front door. Insulation shall be installed between external and internal steel sheets to guarantee, together with steam heating system, the required internal temperature and to maintain the external surface temperature below 60 °C. Insulating material shall be incombustible (e.g. mineral wool).
- c. Preferably steam heating shall be provided (low pressure steam shall be utilized). Heating shall be done using a radiator adequately sized by Vendor. Internal

	GENERAL SPECIFICATION FOR MASS SPECTROMETER	GSTD-0007	
		DOCUMENT NO	
		SHEET 12 OF 23	

temperature control system shall be provided where it is necessary to maintain a constant set temperature.

- d Thermometer shall be provided on the front door.

In case flammable or toxic gases are handled inside the cabinet, suitable warning label shall placed on cabinet front door (e.g. "CAUTION RISK OF H<sub>2</sub>S", or "CAUTION FLAMMABLE GAS IS HANDLED").

Notice color shall be white on red back; letter dimensions shall be at least 20 mm height x 20 mm width.

## 2.5. Sampling Systems Calculations

PDIL/ OWNER shall provide on the analyzer individual specifications the following data that shall be utilized by sampling system Manufacturer for the system design.

- Sampling and return line lengths
- Proposed lines size (to be confirmed by Vendor)
- Sample composition
- Sample take-off point temperature and pressure
- Sample return point temperature and pressure
- Sample take-off point density.
- Sample take-off point viscosity.
- Sample take-off point dew point.

Manufacturer shall provide fast loop and time lag calculations for PDIL/ OWNER review and approval, System time lag shall normally be kept below 60 seconds. As safety design margin, the fast loop shall be calculated on the basis of 50% of the available pressure differentia between sample take off pressure and sample return pressure.

## 2.6. Sampling Systems Components' Sub-Vendor List

Where applicable all sampling systems shall be assembled utilizing components in accordance with the following sub-vendor list. In the event the application should require materials provided by other Manufacturers, the Vendor shall ask PDIL/ OWNER written approval highlighting all the technical aspects carrying to the proposed solution. Components' selection shall be done taking care of standardization criteria, minimizing the choice of different sub-vendors.

## 3.0 ANALYZERS DESIGN

This section provides general guidelines that shall be followed for the selection of the analyzers utilized for this project.

### 3.1. General requirements

Analyzer Vendor shall be fully responsible of the suitability of the proposed analyzer for the particular process application in terms of operating personnel safety and analyzer performances.

 पी डी आई एल PDIL	GENERAL SPECIFICATION FOR MASS SPECTROMETER	GSTD-0007	
		DOCUMENT NO	
		SHEET 13 OF 23	

#### 3.1.1. Analyzer installation

Analyzers not suitable to be directly installed in field shall be placed in common Analyzer House(s). The temperature inside the Analyzer House(s) shall be controlled to ensure adequate ambient conditions.

Analyzers; sample conditioning-systems and fast loops shall be positioned to obtain easy maintenance and routine operational checks. Analyzers control units (if any) shall normally be installed in control room or they may exceptionally be installed in the Analyzer House.

Sample conditioning systems shall be installed on the exterior walls in such a way that analyzer and related sample conditioning systems are located back to back. Cylinders shall be installed against the outside walls of the Analyzer House and shall be provided with fencing for restriction of unauthorized entry. Installation shall be designed for easy replacement. Provisions shall be taken to avoid direct exposure to sunlight.

If required the Analyzer House will be prefabricated type and, if located in hazardous area, shall be provided with redundant forced ventilation system; in this case air intake shall be from a safe area.

CO and flammable gas detection system shall be provided to avoid CO and gas accumulation in the analyzer building or analyzer houses.

Flame proof AC (3.0 Tons) shall also be provided.

Internal of Analyzer House shall be classified as safe area according to IEC 70.16.

#### 3.1.2. Electrical execution

Unless otherwise indicated in the individual analysis instrument data sheets, the field electrical/electronic instruments and equipment will be provided in EEx-I execution according to CENELEC Code. Compliance with IEC/CENELEC codes shall be certified by an internationally recognized institute. Other protection (EEx-d, EEx-p etc) could be used when EEx-i execution is not available or practical. The mechanical protection degree for electrical/ electronic instrumentation shall be IP 65 according to IEC 60529.

Enclosure for field mounted equipment will be heavy-duty construction; wiring shall be fully protected against physical damage. The electrical connections shall be NPT threaded (Female) unless otherwise stated in the individual analysis instrument data sheets.

#### 3.1.3. Analyzers common requirements

Within practicable limits, analyzer type shall be selected to perform a continuous measurement of the component of interest.

Proposed analyzers (whenever possible) shall be microprocessor based complete with auto diagnostic features providing detailed and guided assistance to facilitate Calibration, maintenance and fault finding.

A summary alarm contact shall be provided in case of malfunction; the contact shall be fail-safe design (Normally-Open type, de-energized in alarm conditions).

	GENERAL SPECIFICATION FOR MASS SPECTROMETER	GSTD-0007	
		DOCUMENT NO	
		SHEET 14 OF 23	

As minimum all metal parts in contact with process sample shall be AISI 316. If the application should require different materials (e.g. monel, hastelloy or other), it shall be notified to PDIL/ OWNER..

The use of copper and copper alloy is not allowed (also for carrier gases and instrument air). No plastic composition, fiber or paper are permitted as piping or valving.

If not otherwise stated in the individual specification analysis instrument data sheet , the following performance shall apply:

- sensitivity (minimum detectable limit) shall be 500 ppm of span or less.
- noise (detector deviation at constant input for chromatographs) shall be 0.5% of span or less.

If not otherwise stated in the detailed descriptions and individual specifications, the analyzers shall also be provided with the following:

- 4-20 mA linear output signal fully floating (600 Ohm load).
- Programmable measuring range.
- Self diagnostic.
- Keyboard configuration of functional parameters (range, process alarms, calibration values etc.).
- Storage of software parameters in non volatile memory.
- Automatic and Semiautomatic (on demand, by an external contact) calibration.
- "Hold" function: in case of failure and/or during calibration, the signal output shall be fixed to the last valid measurement, or to a fixed safe value.
- Tropicalization of the electronic parts against humidity and fungus; even those located in air conditioned rooms shall be varnished and electrostatically protected.
- Built-in meter for local indication shall be provided.
- "Zero" and "span" calibration facilities.
- Tropicalization of the electronic parts against humidity and fungus; even those located in air conditioned rooms shall be varnished and electrostatically protected.
- Built-in meter for local indication shall be provided.

### 3.2. Mass spectrometer

Mass spectrometer is common for all sample points.

	GENERAL SPECIFICATION FOR MASS SPECTROMETER	GSTD-0007	
		DOCUMENT NO	
		SHEET 15 OF 23	

Location and operation/design conditions for each sample point are as show on individual specifications.

Each sample point to have a local sampling system with sample probe (in same cases common with other analyzers or local analysis points) and a common final sampling system at the Mass spectrometer.

Mass spectrometer shall be installed in analyzer building and shall be equipped with printer and PC station. Printer and PC station shall be installed in central control room.

Mass spectrometer shall be stand alone units engineered and developed to satisfy the application as stated on Analyzer individual specification.

The analyzer cabinet shall be complete of vortex cooler for cooling of the electronic components.

The minimum configuration of PC shall be as given below

Intel Core-2 Duo Processor, 3 GHz, 4 GB RAM , 500 GB HDD, 22" TFT color, serial, parallel, USB., Ps/2 ports with Windows XP Professional license with HP laser Printer with PCanywhere software and modem connectivity for Remote Login.

### 3.2.1. Electronic and Control section

Analyzer software shall be designed to perform the required analysis.  
As minimum the following features shall be provided:

- Calculation software
- Analysis results continuous updating at the end of each analysis cycle.
- Components data transmission to DCS via 4-20 mA analogic outputs, and serial link transmission MODBUS-RTU (with communication protocol and applicative software).
- Ion source heater control.

Vendor shall confirm availability of such protocol, as industrial products, with the DCS supplier (Vendor shall supply Modbus list for DCS connectivity).

### 3.2.2. Analyzer tagging

Each analyzer will be marked by a stainless steel nameplate permanently fixed which, at least, will include the following informations:

- MFR's name or trademark
- Serial number and model
- Instrument tag
- Range
- Electrical rating (Voltage ,Frequency, Consumption)
- Electrical execution

	<b>GENERAL SPECIFICATION FOR MASS SPECTROMETER</b>	<b>GSTD-0007</b>	
		DOCUMENT NO	
		SHEET 16 OF 23	

- Pressure rating of pressurized parts

### 3.2.3. Screen Display Configuration

The analyzer shall have the following as minimum facility but not limited to

1. Menu Organization
2. Main Menu
3. Password Entry
4. Configure Defaults
5. Normal Analyze Screen
6. Incoming Alarms Screen
7. Manual Port Select
8. Manual Analyze Mode
9. Investigative Scan Display
10. Diagnostic Page
11. Auxiliary Menu Screen
12. Alarm History Retrieval Page
13. System Configuration Menu
14. Add/Delete Compounds Screen
15. Mass/Scan Voltage Configuration
16. Port Definition
17. Analysis Sequence Screen
18. Configuration Summary Page
19. Peak Select Mode Screen
20. Compound Calibration Menu
21. Scan Calibration Gas Screen
22. Calc/Examine /Modify Matrices Screen
23. Analyze Calibration Gas Screen

## 4.0 AMBIENT CONDITIONS

Instrumentation will be suitable to operate in the Fertilizers Complex atmosphere at the conditions specified in the General Conditions. Complex is at the sea site location exposed to the aggressive nature of the salt water atmosphere conditions. Ambient conditions will be taken into consideration for the transport, storage and normal operation.

## 5.0 TESTS AND INSPECTIONS

### 5.1. General

Analyzers and accessories will be submitted to all necessary tests and checks in compliance with IDS (Inspection Data Sheets) to verify that the supply is according to this specification and relevant standards and codes. Manufacturer will submit his internal test procedure during the bid phase. The Buyer reserves himself the right to send his Inspectors to the Manufacturer and Sub-vendor shops to check if the time schedule for the construction is respected together with quality of the product. The Inspector will have free access to the areas involved for the construction of the equipment and the Manufacturer will give him the necessary cooperation. However, PDIL/ OWNER inspection will be in no way release the Supplier from guarantee as to materials, apparatus, workmanship and performance of the equipment supplied by him.

Any fault which will be found during test will be corrected by Supplier at his own cost.

	GENERAL SPECIFICATION FOR MASS SPECTROMETER	GSTD-0007	
		DOCUMENT NO	
		SHEET 17 OF 23	

## 5.2. Test Description

The analyzers will be submitted, but not limited, to the following checks and tests:

### 5.2.1. Visual Test

It will be carried out to verify marking, overall dimensions, connection size, housing classification and construction materials.

### 5.2.2. Performance Test

It will be carried out to verify that instrument performance comply with requirements of para. 2 and 3.

### 5.2.3. Functional Test

It will be carried out to ascertain the functions requested on individual specification. Calibration and eight (8) hours repeatability test will be performed by the Manufacturer before shipment. Repeatability shall be, at least, that specified on Manufacturer technical brochure.

### 5.2.4. Pneumatic Test

The sampling systems will be submitted to pneumatic test in accordance with Manufacturer practice.

### 5.2.5. Factory Acceptance Test

Factory Acceptance Test (FAT) shall be conducted in presence of OWNER/PDIL representative Site Acceptance Test (SAT) shall be conducted for minimum of seven days to prove the guarantees.

## 5.3. Test Certificates

On final test the Supplier will have to provide the following documents in English:

- Chemical analysis/physical properties of construction materials.
- Internal test certificate including tests required in para. 5.2.
- The certificate of calibration shall be given in accordance with the International Standard ISO 9002

## 5.4. Training

Training shall be imparted at Vendor's workshop for one week for two persons. In addition vendor will be required to provide training to representative during commissioning time.

## 6.0 TECHNICAL DOCUMENTATION

### 6.1. General



	GENERAL SPECIFICATION FOR MASS SPECTROMETER	GSTD-0007	
		DOCUMENT NO	
		SHEET 18 OF 23	

All the documentation such as graphic drawings and technical specifications shall be sent to the Contractor who will reserve to approve it within 15 days; after this period, the documents have to be retained approved. The Contractor's approval will not relieve the Vendor of his responsibility for the final performance of the supply. Final issue of Project Documents, shall be supplied in electronic format as specified hereunder.

Only in exceptional case, requiring PDIL/ OWNER prior approval or when Vendor is utilizing software different than those specified at para 6.3 and 6.4 scanned documents in raster format as specified in para 6.5 can be accepted. All the other Vendor documentation, such as Manual, Catalogs, etc. shall be supplied on paper.

## 6.2. Title block and heading

Each document originated by the Vendor shall be numbered according to Vendor procedure.

## 6.3. Specification, Data Sheets and other documents

All shall be produced with Microsoft Office products as Word, Excel or PowerPoint access. The files shall be delivered in a “workable stand-alone” format, without any special features (links to other files, special fonts, macros, etc.), which may affect the possibility of viewing and editing.

## 6.4. Drawings

Drawings will be made using AutoCAD version 12 or 14 or Latest. Vendors are permitted to utilise other CAD software, but the produced files are to be converted in AutoCAD format prior the delivery to Contractor.

Drawings files shall be delivered as “single complete file”, without any reference attached, except when not practicable due to the dimension of referenced files. In this case together with the reference files also the information necessary to manage the files shall be given. Together with the drawings files also the relevant files for plotting format HPGL or HPGL2 are to be delivered.

## 6.5. Scanned documents

The format of scanned documents shall be CCIIT Group IV TIFF or Adobe PDF Acrobat. Quality control on file of scanned documents will be completed prior to delivery, including:  
Deskew  
Despeckle  
Hole Fill.  
Resolution below 200 Dpi is not acceptable.

The following documents (technical) are required to be submitted by the vendor alongwith bid, after placement of order for approval purposes and final documentation before despatch of consignment.

	<b>GENERAL SPECIFICATION FOR MASS SPECTROMETER</b>	<b>GSTD-0007</b>	
		DOCUMENT NO	
		SHEET 19 OF 23	

SL. NO.	DESCRIPTION OF DOCUMENT	ALONGWITH BID	AFTER PLACEMENT OF ORDER	
			FOR APPROVAL/ INFORMATION WITHIN SIX WEEKS	FINAL DOCUMENTS BEFORE DESPATCH OF CONSIGNMENT
1.	Consolidated list of drawings & documents	Yes	yes (I)	yes
2.	Deviation, if any, from the technical spec. giving justification for the same.	Yes	x	x
3.	Catalogue / technical literature of MSP and accessories including cross-sectional view, dimensions, weight etc.	yes	Yes	Yes
4.	Tentative dimensional drawings for each tag no. with technical details like dimensions, weight, special supports, clearances required for easy maintenance etc. , sectional drawings for special control valves.	Yes	x	x
5.	Final certified drawings of MSP	x	yes (A)	Yes
6.	Document required before pre-despatch inspection  A.) Calibration certificate  B.) Hazardous area use conformity certificates.  C.) Electrical wiring diagram.  D.) Documents, manuals etc.	x	x	Yes
7.	Certificates conforming to specific standards from independent recognised agency, wherever applicable, for - Ex-proof items - Intrinsically safe items - Environmental protection - Fire safety	yes	x	Yes
8.	Manuals for installation, operation. maintenance	x	x	Yes
9.	Manufacturer's quality assurance certificate	x	x	Yes
10.	Quality assurance plan	x	yes (A)	x
11.	FAT PROCEDURE			Yes
11.	SAT PROCEDURE			Yes

 पी डी आई एल <b>PDIL</b>	<b>GENERAL SPECIFICATION FOR MASS SPECTROMETER</b>	<b>GSTD-0007</b>	
		DOCUMENT NO	
		SHEET 20 OF 23	

#### NOTES

1. (A) for Approval (I) for information only

Number of sets alongwith bid for approval and as final documentation shall be supplied as stipulated in the purchase order.

	<b>GENERAL SPECIFICATION FOR MASS SPECTROMETER</b>	<b>GSTD-0007</b>	
		DOCUMENT NO	
		SHEET 21 OF 23	

## 6.6 **METHOD OF TENDERING**

### **General**

The Bidder shall present a list of previous applications (References) for equipment similar to the equipment proposed.

### **Technical information**

The equipment offered as a basis shall be of standard production type it shall be based on modern technology, be of a proven and referenced type and designed for continuous operation under the specified operating conditions.

The Bidder shall quote for the materials requested according to the requirements of this specification and of the individual job specifications. With bid shall be supplied the technical documentation.

### **Deviations**

The tender shall be in strict accordance with Purchaser's specifications. However, the Vendor may quote, in addition and as an alternative, different materials from those required in the specifications, provided these materials are suitable for the process conditions specified in the individual job specifications.

Any deviation from the requirements listed in the general specification and in the individual job specifications shall be clearly highlighted.

If no exceptions are listed, the tender - and the possible supply - shall be regarded as being in full conformity with the Purchaser's requirements, and will be accepted after the tests and checks have confirmed that the performance complies with the requirements of the tender documents and order specifications.

6.8. Size of Drawings, Specification and other documents must be according to UNI/ISO standard.

6.10. Addressing documentation

All documentation will be addressed to:

PDIL as per the address given elsewhere.

	<b>GENERAL SPECIFICATION FOR MASS SPECTROMETER</b>	<b>GSTD-0007</b>	
		DOCUMENT NO	
		SHEET 22 OF 23	

#### 6.12. Required Drawings & Documents

S.No.	Description	Notes
1	Sampling system flow diagram	
2	Sampling system dimensional drawings	
3	Sampling system layout	
4	Sampling system pneumatic interconnections	
5	Sampling system interconnecting wiring	
6	Analyzer dimensional drawings and weights	2
7	Analyzer electronic and detector layout	2
8	Analyzer terminal strips· Power and signals interconnecting wiring	2
9	Analyzer internal wiring	2
10	Cabinet dimensional drawings	1
11	Cabinet layout	1
12	Cabinet power supply distribution	
13	Cabinet terminal strips - Interconnecting wiring	1
14	Cabinet internal wiring	1
15	Field equipment installation details	1
16	Fast loop calculation sheet	1
17	Flow meters calculation sheet	1

Notes:

1. If any
2. Necessary when not included in analyzer instruction manual

	<b>GENERAL SPECIFICATION FOR MASS SPECTROMETER</b>	<b>GSTD-0007</b>	
		DOCUMENT NO	
		SHEET 23 OF 23	

## 7.0 SPARE PARTS

Spares shall be as per section 9.0 of the NIT.

## 8.0 PACKING FOR SHIPMENT

The packing for shipment shall meet the provisions contained in the purchase order conditions.

Packing for shipping of equipment shall be crash proof, weatherproof and road/seaworthy.

## 9.0 METHOD OF SUPPLY

### 9.1. General

The supply shall be in strict accordance with the purchase order conditions and the specifications issued for order and shall be constructed in accordance with the requirements of good engineering practice.

### 9.2. Documentation

The Vendor shall forward the documentation required in the "General Purchase Conditions" attached to the purchase order, in the number of copies and within the time specified in this specification at para 6.

### 9.3. Responsibility

The Vendor shall assume responsibility for the project, construction, assembly, and tests of the supply..

### 9.4. Guarantees

The guarantee period must be according to purchase order conditions. The Vendor shall guarantee that all the equipment supplied is free of design and construction defects, or defects related to poor quality of the materials utilized. During the guarantee period the Vendor shall undertake to replace or repair, at this own charge, all parts found defective due to material quality. improper design, workmanship or assembly.

	PROJECTS & DEVELOPMENT INDIA LTD	GSTD-0120
		DOCUMENT NO
		SHEET 1 OF 13

GENERAL SPECIFICATION FOR  
MOTORISED ACTUATOR

0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

CONTENTS

SECTION NUMBER	DESCRIPTION
1.00	GENERAL
2.00	CODES AND INDUSTRY STANDARDS
3.00	MOTORISED ACTUATOR
4.00	INSPECTION, FACTORY TESTS & APPROVAL
5.00	PACKAGING
6.00	IDENTIFICATION & MARKING
7.00	SPARES
8.00	DOCUMENTATION
9.00	METHOD OF TENDERING

LIST OF ATTACHMENTS

ATTACHMENT NUMBER	DESCRIPTION	NUMBER OF SHEETS
Annexure-1	Actuator torque Specification	1



	<b>GENERAL SPECIFICATION FOR MOTORISED ACTUATOR</b>	<b>GSTD-0120</b>
		DOCUMENT NO
		SHEET 3 OF 13

**1.00      GENERAL**

- 1.01

This general specification together with the Instrument specification attached herewith define the technical requirement for the supply of Motorised gate valve, its spares, documentation and testing.
- 1.02

In the event of any conflict between general specification and Instrument specification the later shall prevail.

**2.00      CODES AND INDUSTRY STANDARDS**

The design shall be made in accordance with latest Codes & Standards and statutory requirements.

- AMERICAN PETROLEUM INSTITUTE (API)**  
API 600 Steel Valves - Flanged & Buttwelding Ends  
API 6D Specification for Pipeline Valves (Gate, Plug, Ball and Check Valves)  
API 598 Valve Inspection & Testing
- AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)**  
ASME Boiler and Pressure Vessel Code, including all mandatory addenda  
Section VIII, "Pressure Vessels - Division 1"  
ASME B2.1, "Screw Threads - Pipe Threads, General Purpose (Inch)"  
ASME B16.5, "Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24"  
ASME B16.11, "Forged Steel Fittings, Socket-Welding and Threaded"  
ASME B16.20, "Metallic Gaskets for Pipe Flanges - Ring-Joint, Spiral-Wound, and Jacketed"  
ASME B16.25, "Buttwelding Ends"  
ASME B16.34, "Valves – Flanged, Threaded and Welding End"  
ASME B16.47, "Large Diameter Steel Flanges NPS 26 Through NPS 60"
- AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)**  
ASTM A193/A193M, "Alloy Steel and Stainless Steel Bolting Materials for High-Temperature Service"  
ASTM A194/A194M, "Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service or Both"  
ASTM A320/A320M, "Alloy-Steel Bolting Materials for Low-Temperature Service"  
ASTM A350/A350M, "Carbon and Low-Alloy Steel Forgings, Requiring Notch Toughness Testing for Piping Components"  
ASTM A352/A352M, "Steel Castings Ferritic and Martensitic for Pressure-Containing Parts Suitable for Low-Temperature Service"
- AMERICAN WELDING SOCIETY (AWS)**  
AWS A5.13, "Solid Surfacing Welding Rods and Electrodes"
- FLUID CONTROL INSTITUTE (FCI)**  
FCI 70-2, "Control Valve Seat Leakage"
- INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)**  
IEC 60079, "Electrical Apparatus For Explosive Atmospheres"

	<b>GENERAL SPECIFICATION FOR MOTORISED ACTUATOR</b>	<b>GSTD-0120</b>
		DOCUMENT NO
		SHEET 4 OF 13

3.01      Motorised Actuator

**The motor shall be conforming to Ex"d", Gas group IIC, T3.**

The design, manufacture and performance of equipment covered by this specification shall conform to the relevant Indian/ International standards and codes. In particular the equipment offered shall conform to the following standards with latest revision.

IS-325	Specification for three phase induction motors
IS-2147	Degree of protection provided by enclosures for low voltage switch gears & control gears
IS-2148	Flame proof enclosures of electrical apparatus
IS-2959	A.C. contractors for voltages not exceeding 1000V
IS-4691	Degree of protection provided by enclosures for rotating electrical machinery
IS-4722	Specification for rotating electrical machine.
IS-9334	Specification for electric motor operated actuators

- 3.02.01      The following devices shall be supplied as integral part of the actuator:
- 3.02.011      Electrical drive motor
- 3.02.012      All the accessories required for safe operation and control of actuators shall be Included in the scope of supply but not limited to the following:

a)      Electrically and mechanically interlocked contractors for opening and closing direction.

b)      Fuses and thermal overload relay for protection of motor and control transformer.

c)      Push buttons for opening/ closing and stopping of valve operation.

d)      Thermostat/ thermister with electronic controller for protection of motor.

e)      Separate torque and travel limit switches for both Open and Close positions.

f)      Incoming power supply isolating switch.

g)      Indicating lamps for valve fully open, fully closed and ‘in-travel’ condition.

h)      Space heater preferably with control thermostat.

i)      Local continuous position indicator.

j)      Terminal block fully pre-wired upto contacts on individual devices.

k)      Control transformer

l)      2 nos. earthing terminals.

m)      Hand wheel for manual operation, suitably interlocked to prevent simultaneous manual and electrical operation.
- 3.02.02      The housing material for actuator shall be anodised aluminium alloy and shall be epoxy painted. Vendor to furnish the thickness and type of paint.
- 3.02.03      The motor shall be electrical three-phase squirrel cage induction type. The motor enclosure shall be flame proof as per specification sheets and shall conform to IP – 68 or better. The motor design & construction shall be robust, long maintenance free service life. The motor shall be rated for short time duty 5-15 minutes. Motor shall be able to operate the actuator at 75% of the specified voltage. Motor shall have F class insulation (Temperature rise class B) and winding shall be resistant to corrosive agents such as NH<sub>3</sub>, CO<sub>2</sub> and moisture. Fuses and thermal overload relay shall be provided for protection of motor and control transformer. Electrical and

	<b>GENERAL SPECIFICATION FOR MOTORISED ACTUATOR</b>	<b>GSTD-0120</b>
		DOCUMENT NO
		SHEET 5 OF 13

mechanical disconnection of the motor should be possible without draining the lubricant from the actuator gearcase.

The motor shall be suitable for the following conditions -  
a) Minimum 3 numbers of consecutive starts in hot condition.  
b) Minimum 8 no. of starts in time span of 15 minutes.

- 3.02.04      Push buttons for opening/ closing/ stopping the valve action in the field to be provided. Contact for push buttons shall be “Normally open” type.
- 3.02.05      Lockable selector switch for “local/off/remote” operation of the valve shall be provided as follows :
1.    Position local : The actuator can be operated locally.

2    Position off : The actuator is completely off and cannot be operated either from local control switch or from remote control switch.

3    Position remote : The actuator can be operated only from remote control point. It is not possible to operate it from local control switch.
- 3.02.06      Torque switches shall be provided for opening and closing direction.
- 3.02.07      Local indicating lamps for valve fully open (green) and fully closed (red) condition to be provided.
- 3.02.08      Space heater with thermostat shall be provided.
- 3.02.09      Control transformer shall be supplied.
- 3.02.10      Actuator shall have three cable entries :  
(i) For Power supply (1 1/2"NPT)  
(ii) For remote operation & position indication (1"NPT)  
(iii) Spare (1" NPT plugged).  
Cable glands shall be double compression, flame proof type of SS material.
- 3.02.11      Actuator shall be flame proof confirming to Exd IIC T3 as per IEC with environmental protection of IP 65 or better. All the bolts and nuts used in the actuator, bonnet and other parts of the valve body shall be made of stainless steel. The actuator shall be oversized to at least 25% of sizing.
- 3.02.12      Actuator shall be provided with following control status indicated on DCS/ PLC:
  - Valve opening, closing or moving
  - Valve full open
  - Valve full close
  - Valve position at intermediate
  - Motor tripped on torque in mid travel, motor stalled
  - Remote selected
  - Actuator being open by handwheel
- 3.02.13      The actuator shall include a digital position indicator with a display from fully open to fully closed in 1% increment. Provision shall be made to orientate the display through increment of 90%. Provision shall be made in design for the addition of a contactless

	<b>GENERAL SPECIFICATION FOR MOTORISED ACTUATOR</b>	<b>GSTD-0120</b>
		DOCUMENT NO
		SHEET 6 OF 13

transmitter to give a 4-20 mA analog signal corresponding to valve travel for remote indication when required and actuator output torque for remote indication when required.

3.03

Accessories

3.03.01

Limit switches shall be weatherproof IP-65 or better. Limit switches shall be supplied for valve open and close positions suitable for low current intrinsically safe applications (gold plated contacts of 24V DC 1 A rating).

3.03.02

wherever handwheel has been specified, the same shall be side mounted type and engaged when the motor is declutched by a lever or similar means, the drive being restored to power automatically by starting the motor. The handwheel or selection lever shall not move on restoration of motor drive. Provision shall be made for the hand/ auto selection lever to locked in both hand and auto position. While the hand/ auto selection lever is locked in auto mode, without damage to the actuator motor it should be possible for hand operation while the motor actuator is in running condition or in starting condition. The handwheel drive must be mechanically independent of the motor drive and any handwheel gearing should be such as to permit emergency manual operation in a reasonable time. Clockwise operation of the handwheel shall give closing movement of the valve unless otherwise started.  
Neutral position of the handwheel shall be clearly indicated.

3.03.03

The actuator shall be furnished with a drive bushing easily detachable for machining to suit the valve stem or gearbox input shaft. Normally the drive bush shall be positioned in a detachable base of the actuator. Thrust bearing, when housed in a separate thrust base should be of the sealed for life type.

3.03.04

The reversing starter, control transformer and local control shall be integral with the valve actuator suitably housed to prevent breathing and condensation. The starter shall be suitable for 60 starts per hour and of rating appropriate to motor size. The starter contactors shall be protected from excessive current surge during travel reversal by an automatic time delay on energization of contactor coils. The controls supply transformer shall be fed from two of the incoming three phase and incorporate overload protection. It shall have the necessary tapping and be adequately rated to provide power for the following functions: -

- Energization of contactor coils
- 24 VDC output where required for remote controls
- Supply for all the internal electric circuits

3.04

Fugitive Emissions Considerations

Packing shall limit fugitive emissions. Fugitive emissions of any substance containing more than 5% by weight of volatile hazardous air pollutant as defined in the National Emissions Standard for Organic Hazardous Air Pollutants (NESHAP) shall be limited in accordance with the applicable local regulation or to a maximum of 500 parts per million, whichever is more stringent.

4.00

INSPECTION, FACTORY TESTS AND APPROVAL

4.01

All instruments and accessories shall be inspected & tested to ascertain that the supply is in accordance with approved specification. The inspections & tests shall not relieve the supplier/ manufacturer from his responsibilities for materials and the performance of the instrument supplied.

	<b>GENERAL SPECIFICATION FOR MOTORISED ACTUATOR</b>	<b>GSTD-0120</b>
		DOCUMENT NO
		SHEET 7 OF 13

- Within two weeks of receipt of the Letter Of Intent (LOI) /order, vendor must contact the Inspection Agency specified in the order and finalise with them the Quality Assurance Plan (QAP) for carrying out Inspection and test.
- In absence of any Inspection Agency the vendor must submit the Quality Assurance Plan for principal's approval. All tests, in such cases, shall be conducted by manufacturer's quality department and the results of tests shall be forwarded alongwith the supply.
- Procedure and extent of tests shall be governed by QAP mutually agreed between the vendor and principal's inspection authority.
- No instrument / accessory shall be shipped until all the required tests are successfully completed and certified "Cleared for despatch" by the inspection authority.
- 4.02 The following physical checks, routine tests, as a minimum shall be witnessed by Principal's inspection authority.
1. Physical Check
- a) Physical conformity of the motorised gate valve and its accessories with order specifications including dimensions check -
- Markings
  - Overall dimensions
  - Face to face body dimension
  - Flanges
  - Thickness check
  - Check for accessories, connections & installations.
  - Test of electrical parts & verifications of hazardous area
- In order to check the internal parts the inspector shall have the right to disassemble one valve per type.
2. (i) Routine test for valve
- a) Valve inspection and testing shall be in accordance with API 598
- b) Hydrostatic testing shall be done in accordance with API 6D, in not it will be tested as per ANSI B 31.3. Unless otherwise stated on the data sheet, component testing of the pressure boundary parts is permitted; provided the valve body assembly is subsequently tested to verify the pressure sealing integrity of gaskets..
- c) Seat leakage test with leakage rate conforming to FCI 70.2.
- d) Functional tests : If applicable
- Valve position on energy failure
  - Limit switches
  - Electric actuator
  - Handwheel
- e) The following checks shall be carried out on the valves successfully tested :
- Rust proof painting (except for SS)
  - Cleaning of internal parts of body
  - Protective plugs against infiltration of foreign materials
  - Protection against possible impacts
  - Valve tag plates
- f) Fire safe testing as per API 6FA

	<b>GENERAL SPECIFICATION FOR MOTORISED ACTUATOR</b>	<b>GSTD-0120</b>
		DOCUMENT NO
		SHEET 8 OF 13

- g) Radiography/ultrasonic test shall be carried out for all valves of rating above 600#. In addition butt weld ends of all butt welded valves for all pressure ratings shall be subjected to radiography/ ultrasonic tests.
- h) Magnetic Particle or Die Penetrate test for castings and forging shall be carried out as required.
- i) Checking of material composition & test.
- j) An alloy verification plan will be issued on projects where alloy verification is required in accordance with General Engineering Procedures. This plan will include instrument items to be alloy verified (with verification class defined), required methods of verification and when and where these test are to be performed. Alloy verification requirements will be noted on each valve data sheet (example: "CLASS I ALLOY VERIFICATIONREQUIRED"). Supplier shall perform all required tests to meet the stated requirements.
- k) Valve shall be subjected to 10% hardness test for hard facing.

- 2 (ii) Routine test for actuator  
Each actuator must be performance tested and individual test certificates shall be furnished. The test equipment should simulate a typical valve load, and the following parameters should be recorded.
- (a) Current at max. torque setting
  - (b) Torque at max. torque setting
  - (c) Flash test voltage
  - (d) Actuator output speed or operating time

In addition the test certificate should record details of specifications such as gear ratios for both manual & automatic , drive closing direction , wiring diagram code number etc

**5.00      PACKAGING**

Requirement of packaging stated elsewhere in the bid document.  
Vendor should furnish storage requirement of the valves like  
Valve should be stored open or close?  
Does the valve need to be stroked if stored for an extended period?  
Other requirements.

**6.00      IDENTIFICATION AND MARKING**

- 6.01      Self adhesive tapes or signs are not permissible for permanent marking of any instrument.
- 6.02      Each gate valve shall be fitted with a SS tag plate and shall contain the following information:
  - Tag no.
  - Manufacturer's name, Serial No. and Model
  - Body and trim material and sizes
  - Body rating and end connection
  - Fail action

Each motorised actuator shall be fitted with a SS tag plate and shall contain the following information:



	<b>GENERAL SPECIFICATION FOR MOTORISED ACTUATOR</b>	<b>GSTD-0120</b>
		DOCUMENT NO
		SHEET 9 OF 13

- Tag no.
- Torque rating
- Power rating
- Power supply

A durable terminal identification card showing plan of terminals shall be provided and attached to the inside of terminal box cover indicating wiring diagram number terminal layout.

Besides the above each instrument shall have a separate circular tag number plate in stainless steel with engraved tag number and range and attached securely to the instrument with a soft stainless wire. The size of letters and figures shall be minimum 4mm and the plate should be 25mm diameter with 1-2 mm thick. Also each instrument shall have lamicoid nameplate with 6 mm minimum size black letters on white background and identified with their relevant loop number

- 6.03
- All spare parts shall be fitted with identification plate with the following data clearly printed and easily readable.

  - Spare parts name/model no. as per purchaser’s Instrument specification sheet
  - Serial no.

7.00

**SPARES**

Spares shall be as per enclosed spares list.

8.00

**DOCUMENTATION**

1

**Technical documentation**

1.1

**General**

All the documentation such as graphic drawings and technical specifications shall be sent to the Contractor who will reserve to approve it within 15 days; after this period, the documents have to be retained approved.  
The Contractor's approval will not relieve the Vendor of his responsibility for the final performance of the supply.  
Final issue of Project Documents shall be supplied in electronic format as specified here under.  
All the other Vendor documentation, such as Manual, Catalogues, etc. shall be supplied on paper.

1.2

**Title block and heading**

Each document originated by the Vendor shall be numbered according to Vendor procedure.

1.3

**Specification, Data Sheet and other documents.**

All shall be produced with Microsoft Office products as Word, Excel or PowerPoint access. The files shall be delivered in a “workable stand-alone” format, without any special features (links to other files, special fonts, macros, etc.), which may affect the possibility of viewing and editing.

1.4

**Drawings**

Drawings will be made using AutoCAD version 12 or 14 or Latest.  
Vendors are permitted to utilise other CAD software, but the produced files are to be converted in AutoCAD format prior the delivery to Contractor.

	<b>GENERAL SPECIFICATION FOR MOTORISED ACTUATOR</b>	<b>GSTD-0120</b>
		DOCUMENT NO
		SHEET 10 OF 13

Drawings files shall be delivered as “single complete file”, without any reference attached, except when not practicable due to the dimension of referenced files. In this case together with the reference files also the information necessary to manage the files shall be given. Together with the drawings files also the relevant files for plotting format HPGL or HPGL2 are to be delivered.

**1.5 Scanned documents**

The format of scanned documents shall be CCITT Group IV TIFF or Adobe PDF Acrobat. Quality control on file of scanned documents will be completed prior to delivery, including:  
Deskew  
Despeckle  
Hole Fill.  
Resolution below 200 Dpi is not acceptable.



The following documents (Technical) are required to be submitted by the vendor alongwith bid, after placement of order for approval purposes and final documentation before despatch of consignment.

Sl. no.	Description of document	Alongwith bid	After placement of order	
			For approval/ information within two weeks	Final documents before despatch of consignment
1.	Consolidated list of drawings & documents	Yes	Yes (I)	Yes
2.	Deviation, if any, from the technical spec. giving justification for the same.	Yes	x	x
3.	Catalogue / technical literature of valves and accessories including cross-sectional view, dimensions, weight etc.	Yes	Yes	Yes
4.	Tentative dimensional drawings for each Tag No. with technical details like dimensions, weight, special supports, clearances required for easy maintenance etc.	Yes	x	x
5.	Final certified detailed as per Sl. No. 4 for main item & accessories for each tag no.	x	Yes (A)	Yes
6.	Material test certificates from independent recognised agency showing chemical analysis, physical analysis, Ferrite content on finished products.	x	x	Yes
7.	Certificates conforming to specific standards from independent recognised agency, wherever applicable, for - Ex-proof items - Intrinsically safe items - Environmental protection - Fire safety	Yes	x	Yes
8.	Manuals for installation, operation & maintenance	x	x	Yes
9.	Calculation sheet for actuator sizing etc. for each tag no. including KW rating	Yes	Yes(I)	Yes
10.	Calibration certificates for - Hydrostatic test Seat leakage test Performance test Functional test Special test (if specified) (radiography, ultrasonic etc.)	x	x	Yes
11.	“As supplied” data sheet signed by qualified engineer	x	x	Yes
12.	Manufacturer’s quality assurance certificate for each actuator	x	x	Yes
13.	Quality assurance plan	x	Yes (A)	x

- NOTES**
- 1. (A) for Approval (I) for information only
  - 2. Sl. No. 1 to 12 shall be forwarded to Owner as per details outlined in enquiry /order.
  - 3. Sl. No. 13 shall be mutually finalised with Inspection Authority specified in the order as per clause no.4.01.
  - 4. Number of sets shall be as stipulated elsewhere in the bid document. Final documentations shall be supplied in hard copies as well as soft copies in CD formats. Applicable software are MS Office 2000, Word, Access, Excel. Documentation language shall be English.

	<b>GENERAL SPECIFICATION FOR MOTORISED ACTUATOR</b>	<b>GSTD-0120</b>
		DOCUMENT NO
		SHEET 12 OF 13

**9.0    METHOD OF TENDERING**

**General**

The Bidder shall present a list of previous applications (References) for equipment similar to the equipment proposed.

**Technical information**

The equipment offered as a basis shall be of standard production type it shall be based on modern technology, be of a proven and referenced type and designed for continuous operation under the specified operating conditions.

The Bidder shall quote for the materials requested according to the requirements of this specification and of the individual job specifications. With bid shall be supplied the technical documentation.

**Deviations**

The tender shall be in strict accordance with Purchaser's specifications.

However, the Vendor may quote, in addition and as an alternative, different materials from those required in the specifications, provided these materials are suitable for the process conditions specified in the individual job specifications.

Any deviation from the requirements listed in the general specification and in the individual job specifications shall be clearly highlighted.

If no exceptions are listed, the tender - and the possible supply - shall be regarded as being in full conformity with the Purchaser's requirements, and will be accepted after the tests and checks have confirmed that the performance complies with the requirements of the tender documents and order specifications.

	PROJECTS & DEVELOPMENT INDIA LTD	GSTD-0120
		DOCUMENT NO
		SHEET 1 OF 13

Annexure – 1 Actuator torque Specification

Note: - Vendor to fill the table for all the tags.

Sl. No.	Tag No	Qty	Valve size	Actuator Model	Gear Box Model (if applicable)	Torque (Nm)			R P M	Travel Time Sec.	Max. stem (mm)	Kw Rating
						Valve Torque (Actual)	Valve Torque with 25% safety factor	Actuator Torque				
1												

0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD


	PROJECTS & DEVELOPMENT INDIA LTD	GSTD-0201	0	
			Rev	
		SHEET 1 OF 137		

# GENERAL SPECIFICATION

## FOR


### DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM

0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 2 OF 137		

#### Abbreviations:

AC	Alternating Current
APC	Advanced Process Control
CFF	Common File Format
CPU	Central Processing System
CRT	Cathode Ray Tube
DA	Data Access
DC	Direct Current
DD	Device Description
DCS	Distributed Control System
DVD	Digital Versatile Disc
EDDL	Enhanced Device Descriptive Language
EPROM	Erasable Programmable Memory
EMI	Electromagnetic Interference
ESD	Emergency Shutdown System
FAT	Factory Acceptance Test
FDT / DTM	Field Device Tool / Device Tool Manager
FF	Foundation Fieldbus
FMEDA	Failure modes, Effects and Diagnostic Analysis
GPS	Global Position System
HART	Highly Addressable Remote Transducer
HDA	Historical Data Access
HI	Foundation Fieldbus low speed (31.25kbps) loop powered bus
HSE	High Speed Ethernet
HVAC	Heating, Ventilation and Air Conditioning
HW	Hardware
HWC	Hardware Console
I/O	Input / Output
IAMS	Instrument Asset Management System
LAN	Local Area Network
LAS	Link Active Scheduler
LCD	Liquid Crystal Diode
MCC	Motor Control Centre
MOV	Motor Operated Valve
MTTF	Mean Time to Failure
MTTR	Mean Time to Repair
OIS	Operator Interface System

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 3 OF 137		

OLE	Object Linking and Embedding
OPC	OLE for Process Control
PC	Personnel Computer
P&ID	Piping and Instrumentation Drawing
PID	Proportional, Integral and Derivative
PLC	Programmable Logic Controller
QUAD	Quadruplet
RAID	Redundant array of independent discs
RAM	Random Access Memory
RDBMS	Relational Database Management System
RFI	Radio Frequency Interference
ROM	Read Only Memory
SAT	Site Acceptance Test
SCSI	Small Computer System Interface
SER	Sequence of Event Recorder
SIL	Safety Integrity Level
SIS	Safety Instrumented System
SPD	Surge Protection Device
SQL	Structured Query Language
TCP / IP	Transmission Control Protocol / Internet Protocol
TFT	Thin Film Transistor
UHF	Ultra High Frequency
UPS	Uninterrupted Power Supply
USB	Universal Serial Bus
VDU	Video Display Unit
VFD	Vertical Field Device
VHF	Very High Frequency
WAN	Wide Area Network


Triple Modular redundant (TMR), Quadruple Modular Redundant (QMR) configuration, Flexible Modular Redundant (FMR) configuration, Virtual Modular Redundant (VMR)

## CONTENTS

PART – I GENERAL SPECIFICATION OF DISTRIBUTED CONTROL SYSTEM.


page 05

PART – II TESTING, INSTALLATION, COMMISSIONING AND

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 4 OF 137		


ACCEPTANCE OF DISTRIBUTED CONTROL SYSTEM. page 115

PART - III GENERAL REQUIREMENTS OF  
DISTRIBUTED CONTROL SYSTEM. page 133

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 5 OF 137		


**PART – I**  
  
**GENERAL SPECIFICATIONS  
OF  
DISTRIBUTED CONTROL SYSTEM**




	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 6 OF 137		

## CONTENTS

<b><u>SR.NO.</u></b>	<b><u>TITLE</u></b>	<b><u>PAGE NO.</u></b>
1.0	GENERAL	7
2.0	DEFINITIONS	12
3.0	SPARES PHILOSOPHY	19
4.0	SYSTEM CONFIGURATION	22
5.0	DESIGN AND CONSTRUCTION	24
5.1	DESIGN REQUIREMENTS	24
5.2	FUNCTIONAL REQUIREMENTS	33
5.3	CONTROLLER AND DATA ACQUISITION SUB-SYSTEM	34
5.4	OPERATOR INTERFACE SUB-SYSTEM	44
5.4.1	GENERAL	44
5.4.2	OPERATOR CONSOLES	45
5.4.3	PROCESS DISPLAYS	48
5.4.4	LOGGING FUNCTION AND REPORT GENERATION FUNCTION	55
5.4.5	SELF DIAGNOSTICS	59
5.4.6	DATA STORAGE, ARCHIVAL AND RETRIEVAL	59
5.4.7	ASSIGNABLE TREND RECORDER	60
5.4.8	HARD COPY UNIT	60
5.4.9	SYSTEM SERVERS SIZING CRITERIA	60
5.4.10	SYSTEM OPERATIONAL RESPONSE TIME	62
5.5	ENGINEER INTERFACE SUB-SYSTEM	62
5.6	COMMUNICATION SUB-SYSTEM	66
5.7	OPEN SYSTEM CONNECTIVITY	69
5.8	TIME SYNCHRONISATION	72
5.9	SHUTDOWN SUB-SYSTEM -PLC	73
5.10	FOREIGN DEVICE INTERFACE	83
5.11	INTERFACE WITH SMART TRANSMITTERS	83
5.12	HARD WIRED INSTRUMENTATION	84
5.13	INSTRUMENT ASSET MANAGEMENT SYSTEM (IAMS)	85
5.14	ALARM INFORMATION MANAGEMENT SYSTEM (AIMS)	87
5.15	UNIT HISTORY NODE (UHN)	95
5.16	SEQUENCE OF EVENT RECORDER (SER)	99
5.17	LARGE SCREEN	100
6.0	MISCELLANEOUS REQUIREMENTS	101
6.1	SAFETY REQUIREMENTS	101
6.2	POWER SUPPLIES AND DISTRIBUTION	103

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 7 OF 137		
6.3	EQUIPMENT ASSEMBLY	105		
6.4	EARTHING	112		

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 8 OF 137		


## GENERAL

### 1.1 SCOPE

1.1.1 This specification, together with the data sheets attached herewith defines the minimum functional requirements for the design; hardware, software and firmware specifications, nameplate marking, testing and shipping of Distributed Control System designed for reliable effective and optimum control and monitoring of a process plant .

1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the purchaser's enquiry:-

AG-181	Foundation Fieldbus System Engineering Guidelines
EN 10204	Inspection Documents for Metallic Products.
EN 50039	Intrinsically Safe Electrical System
IEC 60079	Electrical Apparatus for Explosive Gas Atmosphere.
IEC 60529	Degree of Protection Provided by Enclosures.
IEC 60617	Graphic Symbols for Electronic Diagram
IEE 4	Guidelines for Documentation of Computer Software for Real time and Interactive Systems
FF – 569	Foundation Fieldbus Host interoperability support test procedure
FF – 816	Foundation Fieldbus Specification 31.25 Kbits/s Physical Layer Profile
FF – 890~894	Foundation Fieldbus Specification Function Block Application process
ANSI / ISA TR 99.00.01	Security Technologies for Manufacturing and control system
ANSI / ISA TR 99.00.02	Integrating Electronic Security into the manufacturing and control systems environment
EEMUA 191	Alarm System, a guide to design, management and procurement
IS-3043	Code of Practice for Earthing
IS 13947	Degree of Protection provided by Enclosures for low voltage switchgear and control gear
IS 13948	Flameproof Enclosures of Electrical Apparatus
ISA	S 71.01 Environmental Conditions for process Management and Control System : Temperature and Humidity
	S 71.04 Environmental Conditions for Process Measurement and control System: Airborne Contaminants
	S 5.2 Binary Logic Diagrams for Process Operations
	S 5.3 Graphic Symbols for Distributed Control System Display Instrumentation, Logic and Computer System.
	S 5.4 Instrument Loop Diagram


	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 9 OF 137		

	S 5.5	Graphic Symbols for Process Display	
	S 18.1	Annunciator Sequences and Specifications	
	S 50.2	Fieldbus Standard for use in Industrial Control System	
IEC 61000-4-3	Electromagnetic Compatibility (EMC) – Testing and Measurement Techniques – Radiated Radio Frequency, Electromagnetic Field Immunity Test.		
IEC-61000-4-4	Electromagnetic Capability (EMC) – Testing and measurement techniques – Electrical fast transients / bust immunity test		
IEC-61000-4-5	Electromagnetic Compatibility (EMC) – Testing and Measurement techniques – Surge immunity test		
IEC-61000-6-2	Electromagnetic Compatibility (EMC) – Generic Standards – Immunity for Industrial Environments		
IEEE 472	Electrical Surge protection		
IEC-60584	Thermocouple (Tolerances)		
IEC-60751	Industrial Platinum Resistance Temperature Sensors		
ANSI MC 96.1	Temperature Measurement Thermocouples		
IEEE 802.3	Telecommunication and Information exchange between Systems – Local and Metropolitan Area networks – specific requirements – Part 3 : Carrier Sense Multiple access with collisions Detection (CSMA / CD) Access Method and Physical layer specification.		
IEC 61508	Functional Safety of Electrical / Electronic / Programmable Electronic Safety related Systems.		
IEC 61131	Programmable Controllers		
IEC 61511	Functional Safety – Instrumented System for Process Industry Sector		IEC
61158	Fieldbus Standard for use in Industrial Control Systems.		

1.1.3 In the event of any conflict existing between this specification, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

- a) Design Basis / Statutory regulations
- b) Data Sheets
- c) Standard specifications
- d) Codes and standards


1.1.4 In addition to meeting purchaser's specifications in totality, vendor's extent of responsibility shall also include the following:

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 10 OF 137		

- a) Purchaser's data sheet specify the minimum acceptable functional requirements for the control system. It shall be vendor's responsibility to select proper hardware, software and firmware to meet the specified functional requirements.
- b) Purchaser's data sheets specify the scan time / cycle time / response time / macro cycle time and loading requirements. Vendor shall be responsible for sizing and selecting their standard product i.e. hardware, software and firmware to meet the requirements specified in the purchaser's data sheets.
- c) Selection of proper and adequate hardware, software and firmware to meet architectural requirements specified in the purchaser's specifications, keeping the integrity of functional blocks specified in the configuration diagram attached with the material requisition.
- d) Segment design based on requirements specified in the job specifications and its validation during site testing and pre-commissioning.
- e) Adequacy of Bill of material selected to meet purchaser's requirements. Vendor to note that bill of material shall not be verified by the purchaser during evaluation stage. Any hardware, software and firmware required to meet the purchaser's specified requirements shall be provided by the vendor without any implication.
- f) Providing adequate mandatory spares including consumable spares as specified in the purchaser's specifications. Vendor shall be responsible to meet mandatory spare requirements specified by the purchaser.

## 1.2 Bids

- 1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to vendor attached with the material requisition.
- 1.2.2 Whenever a detailed technical offer is required, vendor's quotation shall include the following:
  - a) Compliance to the specifications.
  - b) Detailed specification sheets for each sub-system. The specification sheet shall provide information regarding hardware specifications, software specifications, redundancy requirements, capacity, power consumption etc. of the distributed control system and its accessories. The material specifications and unit of measurement for various items in vendor's specification sheets shall be to the same standards as those indicated in purchaser's data sheets.
  - c) System security features and design details
  - d) Proven references for each offered model in line with clause 1.2.4 of this specification whenever specifically indicated in the purchaser's specifications.
  - e) A copy of approval for flameproof enclosure, intrinsic safety etc whenever specified, from local statutory authority, as applicable, like Petroleum and Explosive Safety Organisation (PESO) / Chief Controller of Explosives (CCE), Nagpur or Director General of Mines Safety (DGMS) in India along with;

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 11 OF 137		

- i) Test certificate from recognised house CIMFR (Central Institute of Mines & Fuel Research) / ERTL (Electronics Research and Test Laboratory) etc. for specified protection class as per relevant Indian Standard for all Indian manufactured equipments or for equipments requiring DGMS approval.
- ii) Certificate of conformity from agencies like LCIE, BASEAFA, PTB, CSA, UL etc., for compliance to ATEX or other recognised standards for all equipments manufactured outside India.

- f) Deviations on technical requirements shall not be entertained. In case vendor has any valid technical reason to deviate from the specified requirement, they must include a list of deviations item wise, summing up all the deviations from the purchaser's data sheets and other technical specification along with the technical reasons for each of these deviations.
- g) FMEDA report and calculations for probability of failure on demand to meet specified SIL requirements (e.g. SIL3).
- h) Catalogues giving detailed technical specifications, model decoding details and other related information for each item / sub-system covered in the bid.

1.2.3 Vendor shall offer only their standard proven product i.e. hardware, system software and firmware, which shall be configured to meet the functional requirements specified in the material requisition. Whenever any bought out item is offered to meet the configurational requirements specified in the material requisition, it shall also meet the functional requirements. Moreover, the equipment being offered / supplied shall be of latest proven version available in the current manufacturing range and meeting the requirements specified in clause 1.2.4 of this standard specification.


1.2.4 The system hardware, software and firmware as offered, shall be field proven and should have been operating satisfactorily for a period of minimum 4000 hours continuously on the bid due date in the validly similar size and application specified in the purchaser's data sheet. Items with prototype design or items not meeting provenness criteria specified above shall not be offered or supplied.

1.2.5 The detailed scope of work, specific job requirements, exclusions, deviations, additions etc. shall be indicated in the job specifications which shall be part of material requisition.

1.2.6 Whenever specified, vendor shall furnish tested values of failure rates, probability of failure on demand and test intervals for safety integrity level analysis.

1.2.7 All documentation submitted by the vendor including their quotation, catalogues, drawings, installation, operation and maintenance manuals shall be in English language only.


1.2.8 Vendor shall also quote for the following;

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 12 OF 137		

- a) Two year's operational spares for each sub-system and their accessories which shall include the following as a minimum;
  - i) All type of electronic modules e.g I/O modules, processor modules, communication modules, memory modules, disc controller module, power supply modules etc.
  - ii) All type of auxiliary items e.g. barriers / isolators, hardwired instruments, annunciator modules, receiver switches, trip amplifiers, temperature element converters etc.
  - iii) Switches, lamps, fuses, connectors, terminals, pre-fabricated cables, circuit breaker, relays etc.
  - iv) Video display units, keyboards, disc drives, PC's, network items (e.g. switches, hubs etc.) etc.
- b) Any special tools and test equipments needed for the maintenance of DCS, PLC's and other items being offered by vendor. This shall also include test equipments for fieldbus testing and configuration like fieldbus tester, fieldbus configurator etc. wherever specified in the data sheets. Vendor must confirm in their offer if no special tools or test equipments are needed for maintenance other than those specifically indicated in purchaser's data sheet.

### **1.3 Drawing and Data**

- 1.3.1 Detailed drawings, data, catalogues and manuals required from the vendor are indicated by the purchaser in vendor data requirement sheets. The required number of producibles, prints and soft copies shall be dispatched to the address mentioned, adhering to the time limits indicated.
- 1.3.2 Final documentation consisting of design manuals, installation manual, operation and maintenance manual etc., submitted by the vendor after placement of purchase order shall include the following, as a minimum:
  - a) Specification sheet for each sub-system, auxiliary instrument and bought out item.
  - b) Certified drawings for complete system including;
    - i) GA drawings for panels, cabinets, marshalling racks, hardwired consoles, operator / engineering console etc with complete dimensions details, internal construction and weight in kilograms.
    - ii) Control room e.g. console room, rack room and engineering room layout with all dimensions in millimeters.
    - iii) Channel base drawing for console room, rack room and engineering room.
    - iv) Input / output assignment

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 13 OF 137		

- v) Fieldbus segment drawing
- vi) Loop wiring diagram
- vii) Power supply distribution single line diagram
- viii) Dynamic graphic diagrams
- ix) System grounding drawing
- c) Design manuals and functional design specifications which shall include hardware design manual, software design manual and special software specifications.
- d) Copy of type test certificates.
- e) Copy of test certificates for all tests indicated in Part II of this specification.
- f) Installation manual containing installation procedure for distributed control system and other items covered in the material requisition.
- g) Power-on, start-up and internal testing procedures.
- h) Software debugging and system configuration procedures
- i) Calibration and maintenance manual containing maintenance procedures including replacement of parts, application modification etc.
- j) Any other drawings and documents specifically indicated in job vendor data requirement enclosed with the material requisition.

## 2.0 DEFINITIONS

The various terms used in this specification are defined as follows:


### 2.1 Distributed control system

The class of control systems which in addition to maintaining and managing data bases in distributed fashion also executes the stated control functions and permits transmission of control, measurement and operating information to and from a single or a plurality of user specified locations connected via a communication sub-system.

### 2.2 Programmable Logic Controller

The class of control systems which can be programmed to execute plant shutdown and / or interlock / sequence logics to the specified safety integrity levels.



	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 14 OF 137		

### **2.3 Accessible**

A system feature that is viewable by and interactive with the operator and allows the operator to perform user permissible control action e.g. set point change, auto-manual transfers or on-off actions.

### **2.4 Assignable**

A system feature that permits an operator to direct a signal from one device to another without the need for change in wiring, either by means of switches or via other data entry devices like key board commands to the system.

### **2.5 Configurable**

A system feature that permits selection through entry of key board commands or commands from other data entry devices of basic structure and characteristics of a device or system, such as control algorithm, display format or I/O termination.

### **2.6 I/O**

Input / Output with respect to process / operator.

### **2.7 Fieldbus**

Fieldbus is a digital two-way multi drop communications link among intelligent measurement and control devices.

### **2.8 System Size**

System size shall be defined as maximum number of process inputs or tags those can be connected to the system and viewable from any one of the VDUs of an operating console in all hierarchical displays without changing the configuration or without operator interaction considering;

- a) all inputs as close loops
- b) all inputs as open loops

### **2.9 Operator console**


Operator console is the operator's main plant interface device via which operator can view, monitor and control the plant and can give instructions to peripherals to execute commands, and shall have protective access to configure and maintain the system.

### **2.10 Engineering console**

Engineering console shall be the engineer's main interface device via which engineer can configure and maintain the system, and shall have protective access to monitor and control the plant, give instructions to peripherals to execute commands,.

### **2.11 Local Level**

All those sub-systems, which directly interface with field devices shall be referred to as local level.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 15 OF 137		

## **2.12 Central Level**

Operator consoles and Engineering Console, which present data acquired from local level devices shall be referred as Central Level.

## **2.13 Data base**

Database shall be defined as the information stored temporarily or permanently in the system which can be accessed by various programs to meet all its functional requirements.

## **2.14 Global Database**

Global database is defined as the database that can be accessed by two or more non-nested modules of a program without being explicitly passed as parameters between the modules.

## **2.15 Loop integrity**

A system shall be said to have loop integrity if the failure of one component in the system/ sub-system does not affect more than one loop.

## **2.16 Interchangeability**

System/sub-systems shall be said to have full interchangeability if the functions and information available on one system/sub-system shall also be available on the other in totality.

## **2.17 System Loading**

System loading for a sub-station is defined as the percentage of time a sub-system spends in carrying out various activities referred to the use of memory, CPU time and communication capacity in the worst case of high sub-system operation out of the designed / designated cycle time of the sub-system.

## **2.18 Bus-degradation**

Bus-degradation shall be defined as a change in the system performance from the specified one measured in terms of display update rate while loading the communication sub-system from 10 through 100 percent.


## **2.19 Redundancy**

A system component shall be termed as redundant if it takes over automatically the operation in the event of the failure of the main component without causing any interruption in the system and upsetting the process. The repaired or replaced device shall be brought in-line only through operator action without upsetting system operation.

## **2.20 Switchover Time**

Time required for a back up instrument / system to come on-line automatically in case of the failure of the main instrument / system.

## **2.21 Processor Cycle Time (Tpc)**

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 16 OF 137		

Processor cycle time is the measure of the processing speed of a processor and is user selectable from the pre-defined discrete values. Processor cycle time for a sub-systems shall be defined as follows:-

a) Controller Sub-system

Processor cycle time for controller sub-system shall be defined as the total time taken by the control processor to read inputs supplied by input module, execute control algorithm and write the outputs for the output module.

b) Data acquisition sub-system

Processor cycle time for data acquisition sub system shall be defined as the total time taken by the processor to read inputs supplied by input processor, perform calculations for all the open loops configured within the data acquisition sub-system and make data available to the communication sub-system.

c) Programmable logic controller

Processor cycle time for programmable logic controller shall be defined as the total time taken by the processor to read input supplied by input module, execute all computations (analog as well as logic as configured) and write the outputs for the output module.

## 2.22 Scan time (ts)

Scan time is the end-to-end response time of a sub-system and shall be defined as follows:

For fieldbus based system refer clause 2.25 for close loop response time.

a) Close-Loops


Scan time for a close-loop shall be defined as the total time taken by a sub-system e.g. controller and data acquisition sub-system to read inputs from the input terminal, process input, perform control algorithms, update control output and write output at the output terminal for all the loops configured within the sub-system.

b) Open-Loops

Scan time for an open loop shall be defined as the total time taken by a sub-system e.g. controller and data acquisition sub-system to read input from input terminal, process input, perform calculations and write output for communication sub-system to pick-up the same for all the open loops configured within the sub-system e.g. controller and data acquisition sub system.

c) Logic Loops

The scan time for a logic loop shall be defined as the total time taken by a sub-system e.g. programmable logic controller to read input from the input terminal, process input, execute logic, updating logic output and write output at the output terminal for all the logics configured within the subsystem.

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 17 OF 137		

### **2.23 Control Cycle time**

Control cycle time is defined as the total cycle time taken by the supervisory computer to read data from control system, perform calculations and update the set point of a regulatory loop configured in the control system e.g. controller and data acquisition sub-system.

### **2.24 Macro Cycle**

Macro cycle is defined as a single iteration of a schedule within a fieldbus device.

### **2.25 Macro Cycle Time**

Macro Cycle time or execution time is defined as the amount of time taken by a fieldbus device to complete the macro cycle. Macro cycle time can refer to a single field device, the LAS or a complete segment made up of multiple devices.

### **2.26 Loop Response Time**

Loop response time for fieldbus based system shall be defined as the total time required to perform the following functions in each of the specified loop configuration;

#### **a) Control function in transmitter**

Execute the analog input and control (PID) function block in transmitter, publish the output on the fieldbus, receive the controller out value and perform analog output function block in final control element.

#### **b) Control function in final control element**

Execute the analog input function block in the transmitter, publish the process variable on the fieldbus, receive the process variable and execute the control algorithm (PID) and analog output function block in the final control element.

#### **c) Control Function in DCS**

Execute the analog input function block in the transmitter, publish the process variable at DCS, execute the control algorithm (PID) in DCS, publish the controller output value on the fieldbus and execute the analog output function block in the final control element.


### **2.27 Display update rate**

Display update rate shall be defined as the time taken by the system to display the information present at the system input terminals updated on the current display on the VDU of an operator console

### **2.28 Call-up time**

Call up time shall be defined as the time taken by the system to display a particular display/data on the VDU after getting the corresponding command from the operator.

### **2.29 User's memory**

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 18 OF 137		

Free memory space available after utilisation of memory required for system operation, configuration and implementation of application and other system related functions for implementation of user defined specific programs such as plant calculations, process optimization or MIS (like free formatting of certain logs). The programs shall either be written in high level language or system specific language.

### **2.30 Event**

An event shall be defined as any action taken by the operator via operator keyboard or switches on hardwired console like change of set point, change of control mode, start/stop of motor, open/close of shut down valves, alarm acknowledge etc.

### **2.31 Sequence of Event (SOE)**

Arranging events in the sequence of their occurrence in time with a specified time resolution by a program is defined as sequence of event.

### **2.32 Sequence of Event Recorder (SOR)**

System of sub-system which presents and / or records the events in the sequence of their occurrence in time with a specified time resolution utilizing its hardware and software capabilities is termed as sequence of event recorder.

### **2.33 Real time trend**

Real time trend shall be defined as a continuously progressing graphical record showing continuously updated parameter with most recent value and a past record of minimum of 10 minutes without depressing any additional key for moving backward in time.

### **2.34 Windowing**

Ability of software program to break the console screen i.e. video display unit into simultaneous or overlapping zones with separate presentations at the same time.

### **2.35 Interoperability**


Interoperability is the capability to substitute a device from one manufacturer with that of another manufacturer as a fieldbus network without loss of any functionality or degree of integration.

### **2.36 Acyclic Period**

Acyclic period is defined as the portion of communication cycle time during which information other than publish / subscribe data is transmitted.

### **2.37 Capabilities File**

A capabilities file describes the communication objects in a fieldbus device. A configuration file can use DD files and capabilities files to configure a fieldbus system without having the fieldbus device active.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 19 OF 137		

### **2.38 Link Active Scheduler (LAS)**

LAS is defined as a deterministic centralised bus scheduler that maintains a list of transmission times for all data buffers in all devices that need to be cyclically transmitted.

### **2.39 Link Master**

Any device containing the link active scheduler personality that can control communication of a H1 fieldbus segment is designated as link master.

### **2.40 Segment**

Segment is defined as a network or part of network that serves as the primary communication highway for the connected field-bus devices.

### **2.41 Resource Block (RB)**

Resource block describes the characteristics of a fieldbus device such as device name, manufacturer and its serial number. Resource block is unique for a device.

### **2.42 Vertical Communication Relationship (VCR)**

VCR is defined as the pre-configured application layer channels which provide the data transfer between applications. Publisher – subscriber, client – server and report distribution are three VCRs in foundation fieldbus.

### **2.43 Link Objects**

Link object contains information to link function block input / output parameters in the same device and between different devices.

### **2.44 Plant Control Network**

Communication network within a plant that has control information circulating between various plant units or processing locations.

### **2.45 Plant Information Network**

High-level communication network which serves various user's within a plant and transfer information for the purpose of unit / plant monitoring. This network is different than control network and is generally realised using open communication protocol network e.g. OPC etc.


### **2.46 OPC node**

OPC node is any node in the network that provides OPC interfaces consistent with OPC data access, OPC alarm and event and OPC historical data access interface specifications certified against OPC compliance and interoperability test specification.

### **2.47 Computer Integrated Manufacturing (CIM)**

Computer integrated manufacturing shall be defined as the integration of process, plant and business operations made possible through information network.

## **3.0 SPARES PHILOSOPHY**

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 20 OF 137		

3.1 The system including programmable logic controller, alarm information management system, sequence of event recorder, hardwired instruments etc. shall meet the following spare philosophy. This philosophy shall also be applicable for items like field-bus accessories, barriers, relays, terminals, lamps, push buttons etc.


### 3.1.1 Mandatory Spares

Vendor shall include following mandatory spares in their scope of supply;

#### 3.1.1.1 Installed Engineering Spares

Installed engineering spares shall be provided in each sub-system for each type of module to enhance the specified system functional requirements by 20%. The basic of offering installed engineering spares shall include;

- a) For a system with conventional and / or smart input / output, 20% spare input / output of each type shall be considered for calculating I/O modules and all other related accessories.
- b) For a system with fieldbus input / output, 20% spare segments of each type of field-bus type (foundation fieldbus, profibus etc.) shall be considered for calculating I/O modules, power supply modules and all other related accessories. When only input / outputs are indicated instead of field-bus segments, the installed spare philosophy as specified in 3.1.1.1 (a) shall be followed.
- c) For all serial input / outputs to the system 20% spare serial I/O channels of each type of serial input / output shall be provided.
- d) A minimum of one spare I/O module of each type as offered to meet type of inputs / outputs specified in the material requisition.
- e) 20% spare accessories like relays, switches, lamps, fuses, circuit breakers, barriers, isolators, terminals etc.
- f) A minimum of one number of input / output module and accessories of, each type such as analog input / output, discrete (contact) input / output, pulse input, serial input / output, foundation fieldbus / profibus PA input / output modules (in case of fieldbus based system) temperature input shall be provided irrespective of those required as per 3.1.1.1(d) as engineering spare.
- g) The engineering spares shall be wired up to the field cable interface and shall be in ready-to-operate condition when field cable is connected to spare assigned terminals.
- h) Spare pairs of the incoming cables shall be terminated on spare terminals in the marshalling / barrier cabinets as applicable.
- i) The system shall be fully engineered considering 20% installed engineering spares including processor loading.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 21 OF 137		

### 3.1.1.2 Spare Space Requirement

In addition to installed engineering spares specified in Clause 3.1.1.1 of this specification, the system shall be provided with following spare space;

- The controller and data acquisition racks shall have 10% usable spare space for installing additional I/O and field-bus segment modules in future. However, the control and data acquisition processor shall have additional 10% capacity to handle these I/O's and field-bus segment. In addition, internal wiring for the same shall be completed up to I/O terminals.
- Each operator console shall contain 10% usable spare group and related display capability in addition to as specified in para 3.1.1.1 of this specification.
- The system shall have capability to extend its historical trending, logging and user's memory by 20% to meet future expansion with/without adding additional memory modules.
- I/O racks of programmable logic controller shall have 10% usable spare space for installing additional I/O cards of each type in future. However internal wiring for the same shall be connected up to the I/O terminals.
- Processor system of programmable logic controller shall have capability to execute additional 20% logics.
- The communication sub-system shall have sufficient capacity to handle additional data contributed by addition of 20% I/O / segments over and above installed engineering spares
- Usable spare space in panels and cabinets to install 10% spare hardwired items like barriers, trip amplifiers, receiver switches, panel mounted instrument, relays etc. in future.


### 3.1.1.3 Spare Memory Requirement

- The system shall be provided with a minimum of 40% spare memory capacity, as required for application program and data base to meet specified functional requirements.
- For field-bus based system, spare memory capacity (and CPU loading) shall be calculated considering all control algorithms being configured in the system and executed at the scan time equal to the specified control loop response time.
- It shall be possible to extend the memory by at least 20% over and above the actual requirement at a later date.

### 3.1.1.4 Spare Software Capability

- Sufficient additional software capacity shall be available in the system to take care of spares requirement as specified in para 3.1.1.1 and 3.1.1.2(a) to (f) of this specification to meet all functional requirements as per para 5.0 of this specification.



 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR <b>DISTRIBUTED CONTROL SYSTEM &amp; PLC SYSTEM</b>	GSTD-0201	1	
			Rev	
		SHEET 22 OF 137		

- b) Unless specifically indicated otherwise, the offered system shall have software licenses to cover all the tag numbers indicated in the material requisition, including installed engineering spares and spare space indicated in clause 3.1.1.1 and 3.1.1.2 of this specification.

### **3.1.1.5 Predefined Mandatory Spares**

- a) Mandatory spares shall be ware-house spares and shall be supplied as loose items.
- b) Mandatory spare module of 5% or one module of each type, whichever is higher, must be supplied for each type of modules being used including in consoles.
- c) For items like hardwired instruments, assignable recorders, Personnel computers, VDU / video screens, keyboards, disc drives, RAID controller, lamps, network components, barriers, fuses and circuit breakers complete item limited to 5% or minimum one of each type shall be supplied as predefined mandatory spare. But this shall not include hardware like discs, terminals, switches, telephone sets etc.
- d) Items like personnel computers, operator consoles servers, engineering consoles etc. where complete item needs replacement instead of individual modules, complete unit shall be supplied as mandatory spares in line with clause 3.1.1.5(b).
- e) Software which need to be separately loaded in the items specified in clause 3.1.1.5(d) above to define the items personality and can't be uploaded from engineering console or any other network device shall be supplied along with additional software.

### **3.1.1.6 Consumable Spares**

Any paper, ribbon, printer heads and ink required for printers, assignable recorders, video copier or any other consumable item shall be supplied along with system required for minimum of six months duration after system acceptance.

### **3.1.1.7 Commissioning Spares**

Unless otherwise specified, vendor shall be responsible to supply all spares which are found necessary to replace failed modules, failed sub-systems, or corrupted / faulty softwares while performing pre-commissioning and commissioning activities.


### **3.1.2 Two years operational spares**

Two years operational spares shall be as per Clause 1.2.8(a) of this specification and shall be quoted separately.

## **4.0 SYSTEM CONFIGURATION**

The system configuration shall consist of the following major sub-systems:-

### **4.1 Controller and Data acquisition sub-system**

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 23 OF 137		

Controller and data acquisition sub-system is the main field interface sub-system and is capable of performing control and data acquisition functions as one integrated sub-system.

Controller and data acquisition sub-system shall interface with field instrumentation like transmitters, process switches and final control elements to monitor and / or control process parameters like flow, temperature, level etc. The sub-system shall include a comprehensive set of control algorithms and auxiliaries to provide close loop control and data monitoring capability of the system.

#### **4.2 Operator interface sub-system**

Operator interface sub-system shall consist of one or more operator consoles for monitoring and controlling process parameters and performing other process related functions.

#### **4.3 Communication sub-system**

Communication sub-system interconnects various sub-systems over which they can communicate with each other to meet all functional requirements.

#### **4.4 Engineer interface sub-system**

Engineer interface sub-system shall consist of an engineering console primarily for tuning, configuring and maintaining the system.

#### **4.5 Supervisory computer sub-system**

Supervisory computer, when specified, shall be employed for providing supervisory level plant control, plant and unit optimization and other computer based plant management capabilities. For the Integrated network , each node where history resides should be minimum RAID-5 configuration to ensure maximum availability of history or otherwise separate redundant Servers in RAID-5 configuration and redundant power supply configuration should be provided

#### **4.6 Programmable Logic Controller**


Plant start up and safety shutdowns shall be performed by separate programmable logic controller which shall communicate with other sub-systems over the communication sub-system.

#### **4.7 Foreign Device Interface**

Foreign Device like programmable logic controllers, gas chromatographs, analyzer systems, gas turbine systems etc. when specified shall communicate with other subsystems over the communication sub system for plant monitoring and control using foreign device interface. The foreign device interface shall be either dedicated or shall be part of controller data acquisition sub-system as specified in the job requirements.

#### **4.8 OPC Server**

OPC Server when specified in this specification is used as synonymous with any server entity on the communication sub-system network which shall allow the user to implement applications, within or

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 24 OF 137		

outside the system, without providing any special drivers or custom interfaces. OPC server, when specified, shall be used to transfer / receive data to / from applications run in other systems.

#### **4.9 Unit History Node**

4.9.1 Unit history node, when specified, shall store the long term historical data of the complete unit and shall interact with central computer system over plant wide network. In addition every history residing node should be minimum RAID-5 configuration.

4.9.2 Unit history modem, when specified shall be a dedicated node and shall be in addition to historical data required for normal plant operation (specified as part of operating interface sub-system).

#### **4.10 Sequence of Event Recorder (SER)**

Sequence of event recorder, when specified, shall be a dedicated equipment which shall identify, store and print alarms with the specified time resolution. SER may also transfer data to operator sub-system over communication sub-system.

#### **4.11 Documentation node (DON)**

Documentation node, when specified, shall be a node on the information network sub-system and shall store unit documentation.

#### **4.12 Alarm Information and Management Sub-system (AIMS)**

Alarm information and management sub-system when specified, shall be a alarm management package which shall gather alarm information from various sub-systems and shall present the desired meaningful analysed data for information and further analysis.

#### **4.13 Instrument Asset Management System (IAMS)**


Instrument asset management sub-system shall acquire store, analysed and present meaningful diagnostic and maintenance related data of field devices for efficient plant maintenance.

#### **4.14 Large Display System (LDS)**

Large Display System, when specified, shall consist of one or more large video screens which shall display either operator selected operator console screen or any pre-selected screen on a back projected large video screens as real time basis.

#### **4.15 Hardwired Instrumentation**

Hardwired instrumentation shall be provided as a back up to the distributed control system for critical process parameters when specified in the job specification.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 25 OF 137		

#### 4.16 Information Network Sub-system

4.16.1 Information network when specified shall interconnect with various plant wide systems like distributed control system/systems, mainframe computers, personal computers, laboratory information and management system (LIMS) etc over which any information can be exchanged without affecting and disturbing the plant control and operations.

### 5.0 DESIGN AND CONSTRUCTION

#### 5.1 Design Requirements

5.1.1 The system shall be microprocessor based having functional distribution and data base distribution sub-system wise. The system design shall ensure that;

- All the functions defined in this specifications are performed in an integrated manner
- The access to the distributed data base is available system-wide.

This system shall also have networking capability with other systems distributed geographically in the various units of a plant, over a plant wide information network such as Ethernet or other industrially recognised open networks.

5.1.2 The system shall be of modular construction and expandable in future by adding additional modules. The type of modules shall be kept to the minimum possible in order to have interchangeability and low inventory.

#### 5.1.3 System Availability


- The system shall be designed 'fault avoidant' as a minimum by selecting high grade components of proven quality and proper design of system electronics.

Redundancy shall be provided, as per this specification as a minimum, to improve the system availability and reliability. Due considerations shall be given to the environmental conditions particularly for field mounted sub- system, if specified in job specifications, during system design.

- The system shall have a high MTBF value and shall have well proven record of operating in hydrocarbon plants.
- The system shall be designed with 99.995% or greater availability. The availability shall be defined as follows;

$$\text{Availability} = \frac{\text{Meantime Between Failure (MTTF)}}{\text{MTTF} + \text{Mean time to repair (MTTR)}}$$

For the purpose of calculations, consider mean time between repairs as four (4) hours unless the manufacturer recommends higher value for MTTR. It is therefore necessary that;

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 26 OF 137		

- i) Vendor covers all necessary spare parts in 2 years recommended operational spares which shall be necessary to meet specified MTTR time.
- ii) Vendor provides adequate training to owner's personnel and cover all necessary maintenance related topics in their training programmes to ensure specified MTTR time.

#### 5.1.4 Operating Environmental Conditions


##### 5.1.4.1 Environmentally controlled location installation

- a) All subsystem of Distributed Control System located in control room, Local Control Room or in Satellite Rack room shall be able to operate satisfactorily from 15°C to 30°C and 20% to 80% non condensing humidity.
- b) In addition to above, all such sub-systems shall also be able to operate satisfactorily in case of air conditioning failure with ambient temperature of 50°C and 90% non-condensing humidity until the system safe operating limits are exceeded. The minimum period of continuous operation shall be 48 hours at least once in a month without any damage or degradation of system performance. Vendor, therefore, shall provide continuous temperature monitoring for each enclosed cabinet housing items / equipments generating heat, such as system cabinets, barrier cabinets, relay cabinets etc and also provide alarm for operator alert in case the safe operating temperature limits are exceeded. Alarm in the operator consoles shall be available for each cabinet while group alarms shall be provided on hardwired annunciator located on hardware console.
- c) Chemical filters have been provided in the incoming air conditioning air to limit the concentration of contaminants below following limits

Contaminants (Corrosive Gases)	Concentration
SOx	<10ppb
Nox	<5ppb
H2S	<5ppb
Cl2	<10ppb
SPM	<0.2gm/m3

All sub-systems and system components shall be suitable for operating continuously in the above mentioned corrosive environments.

- d) Vendor shall provide continuous corrosion monitoring system consisting of transmitter with 4 – 20mA output and switch unit with setting as per contaminant level exceeding limits specified in clause 5.1.4.1(c) of this specification. Unless otherwise specified the number of corrosion monitors shall be as follows;

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR <b>DISTRIBUTED CONTROL SYSTEM &amp; PLC SYSTEM</b>	GSTD-0201	1	
			Rev	
		SHEET 27 OF 137		

<b>Equipment Type</b>	<b>Room Type</b>	<b>Quantity</b>
Corrosion Transmitter	Rack Room / Satellite	1 No.
	Rack Room	
Corrosion Switch Unit	Rack Room / Satellite	3 Nos.
	Rack Room	
	Console Room	1 No.
	Engineering Room	1 No.

Continuous corrosion monitoring trend and alarms shall be provided on the operator console while one group alarm shall be provided on the hardwired annunciator located on the hardwired console.

#### 5.1.4.2 Outdoor Installations

- Sub-systems or system components which are installed outdoor shall be able to continuously operate at ambient temperature of 50°C and non-condensing humidity of 90%.
- Unless otherwise specified, all sub-systems or system components installed outdoor shall have corrosive environmental protection coating meeting the environmental classification class G3 as per ISA-S71.04.

#### 5.1.5 Transient, Static and EMI / RFI Protection


##### 5.1.5.1 The system shall be internally protected against system errors and hardware damage resulting from:

- Electrical transients on power wiring
- Electrical transients on signal wiring
- Connecting and disconnecting devices or removing or inserting printed circuit boards in the Distributed Control System (DCS) and Programmable Logic Controller (PLC).

5.1.5.2 All sub-systems and system components shall be capable of accepting various signal inputs for its direct use while preventing noise errors due to electromagnetic interference (EMI) or radio frequency interference (RFI) including nearby radio stations, hand held two way radios, electrical storms, solenoids, relays or contactors carrying heavy currents as per levels of Environmental electromagnetic phenomenon defined in IEC-61000-6-2. The system shall have total noise immunity from UHF / VHF radio communication equipments (RFI) and (EMI) noise generating equipments as per IEC-61000-4. The surge withstand capability for input/output modules shall be as per IEEE standard 472.

5.1.5.3 System cables for interplant, inter unit, and others routed in the field, the level of surge immunity required for equipment signal ports shall be increased to level 4 as defined in IEC-61000-4-5 and the system shall operate according to performance criterion B as defined in IEC-61000-6-2.

#### 5.1.6 On-line replacement

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 28 OF 137		

5.1.6.1 On-line replacement of electronic module shall be possible in such a way that removal and addition of an I/O module shall be possible and safe without de-energising the system. Furthermore, there shall not be any interruption of the system while replacing a faulty module wherever redundant modules are provided.

5.1.6.2 Apart from system modules, power supply units shall be replaceable on-line without disrupting the process and without effecting the system redundancies.

#### 5.1.7 Electrical Isolation

Galvanic or optical isolation shall be provided for all field signals. The isolation levels shall be as follows;

Analog I/o channel to system ground : 1500 VAC

Discrete I/o channel to system ground : 500 VAC

Isolation shall also be provided between Engineering / operator console/PLC programming terminal and related sub-systems connected to it if there is any possibility of high voltage being transmitted to the sub-systems.

#### 5.1.8 Design Requirements of Equipments in Hazardous Area

5.1.8.1 Unless specifically indicated, the field devices are beyond the scope of this specification. However vendor shall be fully responsible for integrating these devices with their system including compiling and maintaining the engineering data base of these devices and incorporating the data base into the Asset Management System.

##### 5.1.8.2 General Requirements

- Unless otherwise specified, all instruments in hazardous area shall be intrinsically safe type. Other concepts shall be used when specified.
- For conventional instrumentation, entity concept shall be used for selecting proper barriers / isolators.
- Fieldbus segment in classified area may consist only of the type and number of devices which will not cause the segment current draw to exceed the rated barrier / isolator parameters.


##### 5.1.8.3 Fieldbus design in Hazardous Area

The segment design and equipment solution shall be based on the classified area concept used. The functions and entity / safety parameters of power conditioner, safety barriers / isolator, terminators and field devices shall be considered to verify the compliance to the requirements applicable for the specified concept. Following concepts shall be used depending upon the one specified in the job specifications;

##### a) Entity Concept

Certified entity / safety parameters of each device shall be used to match the entity parameters on entity concept.

##### b) FISCO

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 29 OF 137		

Certified FISCO parameters shall be used and shall be matched like entity parameters. All elements in the hazardous area and their interface module shall be certified FISCO.

c) FNICO

Certified FNICO parameters and equipment shall be used to design loop on the basis of FNICO.

d) Multi barriers

The safety barriers / isolators shall be installed in the field in an increased safety enclosure. The enclosure shall be metallic either of SS or of anodised aluminium. The entity / safety parameters shall be matched as in case of entity concept. Vendor's scope shall include barriers duly installed in the box / junction box.

### 5.1.9 Repeat Signals

#### 5.1.9.1 Unless otherwise specified in the job specifications, following philosophy shall be followed for repeat signals;

a) Whenever repeat contact outputs are required as per job specifications following philosophy shall be followed;

i) For intrinsically safe input contacts, isolating barrier with dual contact output shall be utilized.

ii) For all other contact inputs, repeat contact shall be provided using electro magnetic relays.

b) Whenever repeat analogue outputs are required as per job specifications, following philosophy shall be followed;

i) For intrinsically safe analogue inputs, isolating barrier with dual analogue outputs shall be utilized.


ii) For all other analogue inputs, repeat analogue outputs shall be provided using signal isolators with dual output.

### 5.1.10 System Integration

The distributed control system shall be a fully integrated control system , also the Shut Down System (Safety Instrument system(ESD)) and the Fire and Gas system should be fully integrated with the control system . Shut Down system and Fire and Gas system should not be integrated with the control system as or with serial/Foreign/third party device card , however engineering database and engineering tool of all the above three system should be separate, dedicated and independent of each other Foreign devices like analyser system, third party equipment, (like compressors etc) etc. shall be functionally integrated with the distributed control system. Functionally integrated system shall meet the following requirements, as a minimum;

a) The foreign devices shall either be configurable from DCS engineering consoles or from the dedicated engineering consoles of each foreign device.



	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 30 OF 137		

- b) Unless specifically indicated otherwise, each foreign device shall be integrated with DCS through MODBUS (RTU) protocol using redundant interface unit.
- c) Operator console shall display information in the similar fashion irrespective of source of information. Source of information shall be transparent to the operator.
- d) The process alarms and diagnostic alarms shall be presented on the operator console in the similar fashion as DCS alarms.
- e) Whenever specifically indicated, the time of all foreign devices shall be synchronized with DCS clock or GPS, as specified in the job specification.
- f) The data transfer to and fro from other distributed control systems or supervisory computers through information network shall utilize OPC protocol with adequate security.

#### 5.1.11 Surge Protection

5.1.11.1 Surge protection devices (SPD's) shall be provided on the system to limit the surge voltages reaching beyond the safe limits, under normal, abnormal or lightening strike condition. Unless otherwise specified, SPD's shall be provided at least at the following locations;

- a) All serial signal cables (UTP / STP / coaxial and not fibre optical) going from or to control system and from one location to another out side the control building at both ends.
- b) All fieldbus segments at control system end.
- c) All power incoming cable (220 V AC ) UPS or non UPS, at the power supply distribution cabinet.

5.1.11.2 The selection of type and rating of SPD shall be selected such that the introduction of this device shall not change the characteristics or reliability of an application, whether it is for the protection of power system, signal such as fieldbus or analog or communication signal, as applicable.

In case of fieldbus system, the SPR shall be selected such that its inclusion in the segment shall not degrade the fieldbus signal, maximum length of the segment and / or number of devices on a segment significantly.


#### 5.1.12 System Securities

5.1.12.1 The system shall have incorporated a fool proof system security feature in its design which would protect its data base and functioning against viruses, trojans and works through integrated anti virus, fire wall and intrusion detection for the system.

5.1.12.2 All devices and / or servers which interface and interact with external application must be supplied with hardware and software firewalls.

5.1.12.3 All the security protections, hardware or software, as offered shall provide protection against all sort of threats and vulnerabilities which include;

- a) Positive user authentication and login privileges.
- b) Prevention of importation of viruses.

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 31 OF 137		

- c) Packet filtering, content filtering, URL filtering protocol filtering and application level filtering to accept only intended data.
- d) Strict Access controls like password hash files, cryptographic material used in confidentiality etc.
- e) Hardening of operating system.
- f) Firewall proxy.
- g) Network sniffers and file integrity checkers
- h) Scanning, enumeration and vulnerability scanning tools.
- i) Log file analysis tools.

The functionalities indicated above are the indicative security features and shall be provided within and where data import / export utilities apply.

#### 5.1.13 System Software

5.1.13.1 The system software shall be governed by the operating system running in a real time mode and shall be able to meet all functional requirements specified in clause 5.2 of this specification as a minimum. Any other standard/special software package, if available, shall also be offered describing the full capabilities.

5.1.13.2 The operating system and other standard softwares (e.g. OPC foundation fieldbus etc.) shall be of latest version.

5.1.14 The system shall have the capability of detecting the open sensors and short sensor. The sensor status reading on failure either upscale or downscale shall be field configurable.

#### 5.1.15 Emergency Switches (ESD Switches)

5.1.15.1 All Emergency (ESD) switches shall be hardwired and shall preferably pull type with red coloured knob. Control room mounted ESD switches shall be installed on hardwired console.


5.1.15.2 ESD switches shall directly trip the final ESD element without any intermediate device. Where multiplication of ESD switch contacts is necessary fail safe relays shall be utilized (SIL3).

5.1.15.3 In addition to utilizing contacts for direct shutdown, the contacts shall also be used in ESD system (PLC etc) for logic implementation and event history.

#### 5.1.16 Alarm by-pass Switches

##### 5.1.16.1 Startup by-pass (SBS) switches

- a) Unless otherwise specified, all SBS's shall be configured in the ESD system (i.e. PLC) and shall be operable from DCS operator console and PLC operator console when specified. All such by-pass switches shall be alarmed and shall have audit trail.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 32 OF 137		

#### 5.1.16.2 Maintenance by-pass switches (MBS's)

Unless otherwise specified, following philosophy shall be utilized for MBS's;

- All process inputs shall have miniature back lighted MBS (else shall have LED to show by-pass status).
- MBS shall be installed in a cabinet which can be physically lockable. The by-pass status shall also be available in operator console with a common flashing message always appearing on operator server whenever an MBS is operated. All MBS's shall have audit trail.
- Logic-wise common alarm shall also be available on the hardwired console.

#### 5.1.17 Interface with Electrical Input / Outputs

5.1.17.1 All contact input and output contacts from electrical switch gear panels (MCC / PCC etc.) shall be terminated in a dedicated 'Electrical Interface marshalling cabinet' located in control room. All such I/O's shall have intermediate relays.

5.1.17.2 Remote I/O rack shall be provided in sub-station for non-shutdown related data, when specifically indicated in the material requisition.

5.1.17.3 All serial I/O cables from sub-station to control room shall be redundant including remote I/O cable.

#### 5.1.18 Automatic Loop Tuning Software Package

5.1.18.1 It shall be possible to tune a control loop or group of control loops on selective basis at a time automatically unless otherwise specified. Tuning parameters computed by the system shall either be loaded automatically or manually by operator.

5.1.18.2 The automatic loop tuning software shall be used to tune PID control loops. The auto tuning technology used shall utilize principles like Ziegler – Nichols, Cohen – coon or Internal Model Control (IMC).

5.1.18.3 The software package for loop tuning may reside / run on any system hardware including controller sub system, console sub system, engineering sub system, supervisory computer etc. The tuning software must ensure that the process is not disturbed whenever a loop is being tuned.


5.1.18.4 Automatic look tuning package shall be able to study the dynamics of control loops and shall be able to compute response time, dead time, lead or lag time etc. directly from Engineering / operator console.

5.1.19 The system shall be suitable for power supply as specified in para 6.2 of this specification. Suitable battery back-up shall be provided for volatile memory protection only.

#### 5.1.20 System Upgrade Capability

5.1.20.1 System shall be scalable and upgradeable by adding additional hardware, over and above the spares specified, without rendering the initial hardware and software investment obsolete within the capability of the system.

5.1.20.2 This is in addition to the system upgrades, hardware and software, available from vendor as standard from time to time.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 33 OF 137		

#### 5.1.21 Noise Level

5.1.21.1 Noise level generated by any equipment shall not exceed the following limits;

- Noise level shall not exceed 55dBA for equipments installed in console room, engineering room and computer room.
- Noise level shall not exceed 65dBA for equipments installed in rack room and satellite rack room (SRR).
- For control rooms where consoles and cabinets are installed in the same room, the noise level generated by any equipment shall not exceed 55dBA.

5.1.21.2 The noise level shall be measured in dBA at a distance of 1 metre from the equipment generating noise.

#### 5.1.22 Equipment Identification

Unless otherwise specified, all equipments shall be identified by tag numbers indicated in the data sheet / summary sheet attached with the material requisition. The tag number shall be inscribed on a nameplate which shall be fixed with screws.

The nameplate shall be black laminated plastic with core i.e. black with white characters. The size and description shall be subject to purchaser's approval.


#### 5.1.23 System Furniture

All system furniture required for mounting and operation of the system including mounting of tabletop equipments shall be supplied. Furniture for operating personnel shall be as defined in job specifications.

### 5.2 Functional requirements

5.2.1 The system, as a minimum, shall meet the following requirements without the supervisory computer:

- Control
- Data acquisition & monitoring
- Alarming
- Logging & report generation
- Historical data storage
- Trending
- System shall have some free memory space available for the user and CPU shall have the additional capability to perform advance control functions, process optimization programs or generate management reports as specified in job specification in addition to space requirements as per para 3.0 of this specification. The availability of process control language shall be preferred.

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 34 OF 137		

h) System shall support functionalities like remote calibration, remote diagnostics and asset management in case of smart or field-bus based instruments.

5.2.2 In addition to above, following functional requirements shall also be complied, when specifically indicated in the job specifications;

- a) Sequence of event function.
- b) Alarm management
- c) Long term historisation
- d) Open system connectivity

5.2.3 The system when specified with Programmable Logic Controller (PLC) either as integral part of system or as separate third party device it shall perform follow functions;

- a) Process interlocks
- b) Plant safety shutdown
- c) Monitoring the sequence control units, when specified

Plant process and safety shutdown shall be independently performed by programmable logic controller. (PLC shall be communicating with other sub-systems via communication sub-system).


5.2.4 The system when specified along with a supervisory computer, shall meet the following requirements in addition to as specified in para 5.2.1 of this specification.

- a) Advanced Control
- b) Unit and plant optimization
- c) Management information service reports.

5.2.5 Whenever information network alongwith plant wide interconnectivity is specified, the system shall meet any or all of the following requirements in addition to those specified in para 5.2.1 of this specification as specified in the material requisition:-

- a) Centralised information system
- b) Statistical process control/statistical quality control.
- c) Plant optimization, data reconciliation, overall mass balance, etc.
- d) Plant planning and scheduling.
- e) Computer integrated manufacturing with information transfer to achieve functions like production and preventive maintenance scheduling and plant wide coordination etc.


5.2.6 The system as offered shall be fully and functionally integrated meeting the requirements specified above. In addition, the system shall also have capability and capacity to interact with smart and field-bus instrumentation simultaneously. The system shall also be capable of accepting signals from different type of field-buses in the same controller and data acquisition sub-system.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 35 OF 137		

### **5.3 Controller and data acquisition sub-system (CDAS)**

- 5.3.1 Controller and data acquisition sub-system shall primarily be used for plant control and data acquisition and shall interface with physical inputs and outputs from the plant and third party devices.
- 5.3.2 CDAS shall be microprocessor based and fully programmable sub-system which shall be capable of processing the acquired data from input / output devices utilizing a set of algorithms within its defined processing cycle. The microprocessors utilized in controller and data acquisition sub-system shall generally be of latest generation.
- 5.3.3 CDAS shall have a multi-processor architecture with each processor responsible to carryout predefined functions like Input / Output processing, control processing, internal communication, external interfaces etc.
- 5.3.4 The hardware and software capability of this sub-system shall primarily be exploited for processing regulatory close loop and open loop control functions only. Sequencing and interlocking capability shall be utilized whenever specified in job specifications.
- 5.3.5 CDAS shall be capable of accepting signals from various process sensors and devices with linear, non-linear and serial outputs preferably without requiring external or auxiliary signal conditioning devices and processing signals. Typically the inputs shall include 4-20mA DC (both conventional and HART), 1-5VDC, milli volt signal from thermocouples, resistance from resistance temperature detectors (RTD's), pulse input, field-bus (foundation field-bus, profibus PA etc.), serial inputs (MODBUS) and discrete contacts (powered or potential free), as a minimum. System shall also accept other inputs when specified in job specifications.  
System shall be able to accept 2-wire, 3-wire and 4-wire signal inputs without any change in the I/O module.
- 5.3.6 The system shall have capability to generate analog 4-20mA DC (conventional or HART) current signal, 1-5VDC voltage signal, field-bus output signal, potential free contacts for discrete outputs and serial (MODBUS) outputs, as a minimum, apart from others specified in the job specifications.
- 5.3.7 The output from the system shall be capable of driving following loads;
- Analog outputs shall be able to drive loads of output devices such as I/P converters, smart positioners, recorders / indicators etc. In general, it should have load driving capabilities up to 750 ohms.
  - Contact outputs suitable for driving alarm annunciations, status lamps, relays, converters, solenoid valves, contactors / breakers of motor control etc. In general, contacts rating shall as follows;

Intrinsically safe load	:	30V 0.5 Ampere
AC powered loads	:	230 V 5 Ampere

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 36 OF 137		

DC powered loads : 110V 0.5 Ampere

DC powered loads : 220V 0.2 Ampere

- 5.3.8 The system shall be capable of differentiating between out of range measurement (Bad process value) and a failed transmitter signal. In conventional 4-20mA output transmitter this shall be identified by setting bad quality data flags while for smart (HART) and field-bus transmitters data quality indicator from the device shall be utilized.

The detection of device failure alarm and driving output to a pre-defined value shall be configurable within this sub-system.

- 5.3.9 It shall be possible to override or force an input measurement or an output in the system while testing or on failure of an input.

- 5.3.10 Controller and data acquisition sub-system shall have a non-volatile memory for storing configurational data. In case vendor's standard product supports only volatile memory, battery back-up shall be provided to store the data for a period of 72 hours, as a minimum. A battery drain indication along with a potential free contact shall be provided to alert the operator.

- 5.3.11 The sub-system shall have sufficient memory to store the program instructions, CDAS data base, data required for real time trending and point trend and any other data required to be stored to meet specified functional requirements.

- 5.3.12 The sub-system shall incorporate a hardware or software based watch dog timer to monitor the healthiness of the CDAS processor-health.

- 5.3.13 Each controller and data acquisition unit shall have its own dual redundant power supply which can be replaced online. Separate dual redundant power supply unit shall be provided for powering field devices.

- 5.3.14 Controller and data acquisition sub-system shall be modular in construction with rack mounted modules in general. Input / Output modules shall be either rack mounted or DIN Rail mounted type.

#### 5.3.15 Input / Output Modules


##### 5.3.15.1 General

- a) I/O modules shall communicate with processor modules serially either through back-plane or through I/O communication network. I/O network shall always be redundant. Data transferring through hardwired connections shall not be acceptable.

- b) Analog to digit converters for analog 4-20MA / 1-5VDC modules shall meet the following requirements;

A/D Resolution

12 bits

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 37 OF 137		

Repeatability  $\pm \frac{1}{2}$  LSB

Accuracy  $\pm 0.1\%$  of full scale

Common mode Rejection 60dB at 50Hz

Normal mode Rejection 55dB at 50Hz

c) Digital to analog converters for output module shall meet the following requirements;

D/A Resolution 10 bits (min.)

Repeatability  $\pm 1$  LSB

Accuracy  $\pm 0.25\%$  of full scale

d) Each output channel must maintain its own – failure mode value, which is automatically executed upon detection of a communication failure between process and output module.

e) Unless I/O module has universal design it shall have unique keyed facility to prevent faulty operation and termination.

In addition I/O modules shall also meet the specific requirements specified in clause 5.3.15.2 through 5.3.15.7.

#### 5.3.15.2 Analogue Input / Output modules (conventional / smart)


The input module shall meet the following requirements;

- It shall accept 4-20mA isolated input with maximum input resistance of 250 ohms or 1-5VDC isolated input with input resistance more than 500k ohms.
- The input module shall support field powered transmitter i.e 2-wir, 3-wire or 4 wire system.
- Input faults such as open circuit, short circuit and earth fault shall be detected by I/O module.
- The output module shall provide 4-20mA output driving up to 600ohms of total loop resistance at 24V DC.
- The system shall provide 24V DC for loop powered 2-wire transmitter and shall also loop power the 2-wire outputs.
- Input / Output module shall not have more than 16 inputs or outputs.

#### 5.3.15.3 Analogue Input / Output module with HART

- The Analogue Input / output modules for HART signal shall meet all requirements specified in clause 5.3.15.2 above.



	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 38 OF 137		

- b) Input / Output shall fully support the HART communication signal i.e. the American Bell 202 standard frequency shift keeping signal superimposed at a low level on analogue measurement signal.


#### 5.3.15.4 Foundation Fieldbus (H1) Interface Module

- Foundation fieldbus HI interface module shall be capable of supporting multiple segments and able to operate in full redundancy mode.
- Foundation fieldbus H1 interface module shall always be provided in redundant configuration with Link Active Schedulers (LAS) configured in primary and back-up HI interface modules respectively to ensure that failure of primary LAS shall not cause failure of H1 bus communication. Power for H1 segment shall be provided by power conditioner module which shall be separate from H1 interface module to ensure that failure or removal of H1 interface module does not affect the supply of power to the segment.
- HI interface module shall be supplied with link active scheduler (LAS) capability and running foundation fieldbus (FF) function blocks which include PID, PD, Bias, Gain, calculations etc. These function blocks shall be code identical to FB code provided in the field devices. The manufacturer shall guarantee the interoperability of HI interface module with any function box residing in the field device.
- Foundation fieldbus HI interface card shall utilize a fieldbus Foundation Registered mark.
- The sub-system shall accept all the dynamic variables transmitted by the field-bus-device.

#### 5.3.15.5 Temperature Input Module

- The thermocouple input module shall accept grounded or ungrounded inputs from various thermocouple types i.e. T, E, J, K, R, S and B. The module shall be capable of linearising the thermocouple inputs and provide cold junction compensation.
- The module shall have 12 bit resolution with digital accuracy of  $\pm 1^{\circ}\text{C}$
- The RTD input module shall accept 100ohm platinum resistance temperature detector (Pt 100) in 3-wire or 4-wire configuration.
- The module shall be capable of linearising the RTD input.
- The module shall have 12 bit resolution with digital accuracy of  $\pm 0.28^{\circ}\text{C}$

#### 5.3.15.6 Serial Interface Modules

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 39 OF 137		

- a) Serial Interface modules shall be capable of communicating with RS232C, RS422 or RS485 signals.
- b) Unless otherwise specified, all serial interface modules shall be configured in redundant configuration.

#### 5.3.15.7 Discrete Digital Input / Output Module

- a) Digital input module shall be capable of detecting close or open status of powered or potential free contacts. The interrogation voltage of the contacts shall be 24VDC or as per selected barrier for barrier powered contacts.
- b) The input module shall also be suitable to accept inputs from proximity switches or from open collector output from proximity input barrier.
- c) The digital output module shall provide output contact rated for 220V AC 10 Ampere 110V AC 5 Ampere or 110V DC 0.3 Ampere.
- d) The type of contact output ie. normally open or normally closed shall be user selectable.
- e) Maximum number of inputs or outputs shall not exceed 32.

#### 5.3.16 Fieldbus Segment Power supply and terminators


5.3.16.1 The power supply used for powering fieldbus segment shall have a impedance matching network, preferably part of power supply unit.

5.3.16.2 Short-circuit at spur level shall not lead to failure of any fieldbus segment except the short-circuited spur.

5.3.16.3 Unless otherwise specified, fieldbus power supply / conditioner shall meet the requirement of type selected instruments and shall be as per;

- a) Foundation fieldbus power supply Type 131 non – IS power supply intended for feeding IS barriers.
- b) Foundation fieldbus type 133 IS power supply compliant with IS parameters.
- c) For Non-Intrinsically safe segment, the power conditioner shall be capable of each drawing 20mA current supplying power to at least sixteen field devices including a segment terminator.
- d) For intrinsically safe segment, the power conditioner shall comply with FISCO or entity concept requirements as specified in purchaser's specifications.
- e) For a segment designed with Non-insensitive concept, the power conditioner shall meet the requirements of FNICO.

5.3.16.4 Each foundation fieldbus power supply shall have redundant power conditioners (unless limited by concept design), current limited outputs to all foundation fieldbus segment and surge protection as applicable.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 40 OF 137		

5.3.16.5 Individual power conditioners and input power supplies can be replaced without interrupting power or communication fieldbus segment.

5.3.16.6 Terminators

Terminators shall be provided by vendor at both ends of a foundation fieldbus segment. The terminator at DCS side shall be incorporated into the foundation fieldbus power supply / conditioner while field side terminator shall be installed in the junction box.

5.3.17 Control functions and algorithms

Controller and data acquisition sub-system shall have capability to perform conventional and advanced control algorithms for implementation of regulatory and advanced control strategies. This sub-system shall have real time computational capability and shall be able to perform following algorithms and computations in addition to those specified in job specifications;

a) Control algorithms

Proportional (P), Proportional – Integral (PI), Proportional – integral – derivative (PID), adaptive gain, feed forward, cascade, split-range etc.

b) Dynamic Functions

Lead-lag, dead time, timers, counters etc.

c) Signal Selector

High selector, low selector, high-low selector.

d) Calculation Blocks

Linearisation, pressure-temperature compensation, polynomial, multiplication / division / addition / subtraction etc.

e) Signal Limiters

Low limiter, high limiter, high-low limiter etc.


f) Logic Blocks

Logic 'GATES' (OR, AND, NOR, NOT NAND etc), Flip-flops etc.

5.3.18 Controller shall be able to operate in either manual, auto, cascade or computer mode. Mode changeover in either direction shall be procedure-less and bump-less. Following functional capability shall necessarily be possible;


a) In cascade loops, the primary controller shall be able to track the set point of the secondary controller when the secondary controller is not operating in cascade mode.

b) In computer mode, controller shall be able to track computer generated set point and shall hold the last generated value in case of computer failure. In such case, controller shall fall back on auto-mode and continue to operate at the last received set point, in general. Other options like

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 41 OF 137		

pre-defined set point operation and fail safe condition shall also be possible. On the resumption of computer set point again, the controller shall not return to the computer mode automatically. Computer failure indicator shall be provided at central and local level.

- 5.3.19 Controller shall accept the change in set point command from central level (as operator interface function) and take action accordingly. It shall have facility for slow and fast ramping of set point as well as output. In addition, it shall have anti-reset wind-up feature as standard.
- In addition to above, it shall also be possible to change set point, tuning constant, operating mode, controller configuration from the central level i.e. operator's interface keyboard and engineer's interface keyboard.
- 5.3.20 Loop Integrity
- 5.3.20.1 Loop integrity shall be maintained in controller functionality in such a way that the single component failure in the sub-system shall not effect more than one control loop (single loop integrity). This shall be achieved in offered sub-system architecture in one of the following ways;
- By providing one to one controller back-up. In case failure is detected in the active controller all the loops of the failed controller shall be transferred to the back-up controller.
  - Where single loop controller is specified in the purchase specifications, no controller back-up shall be necessary provided no input other than that required for the specified loop is connected to the controller.
- 5.3.20.2 Loop integrity shall be maintained for the data acquisition functionality i.e openloop processing including processor such that a single component failure shall not effect more than 16 analog inputs or 32 discrete inputs.
- 5.3.20.3 Loop integrity shall also be applicable to I/O modules, power supply modules, communication modules and other associated devices as per the philosophy explained in clause 5.3.20.1 and 5.3.20.2 of this specification.
- 5.3.21 Sub-system Redundancy
- 5.3.21.1 In case of redundant configuration (where back-up components are provided), the design shall incorporate a fail-safe automatic control transfer switching mechanism which shall transfer the entire configuration, data base and loop control of the failed controller to the back-up controller. Design must also ensure that data integrity is maintained during switchover and no portion of data to be transferred is corrupted or lost before and during switch over to the redundant (back-up) controller. The indication of the failed controller / component shall be displayed at the level as well as on the central level.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 42 OF 137		

5.3.21.2 The switchover from primary to back-up component / device shall be bumpless and transparent to the operator i.e. the outputs shall be held at the last value during switchover to avoid any process upset. The switchover time shall be of the order of one (1) second.

In case of redundant HI modules, the back-up module shall maintain connectivity with all publishers and shall subscribe to all publishers to minimise switchover time.

5.3.22 Sub-system configuration and on-line modifications

5.3.22.1 Controller and data acquisition sub-system shall be configured from the central level i.e. through engineers interface sub-system under password or hardwired key lock protection. Single loop controller when specified shall be configured from the local level.

5.3.22.2 Sub-system shall allow following configurational functions to be performed for each loop;

- a) Control function parameters
- b) Processor cycle time for each loop tagwise.
- d) Macro-cycle time for foundation fieldbus HI segment as per segment loading.
- d) Output status of each control loop in case of processor failure.

5.3.22.3 It shall be possible to carryout online modifications or perform back-up without interrupting the central software of preventing the operator commands. Such modifications shall be possible without any plant upset or process interruption.

5.3.22.4 Downloading of modifications to the respective controller and data acquisition sub-system shall be possible in running condition.

5.3.22.5 Sub-system shall perform saving and back-up of data base as per changes made automatically.


5.3.23 System Diagnostics

5.3.23.1 Each module shall have a board diagnostic with on board LED for indicating status of the module at local level.

5.3.23.2 All diagnostic subroutines shall carryout various diagnostic tests to check the healthiness. The test shall include memory test (RAM and ROM), on-board processor test and back-up module communication healthiness test etc. Failure of any of the tests shall be alarmed as module failure.

5.3.24 Sub-System Performance

The sub-system response time shall be the indicator for the performance of the sub-system. The control system shall be able to perform control algorithm, calculation function etc. for each loop within the specified response time unless specified otherwise in the purchaser's data sheets, the system

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 43 OF 137		

response time (scan time) and loop response time as defined in clause 2.22 and clause 2.26 (for fieldbus based system) respectively of this specification shall be as follows;

- 20 msec. for anti-surge control loops
- 200 msec. for flow and pressure control loops.
- 500 msec. for all other control loops
- 1 sec. for temperature acquisition and other acquisition loops

The processor cycle time shall be set to achieve the scan time and loop response time values specified above.

Scan time of multi-variable advanced control loops when implemented in controller and data acquisition sub-system shall be specified in purchaser's data sheets.

#### 5.3.25 Controller & data acquisition subsystem loading


The system loading for controller and data acquisition subsystem shall not exceed 60%. The loading as indicated here is the worst case of high system activity referred to the use of memory, CPU time and communication capacity for this sub-system.

#### 5.3.26 Sub-system Sizing

##### 5.3.26.1 Sizing of controller and data acquisition sub-system shall be carried out considering the following parameters, as a minimum;

- a) Unit-wise segregation of CADS as specified in the job specification.
- b) Number and type of inputs / outputs specified in each unit in the job specifications e.g. analogue I/Os (conventional / smart (HART), Fieldbus I/Os, discrete I/Os etc.
- c) Intrinsically safe and non-intrinsically safe I/Os.
- d) Spares philosophy.
- e) Distribution of spare I/O's in I/O modules
- f) Scan time (Response time) and loop response time specified for each type of I/O.
- g) Segment design criteria
- h) Worst-case processor loading specified in the specifications.
- i) Calculation blocks specified in the job specification. Following philosophy shall be followed for computing calculation blocks in addition to those indicated;

PID Blocks	-	No of outputs
Calculation Blocks	-	50% of PID Blocks or 130% of specified calculation Blocks whichever is higher.
Logic Blocks	-	150% of specified blocks or 100% of specified Discrete outputs whichever is higher.
Advanced blocks	-	150% of actual numbers specified.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 44 OF 137		

For the purpose of block calculation, consider actual I/O's along with installed engineering spares. Also consider clause 5.3.26.2 (e) for fieldbus based system.

- j) Serial interface modules in redundant and single configuration as specified.
- k) Any parameter not specified above but required to be considered for size because of vendors standard sizing methodology.

Processor loading factor / calculation available in standard product guide for sizing shall be utilised else vendor shall reduce the sub-system block handling capability by a factor of loading.

5.3.26.2 In addition to relevant requirements specified in Clause No.5.3.26.1, following process control functionalities and requirement must be considered for fieldbus segment design;


- a) The sensor device and the corresponding actuator in a control loop shall be on the same fieldbus segment.
- b) Control loop that include a cascade type controller, the primary and secondary loop measurement as well as final control element shall be on the same fieldbus segment.
- c) Split range measurement and final control element shall be on the same fieldbus segment.
- d) Discrete fieldbus device used in an interlock alongwith a control loop, discrete device shall preferably be on the same fieldbus segment. Discrete device here means fieldbus converter.
- e) The default configuration shall be for control (except high level calculations) to reside in fieldbus device. System shall be configured for control to fail over to CDAS
- f) Type of hazardous area philosophy i.e entity concept, FISCO, FNICO or high power trunk.
- g) Length of each segment with respect to the physical distance between control system (host) and field devices.
- h) Loop response time or macro cycle time as specified.
- i) Sufficient unscheduled time must be kept in each cycle to transmit a cycle information within defined loop response time. This shall be 50% of the specified loop response time.

## 5.4 Operator interface sub-system

### 5.4.1 General

5.4.1.1 The operator interface sub-system shall provide the centralized information to the plant operator/Engineer in the following fields:

- a) Indication of all analog and digital process variables of control loops, open loops and all loop related parameters

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 45 OF 137		

b) Manipulation of control loops including changing set point, mode, output, configuration, tuning, and computational constants.

c) Alarm displays and annunciation.

d) Graphic displays and status indication.

e) Logging and trending including historical trend recording.

f) Trend recording on assignable trend recorders.

g) Self diagnostic messages.

5.4.1.2 The operator interface sub-system shall consist of a single or multiple operator consoles (VDU's driven by console electronics) and hardwired consoles. The number of consoles for a unit shall depend upon the size and operating philosophy of the plant. The number of console shall be specified in the job specifications.

5.4.1.3 The operator interface subsystem shall have either single tier construction or stacked construction. The type of construction shall be specified in the material requisition.

5.4.1.4 The operator station shall comply with ISO 9241-5 'Workstation layout and postural requirements' and ISO 9241-7 'Display requirements with reflections'. The layout of the operator interface sub-system shall be as indicated in the material requisition. The consoles required to meet the shape and symmetry indicated shall be supplied by the vendor.

5.4.1.5 Unless otherwise specified in job specifications, each VDU shall be a 459.7mm active matrix TFT type LCD display unit and shall have native resolution of 1280 x 1060 pixels, as a minimum, with a 160° wide viewing angle.

## 5.4.2 Operator Consoles

5.4.2.1 Each operator console shall consist of the following;


a) Single tier construction shall have three (3) VDU screens with its own dedicated keyboards (a total of three keyboards) each driven by an independent electronics.

b) Stacked construction shall have the two stacks of VDU's with four VDU's (2VDU's / stack) and two sets of keyboards (one keyboard / stack) each stack driven by an independent electronics.

c) Each operator video screen or 2 VDUs of stacked construction shall be driven by a dedicated driver electronics which also keeps the desired data base for various functions defined and termed as workstation. All the three operator workstations shall be operationally interchangeable in such a way that all the three workstations have similar data base and functionalities.

d) The operator console shall also have a logging printer, a alarm and event printer and a hard copy unit, unless otherwise specified in job specifications.



	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 46 OF 137		

#### 5.4.2.2 Hardware Configuration

The operator console shall meet any one of the following configuration options;

##### 5.4.2.2.1 Option I

Each operator video screen shall be driven by a dedicated driver electronics which also keeps the desired data base for various functions defined and termed as workstation in this case each as has data stored in it should be minimum RAID-5 configuration to ensure maximum availability of history/data . All the three operator workstations shall be operationally interchangeable in such a way that all the three workstations have similar data base and functionalities.

##### 5.4.2.2.2 Option II

One or more number of operator console (consisting of three video screens and dedicated keyboards) are driven by a common redundant server machine storing a common database for all the three video screens (three video screens may work like clients to this server).

Server shall be a multifunction higher end server grade machine which may support functionalities such as;

- Data connectivity between CDAS and other sub-systems (i.e. operator sub-system, engineering sub-system, IAMS etc.)
- Database storage and engineering functionality as per Clause 5.4.2.3 of this specification.
- Historisation of data related to associated operator consoles.


This server can also be used for functions like;

- Plant history (UHN)
- Connectivity to information network or OPC node.
- Running specific applications like generating advance controls, MIS reports, IAMS, AIMS etc.

##### 5.4.2.2.3 Option III

- Two parallel servers (each containing same data base, each driving), two of the operator console VDU's are driven by a server which stores complete data base for the units being assigned. In this case, operator console shall have four operator console VDU's (instead of three specified as operator console). Similar philosophy shall apply in case of stacked VDUs operator console.
- In case, multiple servers are used to support different functions like data connectivity, data base storage and historian function, similar philosophy as 5.4.2.2.3(a) may be followed.

5.4.2.3 The system shall have global data available at each operator console electronics and all the functions explained in Clause 5.4 shall be available / executed at operator console. However, in case functionalities are distributed in various intelligent hardwares / softwares or in case of distributed database / console functions is supported by the standard system architecture, each data base electronics / functionality shall be RAID 5 configuration dual redundant. Further any change made in the data base of one operator console shall automatically update the data base of other operator consoles if configured identically. Following shall apply;

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 47 OF 137		


- a) history function, for the units monitored and controlled from the operator console, shall be RAID 5 configuration dual redundant with each node have dual disc drives dedicated for history storage.
- b) Data base storage function for the units being monitored and controlled by the unit shall be RAID 5 dual redundant and shall have dual disc drive configuration.
- c) All stations used for data storage and such functionalities shall have RAID5 configuration.

5.4.2.4 The operator, as a minimum, shall have access to the following through the operator key board at all times:

- a) Selection of all the displays including the direct selection of loop in alarm, page turning facility, overview, group view and loop view selection etc.
- b) Selection of loop for operation.
- c) To acknowledge alarms as and when they are annunciated on the operator console.
- d) Facility to enter any changed parameter like setpoint, manipulated variable, digital commands and to cancel any wrong entry while making such change.
- f) Facility for easy positioning of cursor for the selection of any parameter.
- g) Selection of hardcopy printout, logging printout, alarm history printout and assignable trend recorder points.
- h) Auto/manual/cascade/computer mode changeover of each controller.

5.4.2.5 In addition the Engineering keyboard shall have the following capabilities for restricted user/engineer through a key-lock or with password protection;

- a) Data base configuration including overview, group, loop, multi-loop and multi-variable control configuration.
- b) Group or multi-group alarm inhibit from a plant under maintenance.
- c) Reconfiguration of alarm settings and their values, addition and deletion of components in a loop.
- d) Tuning of control loops including change of P, I, D and dead-time contacts
- e) On-line compilation of graphic displays using standard user defined symbols.
- f) Changing of parameters to be logged.
- g) Setting of real time clock.
- h) Assigning of parameters for historical trending.
- i) To call detailed self-diagnostic for maintenance.

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 48 OF 137		

Any change made for any parameter for an input from any display shall be automatically updated on all displays configured for that input.

#### 5.4.2.6 Operational Protection

A key-lock switch or software password shall be provided for operational protection. Following minimum level of access and authorisation shall be available;

- |                  |   |   |
|------------------|---|---|
| Operator Level   | - | Authorises all commands for plant operation.                        |
| Engineers level  | - | Authorises all commands for plant operation and system engineering. |
| Management Level | - | Authorises all operational data and reports to be viewed.           |

Other levels of key-lock / password protections if available as standard with the system shall also be offered.

#### 5.4.2.7 It shall not be possible to override any process variable or digital status from operator keyboard.

#### 5.4.2.8 Each keyboard either integral or as a separate attachment shall have a set of dual function user configurable keys. These keys shall be configured to access important pages in single keystroke. These keys shall have LEDs which flash on pre-configured alarm conditions. A minimum of 32 number of such keys shall be offered with each keyboard. Systems, which do not support dual function keys with their standard keyboard shall offer either;

- i) a dedicated VDU and keyboard with each operator console configured with an intelligent graphic which would replicate the functionality of dual function keys.
- ii) a dedicated keyboard with dual function keys alongwith each standard keyboard.


#### 5.4.3 Process displays

##### 5.4.3.1 Process information and operational aids shall be presented to the operator in the form of display. These displays shall cover all points related to tag numbers built within the system. The process displays shall include different type of displays and the functionalities associated with each of these displays. Various types of process displays, as envisaged, are detailed out in the clauses to follow. The details provided herein are typical and explain only the functional requirements. The systems as offered must provide displays which meet these functional requirements.

##### 5.4.3.2 Overview display


##### 5.4.3.2.1 Overview display shall present the overall status of a unit or large segment of the process plant. The analysed data and alarm conditions are displayed with colour changes.

##### 5.4.3.2.2 Overview display shall incorporate a minimum of 128 analog or discrete inputs which can be monitored simultaneously on the VDU screen (Referred as page). Each page shall be organized into a

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 49 OF 137		

suitable number of groups. Each group shall be identified separately. Each group shall further incorporate suitable number of inputs (Referred as tags). Suitable identification and description shall be shown for each group on the overview display to relate it to a group or loop display.

- 5.4.3.2.3 All analog points in the overview shall be represented as variable lengths indicating deviation above or below the normal operating value or set point.
- 5.4.3.2.4 Alarms shall be displayed in change of colour against each variable if the variable crosses a set value. Control loops operating in manual mode shall be indicated.
- 5.4.3.2.5 An input in alarm condition shall be identified by flashing.
- 5.4.3.2.6 In case, any hard wired instrumentation backup is provided, overview pages shall be assigned indicating the tag number and type of hardwired instrument.
- 5.4.3.2.7 The operator shall be able to call directly any group display or loop display or any predetermined displays covered in the overview display.
- 5.4.3.2.8 It shall not be possible to acknowledge alarms directly from the overview display.
- 5.4.3.3 Group Display
- 5.4.3.3.1 Group display shall be limited to the group of inputs as displayed in the overview display. Each group shall preferably include eight (8) number of inputs.
- 5.4.3.3.2 Each input in the group shall be identified by the tag number, unit of measurement and process description which shall be displayed on the VDU screen.
- 5.4.3.3.3 Display, as a minimum, shall show following degree of details:
- Process variable in analog form shall show, as a percentage of the transmitter span on a linear scale bar graph of 0- 100% or engineering units and in digital form as alphanumeric display in engineering units.
  - Set point value in analog form as a percentage of the transmitter span on linear scale bar graph of 0-100% engineering units and in digital form as alpha-numeric display in engineering units.
  - Output value in analog form as a percentage of linear scale bar graph of 0-100% and digital form as percentage.
  - Controller mode i.e. auto, manual, cascade, computer.
  - Process alarm on process variable, deviation or velocity.
  - Selected loop within the group shall be identified by cursor marking or similar identification.
  - Control valve failure position.

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR <b>DISTRIBUTED CONTROL SYSTEM &amp; PLC SYSTEM</b>	GSTD-0201	1	
			Rev	
		SHEET 50 OF 137		

h) The contact input / output shall be represented by simulated graphic lamps and configurable alphanumeric status description.

5.4.3.3.4 It shall be possible to control the process from group views. Following control actions shall be possible;

- a) Increase / decrease of set point value either slow or fast.
- b) Change of controller mode i.e. Auto/manual transfer.
- c) Changing output to the final control element.
- d) For digital points, start/stop or open/close command.

5.4.3.3.5 It shall be possible to repeat any tag number in more than one group/console. However it shall be possible to control or change configuration from only pre-assigned group/console.


5.4.3.4 Loop Display

5.4.3.4.1 Loop display shall provide a separate detailed display for each of the process inputs. The graphic representation of analog and digital points shall be similar to group display. However in addition following information shall also be presented in alphanumeric form as a minimum


- a) Controller tuning constants.
- b) Process variable zero and span values.
- c) Alarm set point on various parameters.
- d) Limits on set point, output, velocity etc.
- e) Controller action (direction/reverse).
- f) Failure position of final control element.
- g) Computational constants like ratio or bias.
- h) Integrated value.
- i) Output to the final control element.
- j) Engineering units.

5.4.3.4.2 It shall be possible to change the following through the keyboard of operator console:

- a) Tuning constants.
- b) Scale, zero and span.
- c) Limits on set point, output, velocity etc.
- d) Configuration of any loop.
- e) Alarm set points.
- f) Control mode.
- g) Output to the final control element.
- h) For digital points, it shall be possible to issue start/stop or open/close command.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 51 OF 137		

- 5.4.3.4.3 Loop control parameters changes as specified in para 5.4.3.4.2 (a) to (e) shall be restricted by a key lock control or password.
- 5.4.3.4.4 The loop display shall also contain a trend displaying process variable, set point and output with a sample interval time of maximum 1 second and full scale time base of minimum 60 seconds for tuning the process control loops.
- 5.4.3.5 Graphic display
- 5.4.3.5.1 It shall be possible to display dynamic graphic of different sections of plant on the operator console VDU screens. Graphic displays shall be field configurable only through engineering key-board with standard / user defined graphic symbols. Dynamic graphic displays if different sections of the plant shall be displayed on different pages.
- 5.4.3.5.2 The system shall have graphic symbol library as per ISA-5.1 and 5.3. In addition standard industrial symbols like distillation columns, heat exchangers, pumps, compressors, tanks etc. shall also be provided as a standard.
- 5.4.3.5.3 Graphic displays shall be interactive type through which it shall be possible to control the process. It shall also be possible to send motor start/stop and shutdown valve open/close commands, as specified in job specifications, from this display.
- 5.4.3.5.4 It shall be possible to view the process variable and alarm points and view and change set point value, manipulated variable, controller mode etc. from the graphic display. Also rotating machinery (i.e. compressor / pump) status and valve status shall be displayed on the graphic display with different colours.
- 5.4.3.5.5 Various colours used in the generation of graphics like colour of the process lines, utility lines, Instrument signal lines and event modifier conditions shall be finalised during detailed engineering. The colours used to identify event modified conditions shall generally be as follows unless otherwise indicated during detailed engineering.
- |                |   |                                   |
|----------------|---|-----------------------------------|
| Red            | : | All points alarm                  |
| Blue           | : | Valve open, pump running.         |
| Green          | : | Valve closed, pump stopped.       |
| Flashing green | : | Shut down valve transition state. |
- 5.4.3.5.6 It shall be possible to go from any graphic page to related graphic pages or any group view or alarm summary in single key stroke using soft key function.
- 5.4.3.6 Trend Display
- 5.4.3.6.1 The system shall be capable of displaying the following trends:

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 52 OF 137		

- a) Real time trends for the parameters specified in job specifications displaying current data for a period of minimum one (1) hour as defined in clause 2.33 of this specification. However it shall be possible to assign any parameter for real time trend.
- b) Historical trend for number of parameters as specified in the job specification for a period of 30 days with sampling rate of 10 minutes. However, it shall be possible to assign any parameter for historical trending.

5.4.3.6.2 Historical data shall be stored on the nonvolatile memory device like hard disc in such a way that such historical data can be utilized for archival storage and subsequent recall.

5.4.3.6.3 Real time and historical trend shall be possible on any parameter or variable like measured variable, set point, output, calculated variable etc.

5.4.3.6.4 It shall be possible to sample and store data of instantaneous and average value at the intervals mentioned below. However it shall be possible to display by scrolling or expanding the time base for all the trends.

- a) At intervals 1 second or higher for the real time trend.
- b) At 1 minute, 10 minute & 1 hour interval for historical trend.

Historical data trends shall be displayed for a period of minimum up to 72 hours for a data sampling rate of 1 minute.

5.4.3.6.5 The requirement of fast trend (trends with sample time faster than Real time trend) if any, shall be specified in the job specification. This shall be in addition to tuning trend requirement specified in this specification.


5.4.3.6.6 Selection of the tag number and sampling time for real time and historical trending shall be possible from operator keyboard.

5.4.3.6.7 The system shall also have a multi trend capability in such a way that it shall be able to display set point, measured variable and output on the same display, the trend of either the same process variable or any other process variable.

5.4.3.6.8 Trend display shall be single line type or bar graph type with additional information like loop tag number, engineering units, span, present value of the trended point, alarm status etc displayed.

5.4.3.7 Closed Circuit Television Window display

It shall be possible to display close circuit television (CCTV) video monitor image on the operator console as a CCTV window. A function key on the operator keyboard shall be assigned to select the

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 53 OF 137		

desired CCTV monitor window. The CCTV window on the operator console video shall always be on-top.

#### 5.4.3.8 Alarm Monitoring and display

##### 5.4.3.8.1 Alarm Management


- a) It shall be possible to display process as well as system alarms on the operator console for operator's attention and action. Alarms shall appear immediately on the operator console as and when they occur on priority basis.
- b) It shall be possible to set process alarm limits from the engineering keyboard i.e. alarm limits on absolute value of measured variable; rate of change of measured variable; high and low deviation set points; high, extra-high, low and extra-low points on process variable and output etc. In addition, it shall be possible to derive alarm conditions on the basis of few calculations performed by the system.
- c) Alarm messages shall be displayed by flashing the page and group number of the input under alarm irrespective of type of display. It shall be possible to access the group or tag in alarm condition with a maximum of two key-strokes of operator's console keyboard. The plant overview display, in addition to display alarm message, shall also be able to provide warning by changing colour of excessive deviation of process variable from their set value.
- d) All alarms shall be displayed as and when they occur or generated with change in the colour of display in the following sequence, activating an audio signal:
 

Continuous flashing	:	Un-acknowledged alarm
Steady display	:	Acknowledged alarm
- e) The system shall not put off the audio alarm and visual flashing even after the condition returns to normal unless it is acknowledged by the operator.
- f) In order to provide immediate attention to critical alarms, alarms shall be classified in the priority of their criticality.
- g) In addition to alarms appearing on the different displays as mentioned in para 5.4.3.1 to 5.4.3.5 of this specification, the system shall also be able to display alarm summary and alarm history as per para 5.4.3.8.2 and 5.4.3.8.3 of this specification.

##### 5.4.3.8.2 Alarm summary display

- a) It shall be possible to display summary of all alarms in the sequence of their occurrence and shall disappear from display only when they are acknowledged and cleared. The alarm display shall list the following for each alarm as a minimum:-
  - i) The date and time of occurrence.



 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR <b>DISTRIBUTED CONTROL SYSTEM &amp; PLC SYSTEM</b>	GSTD-0201	1	
			Rev	
		SHEET 54 OF 137		

- ii) Point identification (i.e.Tag number)
- iii) Point description.
- iv) Type of alarm (absolute value or deviation.)
- v) Serial number of alarm in the sequence of its occurrence.
- b) The system shall be able to display on alarm summary a minimum of 100 alarms.
- c) Alarms shall preferably be listed in the form of alarm list like current, List I, List II etc. The minimum number of alarms per list shall be 25. Alternately system may provide a common list of alarms in the sequence of their occurrence (with respect to time).

#### 5.4.3.8.3 Alarm history

- a) The history of alarm conditions shall be maintained in the database for alarm history display and printed on shift-wise basis for the parameters specified in the job specifications. The alarm display and print out shall list the following for each alarm as a minimum:-
  - i) The data and time of occurrence.
  - ii) Point identification (i.e. Tag number)
  - iii) Point description.
  - iv) Type of alarm (absolute value or deviation.)
  - v) Time of acknowledgement.
  - vi) Time of return to normal.
  - vii) Serial number of alarm in the sequence of occurrence.
- b) The system shall be able to display and print out the alarm history of minimum of 300 alarms.
- c) Alarms shall be listed in the form of alarm lists like List I, List II, List III etc. The minimum number of alarm points per list shall be 25. Alternately system may provide a common list of alarm in the sequence of their occurrence.


#### 5.4.3.8.4 System alarm

- a) System shall have capability of on-line self diagnostics as mentioned in para 5.4.5 of this specification.
- b) Any abnormal conditions in and sub- system or any other functional device shall be displayed as system alarm message on the operator console irrespective of the display selected.

#### 5.4.3.9 Configuration display

5.4.3.9.1 Configuration display shall provide a separate detailed display for each loop indicating the configuration of that loop. When control requires more than one loop, all interrelated loops shall also be displayed. Following information is required to be available on configuration display.

- a) Loop configuration giving designation of each block.
- b) Control block interconnection showing soft-wiring or hardwiring.
- c) Value of each block parameter like P.I.D., ratio, bias, dead-time, lead- time etc.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 55 OF 137		

5.4.3.9.2 It shall be possible to configure & reconfigure the loops from this view using user friendly software.


5.4.4 Logging and Report Generation function

5.4.4.1 It shall be possible to log all real time data, historical data, computed parameters, operator actions, alarms and events etc from operator consoles irrespective of data source connected to communication sub-system. In general, the data type shall include;

- a) All measured and manipulated variables (inputs as well as output data)
- b) System calculated variables
- c) Historical data values
- d) Alarm and event data
- e) Operator data entry and operator actions
- f) Equipment status data
- g) Data through serial links
- h) Data through OPC server
- i) Batch related data
- j) System clock time
- k) System diagnostic data

5.4.4.2 The system shall have a report builder and report scheduler which shall have following capabilities;

- a) The system shall be able to generate reports on hourly basis, shiftly basis (8 hourly), daily basis and in some cases weekly or monthly basis, as specified in job specifications.
- b) The system shall be able to generate reports as per operator command either on-demand or on predefined time.
- c) In general, the type of reports shall be;
  - ° On demand report initiated by operator action
  - ° Predefined time initiated report e.g. hourly, shiftly, daily etc.
  - ° Event driven report
  - ° Shutdown driven report
  - ° Equipment runtime status report
- d) The generation of on demand report shall not affect any scheduled report.
- e) These reports shall be stored in separate files independent from historical and trend data files.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 56 OF 137		

5.4.4.3 All parameters required for logging shall be stored in the system memory as per data base update rate. The system shall be able to perform following functions on all such stored data prior to logging as per the requirement of the report;

- a) Basic arithmetic calculations such as averaging, summing, multiplication, division etc.
- b) Advanced calculations like efficiency calculations, conditional calculations etc.
- c) Extended log reports such as weekly and monthly reports.
- d) Batch Reports

5.4.4.4 The formats used to generate log reports shall be user definable, in general. Typical log formats for hourly, shiftly and daily reports have been attached alongwith (Refer Annexure 1) for reference. System shall have a user friendly structured programming language suitable to generate and access various reports. System may utilize high level language for generating reports with advanced calculations. High level language compiler software shall be supplied as part of standard system function.

5.4.4.5 Number of log reports generated for a project shall be governed by the number and type of log formats defined for a project like hourly report format, daily report format, shutdown report format etc. Number of pages in each log report shall be sufficient to accommodate all the parameters defined in the job specifications.


5.4.4.6 In addition to the real time and historical data, the report builder programme shall incorporate report title, sub-headings, notes and messages.

5.4.4.7 Hourly report shall be printed only as and when initiated on demand by the operator and shall not be printed automatically after the end of the hour. All other reports shall be printed automatically at the end of the pre-defined time as well as on demand by the operator. The maximum storage time for a log information shall be 15 minutes after the pre-defined print out time for a format, within which time log report must be printed. In case report could not be printed within the scheduled defined time, data shall remain stored till the report is finally printed.

5.4.4.8 Logging hardware

Data required to be logged shall be finalised during log report finalisation stage. However, typically following shall apply;

- a) All tag numbers, analogs as well as digitals, shall be available for hourly log.
- b) All flow tag numbers and other selective tag numbers shall be available for daily log report.
- c) Only selective tag numbers shall be available for weekly and monthly report.

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR <b>DISTRIBUTED CONTROL SYSTEM &amp; PLC SYSTEM</b>	GSTD-0201	1	
			Rev	
		SHEET 57 OF 137		

- d) Average (over the defined period) for flow and instantaneous shall be used for log printing with maximum and minimum value as defined in log formats.

#### 5.4.4.9 Logging Hardware and Software

- 5.4.4.9.1 The system shall be supplied with all hardware and software necessary to meet functional requirements specified in Clause 5.4.4.7 of this specification. Log reports shall be generated, compiled and printed using system standard hardware and software. No separate computer / server shall be used.

Separate server, if necessary, may be utilised, to generate extended logs or reports requiring advanced calculation.

- 5.4.4.9.2 It shall be possible to archive log reports on an external computer. Facility shall also be available to retrieve these reports as a magnetic tape or a disc for future reference.

- 5.4.4.9.3 In the event of printer failure, the system shall maintain the data in the point buffer memory of the report originating device buffer with a printer failure alarm.

It shall also be possible to print the report at an alternate printer without any data loss, whenever necessary.

#### 5.4.4.9.4 System Printers

- a) In addition to configuration and maintenance (C&M) printing, printers shall be used for printing reports like log reports and alarm and event reports.

C&M printers shall be dedicated for each machine whenever such a function is required.

- b) All printers shall be low noise industrial type and shall be suitable for continuous duty.


- c) Logging printer

Logging printer shall be A3 size colour laser printer and shall be able to meet the following requirements;

- i) Logging printer shall be able to print the following reports;

- Printing of hourly, shift-wise, daily and weekly log.
- Shut down report printing.
- Any other report defined in the job specification.

- ii) In addition to above, logging printer shall also be used for printing hard copy of any video screen, whenever necessary.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 58 OF 137		

d) Alarm and event printer

Alarm and event printer shall be low speed dot matrix printers capable of meeting the following requirements;

- i) Alarm and Event printer shall be able to print out following reports;
  - Log the process and system alarm messages with a time stamp as and when they occur
  - Print the alarm history for every shift of operation or on demand from operator console.
  - Log events such as operator actions as defined in para 2.30 of this specification, as and when they are initiated.
  - System alarms as per self-diagnostic reported alarms.
- ii) Alarms and Events shall be clearly distinguishable on the report, preferably by colour.
- iii) Print out shall show as a minimum the tag number, description, date and time of occurrence, time of acknowledgement and time of return to normal.
- iv) The time stamp shall include month, day, hour and minute.

e) Multifunction printer


Multifunction printer be a colour laser printer which shall be able to print out log reports as well as alarm and event reports. Multifunction shall be specified either common for a unit or a group of units. The functionality of multifunction printer shall be same as (a) through (d) specified in clause 5.4.4.9.4 of this specification.

The command for printing of any report shall be generated from any operator and / or engineering console. The reports shall be generated in the priority of which shall be as per request time for printing report.


f) Hard-copier

- i) Hard-copier shall preferably be a coloured heavy duty laser printer. The command for copying shall be initiated from any operator console.
- ii) The screen display may be changed on the console after the copy command is initiated for any screen. This video copier shall have buffer memory storage for at-least two screen pages.

#### 5.4.5 Self diagnostics

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 59 OF 137		

- 5.4.5.1 The self diagnostic message for a subsystem failure shall appear on the operator console irrespective of display selected. The choice of the detailed self diagnostic displays shall be made by a key-lock switch.
- 5.4.5.2 The system shall have an extensive set of self-diagnostic routines which shall locate and identify the system failure at least up to module level including redundant components.
- 5.4.5.3 At the local level, failure of a module in a sub-system shall be identified by an individual LED display.
- 5.4.5.4 Failure of a subsystem shall be annunciated with the change in colour. To aid system maintenance and for effective fault location, following displays shall be provided as a minimum.
- 5.4.5.4.1 Communication system status display.
- The display shall show an over view of different sub-systems connected over the communication sub-system showing status of each sub-system. When a failure is detected by the system self diagnostic routine, the display shall indicate the location and nature of malfunction. Display shall as a minimum have
- Type of sub-system.
  - Failure of communication bus/link with the sub-system.
- 5.4.5.4.2 Sub-system diagnostic display
- One display page shall be available for each sub-system on the communication sub-system which can be called on demand.
- The display as a minimum shall contain:
- Sub-system number and type
  - Error code and description
  - Details of failed module
- 5.4.6 Data Storage, Archival and Retrieval
- 5.4.6.1 **Historical data shall be stored on a non-volatile memory device like hard disc which can be subsequently recalled by operator on any screen. System must support multiple historical data discs in order to avoid data loss in case of disc crash.**
- 5.4.6.2 It shall also be possible to store and retrieve this data on removable mass storage media like floppy disc, cartridge or tape etc.
- 5.4.7 Assignable Trend Recorder
- 5.4.7.1 It shall be possible to provide real-time trend on the assignable recorders for any process or calculated variable. The variable shall be assigned through the keyboard of operator console on any point and any recorder connected to that console.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 60 OF 137		

5.4.7.2 Assignable trend recorders shall be located on the hard wired console. Each recorder shall have four pens.

5.4.8 Hard copy unit

5.4.8.1 Hard copy unit shall be used to make permanent copy of any VDU page when demanded through the operator console/Engineer console.

5.4.8.2 VDU page shall not be locked for more than 5 seconds while taking the video-copy.

5.4.8.3 Copies of display shall be in full colour.

5.4.9 System Servers sizing criteria

5.4.9.1 The servers provided as part of standard system architecture shall have fault tolerant architecture with a minimum availability of 99.999%. The design requirements of each server shall be dependent on its functional requirements such as;

- a) Guaranteed throughput performance.
- b) Continuous and consistent data connectivity even during fault.
- c) Continuous and consistent processing of data even during fault.
- d) Fault tolerant operating system.

The fault tolerant configuration of server shall include synchronised redundant processors such that failure, if any, is transparent to the user and server applications.

Transparent to the user implies that the data display on the graphic of any VDU shall not be lost for more than three (3) seconds in case of failure of the main server.

5.4.9.2 In case if redundant server configuration, the maximum switchover time shall not exceed ten (20) seconds.

System servers which have switchover time exceed 3 seconds, shall ensure that real time data is available on at least two of the three operator console VDU's even during switch over.

5.4.9.3 All machines that are used for data is storage shall be high end server garde machine with minimum RAID – 5 configuration. General purpose servers( below RAID 5 Configuration) shall not be acceptable.


5.4.9.4 Server Sizing

5.4.9.4.1 Unless otherwise specified, following criteria shall be considered while sizing the server / servers used for driving operator console( for configurations where data is not stored in the operator station);

- a) Number of operator workstation (clients)

Consider 1.2 times the specified number of operator workstations rounded to next higher whole number for each type.

- b) Number of Engineering workstations (clients)

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 61 OF 137		

Consider 1.2 times the specified number of engineering stations round to next higher whole number.

- c) Number of Controller and data acquisition nodes

Consider 1.4 times the specified number of CDAS nodes.

- d) Maximum number of nodes / sub-systems on the network should be less than 60% of the system capacity specified in the standard printed catalogues of manufacturers.

- e) Maximum history storage tag numbers per second

Consider 1.4 times the specified number of tag points in the material requisition with storage rate of 1 second.

- f) Maximum number of trends

Consider 1.4 times the specified number of trend points. Where no separate trend points are indicated consider all analog inputs and outputs as required trend points.

- g) Maximum number of Reports

Maximum number of log reports (formats) shall be 50 with 1000 points in each log report.

- h) Maximum number of Tag data

Consider 1.4 times the total number of tags and associated parameters i.e. process variable, set point, manipulated variable, auto-manual-computer status, alarm values, diagnostic data from field devices, serial data (process and diagnostics) from third party devices SOE data etc.

- i) Maximum number of process alarms, operator events and operator messages

Consider 1.4 times the maximum specified parameters. Where no operator-events or operator messages are indicated in material requisition, consider a total of 1000 points for sizing.

- j) Number of Peripheral devices

Consider 1.4 times the maximum number of peripheral devices specified in the configuration diagram.

- k) Maximum number of fieldbus segments

Consider 1.4 times the maximum number of fieldbus segments specified or computed by the vendor, as applicable.


- l) Maximum number of data for UHN and OPC node ( If applicable )

Consider 1.4 times the maximum number of tag data specified in the job specification. Where no separate data is given in the job specification consider through put requirements specified for UHN and OPC node sizing in this specification. The polling rate shall be considered as 1000 tags per second.

- m) Maximum amount of Asset Management data

Consider 1.4 times the maximum data available from field devices for asset management.



	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 62 OF 137		

5.4.9.4.2 While sizing the server / system consider the following operational features;

- a) Number of Operator Console VDU (WS) : 33% of 'A'  
with over view display.
- b) Number of operator console VDU's (WS) with : 33% of 'A'  
trend displays.
- c) Number of operator console VDU's (WS) with graphic : 33% of 'A'  
displays.

Consider 'A' as number of workstations specified in clause 5.4.9.4.1(a) of this specification.


#### 5.4.10 System Operational Response Time

The system shall meet the following response times beyond which the delay may have detrimental effect on the operator's performance;


- System activation or Logging-on of a terminal : 1 sec.
- Display call-up time
  - Simple pages like menu display : 0.5 sec.
  - Graphic page : 1 sec.
- Command execution response : 4 sec
- Data entry error reporting : 1 sec.
- Response to mouse / keyboard commands : 0.5 sec.

### 5.5 Engineer interface sub-system

- 5.5.1 Engineer interface sub-system shall be primarily an engineer's interface which shall normally be used for configuring, tuning and maintenance of the Distributed Control System. This sub-system shall also be used as operator console whenever necessary (e.g. during start-up etc).
- 5.5.2 It shall consist of an Engineering console which shall be able to perform all engineering functions related to each operator console and other sub-systems e.g. controller and data acquisition sub-system, interface devices etc (except PLC for which dedicated engineering console shall be provided). It shall also be possible to configure field-bus function blocks on any segment from engineering console.
- 5.5.3 Each Engineering console shall consist of single or multiple colour 459.7mm active matrix TFT LCD video screens with full integrated audio capability and shall have an integral USB hub. The video screen shall have a native resolution of 1280 x 1024 pixels with wide viewing angle. Each engineering video screen shall be provided with one operator key-board and one engineering keyboard. This, as a minimum shall also have one configuration and maintenance printer.
- 5.5.4 Engineering console shall also have, the capability of an operator console. However, the operation of the plant shall be restricted from this console. All the operator console displays as specified under clause 5.4.3 of this specification shall also be available on Engineering console.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 63 OF 137		

- 5.5.5 Engineering console like any other sub-system shall be capable of communicating with all other sub-systems over the communication sub-system.
- 5.5.6 Engineering console shall have individual dedicated electronics with RAID 5 disk configuration.
- 5.5.7 It shall be possible to perform all system configuration functions and configuration modification functions from the Engineering console typically;
- Data base configuration including overview, group view, loop view, trend view, sequential programming, multi-loop multi-variable control configuration for connection, smart and field-bus based inputs.
  - Group or multi group alarm inhibit from the plant under maintenance.
  - Configuration or re-configuration of alarm settings, their values, addition or deletion of any control block or component in a loop.
  - Compilation of graphic displays.
  - Setting of real time clock.
  - Compilation of logs/reports/historical trend points.
  - To call detailed self diagnostic displays for maintenance aid.
- 5.5.8 Configuration Requirements
- 5.5.8.1 It shall be possible to configure conventional, smart (HART) and fieldbus I/O's and control strategies the same way. The device configuration application for HART and fieldbus devices shall utilize EDDL or FDT / DTM as specified in data sheet. It shall include the following;
- Capability to display all device parameters directly from the device itself.
  - Modify and download device configuration directly to device.
  - Separate display of process values and device alarms.
  - Capability to modify multi-device and download all at the same time.
- 5.5.8.2 Fieldbus HI interface configuration
- The configuration software shall have capability to configure all HI fieldbus interfaces such as;
    - LAS assignment and management
    - LAS scheduling
    - Macro cycle time calculations / optimisation
  - Interface configuration software shall support multiple LAS as a segment. Graphical tool shall be provided which shall provide sequence of execution, execution time of each fieldbus device and overall macro-cycle time.
- 5.5.8.3 Fieldbus Function blocks

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 64 OF 137		

- a) The configuration software shall be able to configure all fieldbus functional blocks available in fieldbus devices.
- b) Function block configuration shall be downloaded from engineering console to field devices on line.
- c) Downloads that will result in change in segment macro-cycle shall proceed with a positive confirmation before the download is allowed.

#### 5.5.8.4 Segment Scheduling

- a) The engineering software shall have capability to carryout segment scheduling against the scheduling constraints such as number of parameters which LAS can transmit during the single cycle.
- b) Response time for an HI segment shall be from 32 $\mu$  seconds to 2.2milliseconds.

#### 5.5.8.5 Automation configuration tool

##### 5.5.8.5.1 The configuration software shall be capable of auto-detection of following I/O devices;

- a) Identification of I/O ports and all types of I/O modules with software configuration defined. If mismatch is detected, an alarm message shall be generated.
- b) Function block configuration tool shall be capable of identifying the installed field devices. An alarm message shall be generated in case of mismatch.
- c) Automatic address and tag name assignment for fieldbus devices. These capabilities shall also include handling of any foundation fieldbus registered device using the device DD and CFF files.

##### 5.5.8.5.2 The system shall be pre-configured to identify the attributes of all I/O interface ports and general characteristics of any connected field device, which comply with FDDL (of latest version) or FDT / DTM as specified.


#### 5.5.9 Tuning of a control loop shall be possible from Engineering as well as from operator console, the location for tuning shall be selected by the operator.

#### 5.5.10 On-line Configuration


The system shall have the capability to copy, store, modify and restore the configuration data on-line without shutting the system partly or completely. The system shall be capable of downloading controller configuration from engineering console without taking controller off-line.

#### 5.5.11 Off-line Configuration

##### 5.5.11.1 It shall be possible to generate system configuration i.e. controller and data acquisition sub-system and display configuration including graphics from an independent PC with windows software loaded. System engineering features like continuous control, advanced controls, displays, alarm, historical functions, logging functions etc. shall be configurable from above station. The configuration shall be possible without the availability of actual engineering station. Configuration generated off-line shall be loaded on to engineering station without any limitation.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 65 OF 137		

- 5.5.11.2 Fieldbus engineering software tool shall be able to perform offline fieldbus engineering by accessing CFF and DD files of field devices without connecting the field devices.
- 5.5.12 During the normal operation, the Engineering console, in no case, shall interfere with the process operation or system software. However any change in the configuration shall be down loaded into the system with proper knowledge of the operator.
- 5.5.13 All detailed diagnostics of the system shall appear on the Engineering console with a print out on the Configuration and Maintenance (C & M) printer. A common diagnostic message on the operator console shall indicate the need of the maintenance.
- 5.5.14 To aid the system maintenance and effective fault identification, following displays shall appear on the engineering console;
- Communication system status display
  - Device diagnostic display and System diagnostics upto module level should be possible from the diagnostic software. The details of system diagnostics are described under para 5.4.5 of this specification.
- 5.5.15 Any special diagnostic package, in addition to as mentioned under para 5.4.5 of this specification, if available with the system shall also be offered. Detailed description and capability of this package shall be supplied.
- 5.5.16 C&M Printer shall be used for printing the configuration or configuration changes, printing system alarms as and when they appear and to print out any engineers command from Engineering console. Hard copy unit, when specified, shall be used to take hard copy of the engineers console screen.
- 5.5.17 The system shall have adequate security features to secure plant operation and DCS data base. Engineering console shall have the following security features, as a minimum;
- Key-lock or password protection for accessing operator functions and engineering functions.
  - Redundant disc and RAID-5 controller configuration
  - Disc interface to enable 'disc down loading' / database or configuration data back-up.
  - Defuncting / inhibiting all functions other than those functions which are required for engineering and operation as defined above.
- 5.5.18 System Back-up and Re-initialization
- The entire control software including control database (application program), system software, source code, schematics etc shall be backed up on system hard disc automatically at a regular interval.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 66 OF 137		

- b) It shall be possible to have a complete back-up of system including the historical data on-demand without interrupting the system normal function.
- c) It shall be possible to have back-ups on remarkable media like CD-RW, DVD-RAM or DVD-RW.
- d) The maximum time acceptable for reloading a device like console is five (5) minutes.

#### 5.5.19 Global database Management and Configuration

5.5.19.1 System configuration software shall provide a common database configuration environment and shall support the following data management facilities, as a minimum;

- a) System design shall follow the data centric approach and shall manage entire system data in global manner. Paths and connections between data objects shall be automatically maintained when configuration is changed.
- b) Whenever the offered system maintains multiple data bases, the design must ensure a close coordination between these data bases such as management of cross reference table and data reconciliation algorithms.
- c) Configuration of operator graphics including management of change tools so that the changes made in graphics are updated uniformly throughout the system.
- d) All control historical trend function configuration and interconnection between data elements in the system without any need to maintain user based cross references.

### 5.6 Communication sub-system


5.6.1 The communication shall be a digital communication network bus, that provides a high speed data transfer rapidly and reliably between the operator consoles, process I/O devices, process computer and other devices connected to it. Each network node shall be capable of communicating with other nodes over the communication network.

5.6.2 The Communication network topology shall preferably be bus structure. Other vendor standard topologies shall also be acceptable provided these meet all the functional requirements specified in this specifications and in the material requisition.

5.6.3 The communication over the communication network shall not be affected even if a node connected to network is powered down or fails to respond. It shall be possible to connect or disconnect a device from the system without disturbing the operation.

5.6.4 The communication sub-system shall be dual redundant, consisting of two separate communication networks and two separate communication system interfaces for each device. The systems requiring traffic directors shall be avoided. However, if unavoidable, dual redundant traffic directors shall be provided


5.6.5 Design shall ensure that there is no cause of common mode failure in communication sub-system.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 67 OF 137		

In general, both the communication networks / devices shall be active at all the times in such a way that either they shall take the communication data load or switch the communication path at regular interval whenever vendor standard data transfer technique allows data transfer to one network while redundant network takes control on the failure of the main network fails. Vendor shall ensure that there shall not be any system degradation or data loss before, during and after the changeover.

Redundant communication network and communication components / modules shall be continuously checked for their availability and healthiness. In case of main bus failure or any communication device failure, the transfer to the back-up device or bus shall be automatic without interrupting the system operation and without any operator's intervention. Information about the failed device / bus shall be displayed on the operator console.

- 5.6.6 Communication network protocol used within the system shall safeguard against false data transfer and allow error detection, recovery failure detection and initiatives of switchover to the redundant network / network component / module.
- 5.6.7 In addition to automatic switchover of communication network on detection of failure of active / one of the network / network device, it shall be possible to switch over the communication from main bus to the redundant bus manually without disturbing the system operation. Manual switchover shall be effected whenever the network integrity and switchover is to be verified during testing.
- 5.6.8 The mechanism used by the communication system for error check, parity error, over-run error etc and other advanced codes.
- 5.6.9 In general, the transmitting message shall identify the transmitting the receiving device. The transmitting device shall receive a reply from the receiving device on the receipt of correct message. Lack of response shall be considered as a receiver failure. These shall be positive acknowledgement of all messages transmitted over the communication network.
- 5.6.10 Communication speed on the communication bus shall be sufficient to update the operator console data base once in every second. The overall system performance shall not be degraded whether communication sub-system is 10% loaded or 100% loaded. Degradation of communication bus shall be as defined under para 2.18 of this specification. Failure of one or more nodes shall not degrade the communication performance in any way.
- 5.6.11 Network Diagnostics
- 5.6.11.1 Network management software shall be resident on all the network modules in order to ensure reporting of node status to other network nodes and reporting node failure alarm within one second.
- 5.6.11.2 Communication network diagnostics shall run continuously so that the failure of any network / network component / communication module is alarmed without any delay.

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR <b>DISTRIBUTED CONTROL SYSTEM &amp; PLC SYSTEM</b>	GSTD-0201	1	
			Rev	
		SHEET 68 OF 137		

The diagnostics sub-routines shall detect and isolate faulty network component and noisy network cables. Communication shall automatically transfer to the redundant component/ module / network whenever the failure is detailed without interruption of system operation and loss of data.

5.6.11.3 Diagnostic sub routines shall be available to monitor the network performance and generate an on-demand report of all the accumulated number of errors over a specified time period.

5.6.12 Network Components and their Requirements

5.6.12.1 All hardware like network cables, connectors, media converters, network switches and hubs and fibre-optic patch-cards required for completing communication network shall be supplied by the vendor.

5.6.12.2 Network can be either screened twisted pair copper and / or fibre optic cable. All network cables shall be armoured type. Fibre optic cable in addition shall be jelly filled for protection against ingress of moisture.

5.6.12.3 Communication network if routed outside the control room shall be fibre optic type only and shall support the use of media converters for fibre optic network. The system design shall allow the use of unequal network lengths in case of redundant network configuration to make-up for the difference in routing lengths.

5.6.12.4 Type and specifications of the fibre-optic cable shall be decided by vendor based on the distance, bandwidth required for data transfer and allowable signal attenuation. Minimum two number of spare fibres shall be provided in fibre optic cable.

5.6.12.5 Fibre optic cable shall always be routed in enclosed HDPE conduit with matching fittings. HDPE conduit shall be as per IS-4984 or as per equivalent IEC code. The outer sheath colour of HDPE conduits shall be orange with black for the fittings throughout the fibre optic cable run.

5.6.12.6 The network devices such as network switches, media converters, connectors etc, utilized in communication sub-system shall be of industrial grade type and of rugged design. These components shall be selected as per the make and model number listed in the vendor standard product guide.

5.6.12.7 The network switches used shall have multiple speed ports (10/100/1000 MBPS) and shall have;


- Multi-processor design for high performance operation.
- Routine diagnostics to detect and isolate noisy cables and jabbering nodes.

5.6.13 Network Loading and OPC Server

Worst-case network loading for the systems supporting determinable protocol shall not exceed 50% while for non-determinable protocol shall not exceed 15%.


5.7 **Open System Connectivity**




	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 69 OF 137		

- 5.7.1 The system shall be capable of interacting with other plant systems and computers over a well established communication network like ethernet (HSE) conforming to IEEE 802.3. This connectivity with the other systems shall always be made via a firewall.
- 5.7.2 The system software shall be support industry standards like Windows, OSF/ MOTIF, TCP/IP etc. as applicable.
- 5.7.3 The method of data access by any user on this network shall be by I/O Tag name and not by any physical or logical address.
- 5.7.4 Whenever the communication network is required to connect to any other system network or to plant information network, fire-wall (hardware and software) and routers shall be used.
- 5.7.5 The system shall be capable of acting as a Dynamic data Exchange (DDE) or OPC client or server to exchange real time data with DDC or OPC compliant application.
- 5.7.6 When OPC is used for interfacing, system shall exchange the data with any client's application in the standard OPC format. Design shall ensure that OPC connectivity tools are fully integrated within the standard product providing seamless integration. Following shall be ensured;
- System shall provide alarm and event information with no point building from other OPC alarm and event server directly into DCS system alarm summary.
  - Allows OPC data access clients to view DCS system data, hierarchical area, point and parameter structure.
  - Allows access to historical data from DCS.
  - Allows third party OPC server information to be mapped, displayed, alarmed, get historical data and controller data into the system server.
  - Integrates supervisory monitoring, alarming and control data between two or more OPC servers.
  - All graphic applications and all control function blocks supported by operator console software shall have direct access to data integrated with DCS via OPC.
  - OPC data groups, items and tags shall be viewable in any browser function provided in graphics, devices or control configuration tools as if it were data native to the controller sub-system.
- 5.7.7 OPC Server



	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 70 OF 137		

- 5.7.7.1 Vendor shall offer integrated or dedicated OPC server in a high grade minimum RAID 5 Configuration only This node in no way restricts the data transfer. In any case, the device shall be intelligent with adequate memory and software capabilities.
- 5.7.7.2 OPC Data Access (DA) Server
- OPC data access server functionality shall allow bi-directional data transfer between multiple OPC data access servers for monitoring, alarming and control. DA server shall read and write process data using item ID is identifier.
  - Rate of data transfer in case of DA server is typically 1000 tags per second.
- 5.7.7.2.2 OPC Historical data access (HDA) Server
- OPC client shall access DCS data by connecting to HDA server. It shall also automatically save instantaneous data acquired from DA server and A&E server to be a historical database in HDA server.
  - HDA server shall be able to receive and publish data timely and efficiently whether online or from archived source. System shall be able to read raw data at the rate of 1000 tags per second and read manipulated data at the rate of 100 data per second.
- 5.7.7.2.3 OPC Alarm and Event (A&E) Server
- OPC A&E server shall publish DCS alarm and events to OPC clients. The server shall support event types such as conditions, tracking and simple events (e.g. component failure). It shall also publish DCS alarm and event such as process alarms, alerts, messages, event, sequence of events and operator changes.
  - OPC A&E server shall write the following messages to DCS, as a minimum;
    - System and process alarm messages
    - Mode change and status change message
    - Sequence message
    - Operator guide message
    - OPC server alarms and errors
    - Engineering maintenance messages
  - The maximum number of alarms and events received by OPC A&E server shall be of the order of 1 A&E per second.
- 5.7.7.2.4 OPC Batch Server
- OPC batch server shall read and write the batch related data and information of DCS.
- 5.7.7.3 The OPC server software shall have the following features, as a minimum;
- It shall meet support standard OPC standard interface functions such as DA, A&E, HDA, Batch and security as specified by OPC foundation.
  - The software shall be able to interact with another OPC compliant software loaded in another Third party server machine associated with different make of DCS or control system without the need of any additional hardware or / and software.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 71 OF 137		

- c) The software shall support automatic data back-up in such a way that process data acquired by DA / A&E server are automatically saved as back-up data on a disc without client having requested to save the data by server.
- d) The software shall allow viewing of contents of OPC server from OPC client.
- e) The software shall have capability to restrict the access of OPC server to its client to avoid exceeding the maximum accessible data to avoid load concentration which may slow down the data access.

#### 5.7.7.4 System Sizing

Following criteria shall be followed for sizing OPC nodes;

- a) Number of third party OPC servers / nodes (This shall include UHN connected to other DCS systems) shall be minimum 10. Ten (10) concurrent licenses shall be supplied as part of OPC node.
- b) In addition to third party servers, consider the following;
 

Number of client per OPC node	:	10
Number of third party OPC devices	:	10 (when specified)
Such as RTU's		
- c) Follow up rate of data read / write shall be considered for sizing;
 

OPC client data read (cache read)	:	1000 per second
OPC client data read access (Device)	:	500 per second
OPC client write	:	500 per second
- d) Maximum number read and write data for OPC node : 2000 data points  
(unless otherwise specified)

One data point shall include PV, MV, SP for analog control loop.

#### 5.7.7.5 System performance


OPC node shall meet the following performance requirements;

- |  |   |                |
|--|---|----------------|
| Data read and write on client machine                  | : | max. 5 seconds |
| (This includes data display update for real time data) |   |                |
| Data read and write on server machine                  | : | max. 5 seconds |
| Maximum server loading                                 | : | 50%            |

#### 5.7.7.6 OPC node configuration shall be minimum RAID -5

#### 5.7.7.6.2 OPC node shall be supplied with operating system and other softwares to meet functional requirements specified herein.

#### 5.7.7.6.3 Whenever OPC node is provided with historisation or dedicated , it shall have RAID 5 configuration.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 72 OF 137		

5.7.7.6.4 The system when specified, shall offer a standalone software application that provides OPC server redundancy by transparently redirecting client requests to secondary OPC server when primary OPC server is unavailable or fails.

## **5.8 Time Synchronization**

5.8.1 The system shall have capability to synchronize the time of all the sub-systems within the system either by internal or external clock as specified in the job specification.

### **5.8.2 Time Synchronization with Internal clock**

Unless specified otherwise, all the sub-system node clocks shall be synchronized with designated system master clock. Master clock shall either be assigned automatically by system or assigned manually during system configuration. In both the above cases, whenever the master clock node fails, an alternate sub-system clock assumes the charge of time synchronization. In no case, the system shall operate without time synchronization.


### **5.8.3 Time Synchronisation with External Clock**

- a) When specifically indicated, the time shall be synchronised with external time reference eg GPS. This shall ensure that data acquired by all sub-systems will have the same and common global time reference. All hardware and / or software required to meet this requirement shall be supplied by the vendor.
- b) In general, the system shall be provided with an external GPS antenna connected to a master clock server. This server shall synchronise all DCS clocks and also provide time synchronising outputs to synchronise all non DCS sub-system clocks. The node shall not exceed 30 millisecond time difference between GPS and any node clock come.
- c) In case of failure of master clock server the time synchronisation shall be carried by the designated DCS master clock.


## **5.9 Shutdown Sub-system - Programmable logic controller (PLC)**

5.9.1 Programmable logic controller shall be microprocessor based system which shall be used to execute all the process and safety shut-down logic of the plant when specified, it shall also execute plant interlock logics as well. Programmable logic controller shall be an independent unit and shall not depend on any of its functionality on any other system including Distributed Control System.

5.9.2 The system shall be designed fault tolerant and shall utilize high quality components of proven quality. Any single system fault shall not degrade the system safety or functionality of effect operation. The system shall have certified Safety Integrity Level as per IEC-61508 / 61511 as applicable and specified in job specification. Unless otherwise specified it meet the availability requirement specified in Clause 5.1.3 of this specification.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 73 OF 137		

- 5.9.3 The system shall have a very high noise immunity in order to ensure safe and reliable operation when subjected to electrical radio frequency interference and Electro-magnetic disturbances expected in a plant.
- 5.9.4 Unless otherwise specified, the scan time of programmable controller shall be of the order of 250 milliseconds. Scan time for a PLC shall be as defined under para 2.21(c) of this specification.
- 5.9.5 Operation of PLC shall be completely unaffected by a momentary loss of power of the order of 20 milliseconds.
- 5.9.6 On line replacement of any module of programmable logic controller shall be governed by Clause 5.1.6 of this specification in general. However, in case of Triple redundant, Quadruple Modular Redundant (QMR) configuration, Flexible Modular Redundant (FMR) configuration, Virtual Modular Redundant (VMR) configuration there shall not be any process upset while replacement of failed module.
- 5.9.7 It shall be possible to Hot swap any faulty system module without degrading the system safety or operation or freezing the output status. The switchover to the healthy module shall be bumpless. The swapped module shall take over the function of the failed module without any manual programming.
- 5.9.8 The system shall be programmed in principle as per the logic diagrams furnished during detail engineering. Vendor shall prepare their own Logic/Ladder diagrams depending upon the capability of the programmable logic controller offered by them. Owner / Consultant reserves the right to revise or review the logic diagrams even after acceptance of any offer. The programming language of offered PLC shall be as per IEC 61131.
- 5.9.9 Whenever the requirement of SIL is specified for the, it shall meet the requirements of SIL level specified and shall be certified by an independent body (e.g. TUV) for complying requirements of IEC-61508 / 61511 as specified. For shutdown application requiring SIL certification, PLC shall always meet SIL 3 requirements.
- 5.9.8 Power supplies in the system shall be provided as follows:
- 5.9.8.1 Each I/O rack shall have a separate independent power supply system. Each power supply shall be sized to take full load of the I/O rack/signal conditioning panel/rack and shall be provided with dual redundant power supply.
- 5.9.8.2 Each processor shall be provided with separate power supply. Failure of one power supply shall not affect the system operation in case of dual processor system. Wherever triple redundant system is specified each processor shall preferably be provided with a separate power supply. Also separate power supply must be provided for each multiplied process I/O channel.
- 5.9.9 System Architecture

	<b>GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM &amp; PLC SYSTEM</b>	<b>GSTD-0201</b>	<b>1</b>
			Rev
		<b>SHEET 74 OF 137</b>	

#### 5.9.9.1 General

- PLC system configuration / architecture shall be as specified in the job specification. For emergency shutdown system application specified with SIL 3 classification, the system configuration shall be TMR QMR, FMR or VMR
- Regardless the action feature selected (except for single architecture), the failure of single component shall not result in a failure of correctly executed safety function. The degradation mode for the selected configuration e.g. 3-2-0 or 4-2-0 or 3-2-1-0 etc. shall be documented in SIL certification report.
- In general, the PLC system shall comprise of various sub-systems as described in the subsequent clauses of 5.9.9.

#### 5.9.9.2.1 Input/Output system

5.9.9.2.2 Each I/O module shall have its own processor working asynchronously w.r.t control processor and other I/O processors. However, I/O modules configured in redundant configuration, shall have their processors properly synchronized.

5.9.9.2.3 Unless otherwise specified, system shall accept analog 4 – 20mA inputs and contact inputs. The maximum number of Input/Output per I/O module shall be limited as per the following table.


Sl. No.	Type of Configuration	Maximum No. of I/Os
1	Single I/O system	8
2	Dual I/O system	16
3	Triple Modular Redundant system (TMR)	32
4	Quadruplicate Modular redundant System (QMR), Virtual Modular Redundant (VMR) configuration	16
5	Flexible Modular Redundant (FMR) configuration,	16

In case of PLC certified for SIL requirements, the maximum number of I/O's shall be governed by the SIL certification applicable for specified SIL level.

5.9.9.2.3 Each I/O shall be galvanically isolated from external control circuit by suitable means. The minimum isolation level between I/O and logic circuit shall be 1000 volts DC.

5.9.9.2.4 Each I/O shall be protected against the reversal of polarity of the power voltage to I/O.

5.9.9.2.5 Each input shall be provided with filters to filter out any noise in the input line and contact bouncing noise, as applicable.

	<b>GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM &amp; PLC SYSTEM</b>	<b>GSTD-0201</b>	<b>1</b>
			Rev
		<b>SHEET 75 OF 137</b>	

- 5.9.9.2.6 All the inputs shall be double ended i.e. two wires per input and not with common return for all inputs.
- 5.9.9.2.7 The interrogation voltage to the inputs and power supply for 2-wise instruments shall be powered from separate redundant power supply / supplies and shall not be a part of PLC, unless otherwise specified. This power supply shall be supplied at one point and shall be distributed by the vendor.

- 5.9.9.2.8 a) Each I/O module shall have a LED per channel to indicate the status of each Input/Output.
- b) When specified, input module shall be capable of monitoring the input contacts for any wire open fault (i.e. 4 – 20mA).

5.9.9.2.9 Analog input module

- a) Input module shall be capable to accept input from transmitters (.e.g. 4 – 20mA ).
- b) The module shall have 12 bit A/D resolution accuracy of  $\pm 0.25\%$  of full scale over the entire range, unless otherwise specified.

- 5.9.9.2.10 a) Output contacts from the PLC shall be potential free dry contacts with contact rating as per para 5.9.9.2.10 b) of this specification. Wet contacts/ powered contacts / TTL outputs etc. shall not be acceptable. Vendor must provide arc suppression device for each output contact.
- b) The output contact rating shall be as follows:

Sl. No.	APPLICABLE FOR	VOLTAGE RATING	CURRENT RATING
1.	All output cards driving solenoid valve and alarm annunciator system unless otherwise specified.	110 V DC	0.5 A
2	All motors/pumps/compressor output cards unless otherwise specified. Category – I Category - II	240 V AC 220 V DC	5.0 A 0.2 A

The category of contacts shall be specified in the material requisition.


- c) Each output shall be short circuit proof and protected by fuse. Visual indication of fuse blown must be provided for each module.
- d) When specified contact output module shall have monitored output features like 5.9.9.2.8(b).

- 5.9.9.2.11 The communication of I/O system with central processor shall be carried out redundant with complete error checking.

- 5.9.9.2.12 Where inputs or outputs have multiple field devices for the same measurement or device, the outputs shall be configured in separate I/O modules.


- 2.9.9.2.13 Where single input signal is available for TMR VMR, FMR, or QMR configuration, inputs shall be multiplied to feed independent inputs to each input modules.

5.9.9.3 Processor system

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 76 OF 137		

- 5.9.9.3.1 The processor shall have capability to implement all the control functions required to implement the logic scheme attached alongwith, as logic/ladder diagram.
- 5.9.9.3.2 The size of the memory shall be sufficient for storage of the program instructions required by the logic schemes and other functional requirements. Offer shall indicate the amount of memory capacity occupied by the actual program and spare capacity available for later program modifications or additions.
- 5.9.9.3.3 Memory shall be non-volatile. However in case volatile memory is provided, battery back up shall be provided with a minimum of 3 months lifetime to keep the program storage intact. A battery drain indication shall be provided at least one week before the battery gets drained. A potential free contact shall be provided for hardwired annunciation in the central control room.
- 5.9.9.3.4 Watchdog timer shall be a software device. The healthiness of processors shall be continuously monitored by watchdog timer. Any hardware or software problem in the processor system, which shall include, CPU, memory, power supply, communication interface etc. shall cause the watch dog timer to report processor failure.
- 5.9.9.3.5 Wherever Qurd redundant processor is specified, redundancy, shall be provided in such a way that in case of failure of the main processor, the standby shall take over automatically. The changeover, shall be bumpless and the system shall be fail proof, unless any other requirement is specified in the job specifications. Redundancy shall be provided for complete processor system including CPU, memory, power supply and communication sub system.
- 5.9.9.3.6 In case of triple redundant system all the three processors shall execute the same instructions / programs and check their results and majority vote to correct any faulty result. The faulty processor diagnostic shall be made available.
- 5.9.9.3.7 In case of VMR, FMR, QMR system, individual processors shall execute the same instructions / programs and check their results within same CPU module and vote to correct any faulty result. The faulty processor diagnostic shall be made available.
- 5.9.9.3.8 Failure of a single processor in triple redundant system and two processors in quad system shall not affect the system. In case of failure of complete processor system i.e. both processors in case of dual configuration, two or more in case of triple redundant system and more than two in case of quad system, outputs shall take failsafe state automatically unless otherwise specified in the data sheets.
- 5.9.9.3.9 In case multiprocessor configuration is offered, the processors must be able to communicate with each other over the interconnecting data link. Vendor must ensure that system performance shall not be degraded by any means when such a system is offered.



	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 77 OF 137		

5.9.9.3.10 It shall be possible to generate the first out alarm contact by the PLC in case where a group of parameters are likely to trip a system.

5.9.9.4 PLC console (Programming)

5.9.9.4.1 The PLC console shall be used for programming, program storing, fault diagnostics and alarm monitoring and should be completely independent of control system(DCS) network /functionality/hardware/software. Whenever specified, it shall also be possible to use this for plant operation. The functionality to operate as engineering terminal or operator terminal or both shall be specified in the material requisition.

5.9.9.4.2 It shall consist of a at least one coloured 21" size TFT screen and one programming / operating keyboard and printer unless specified otherwise.

5.9.9.4.11 PLC console when used for plant operation shall also meet the following functional requirements.

5.9.9.4.3 The keyboard shall preferably be touch sensitive sealed type, easy to operate with each key clearly identified.

5.9.9.4.4 All illegal entries shall be rejected by the terminal and shall be identified by warning signal on VDU.

5.9.9.4.5 Manual forcing of any input or output contact connected to PLC shall be possible from keyboard. Forced functions shall have an associated audit trail.


5.9.9.4.6 It shall be possible to modify, add or delete the application program on line without affecting the outputs.

5.9.9.4.7 PLC Console shall display logic and/or ladder diagram indicating power flow and shall show description and status of each contact. It shall also be possible to display process alarms and diagnostic messages as and when they appear. Further it shall also be able to display I/O map in a user defined format.

5.9.9.4.8 It shall be possible to print out the ladder/logic diagram on the dedicated PLC printer. The printer in addition shall also print out;

- a) The diagnostic messages as and when generated and diagnostic reports, when called for.
- b) Process alarms connected to the programmable logic controller as and when they appear and alarm report whenever initiated. The choice of printing alarms on this printer shall be operator selectable from a key lock switch on PLC console.
- c) The I/O maps showing status of all inputs and corresponding outputs in a user defined format.



	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 78 OF 137		

5.9.9.4.9 The PLC console shall be provided with self diagnostics feature which shall display error messages and initiate an audible alarm if the fault is detected. A potential free contact for diagnostic group alarm shall be provided which shall be connected to the hardwired alarm and annunciator system.

5.9.9.4.10 The system shall be able to identify the failure at least up to the module level including I/O system and redundant processor and report print out.


- a) When PLC console is specified, it shall have complete graphic capacity and shall be used for plant operation, process monitoring and control, fault diagnostics, alarm monitoring and report generation.
- b) At least three number cursor control devices shall be provided in addition to keyboard which may include touch screen, mouse, track ball etc.
- c) PLC operator console shall have complete graphic capability and shall be able to display process dynamic graphics, overview and group view displays. It shall be possible to operate the plant i.e. start and stop of rotating machinery, opening and closing of valves etc. from dynamic graphics and group displays available on PLC operator console.
- d) It shall be possible to monitor, historise and print out all process alarms, diagnostic alarms and alarm reports.
- e) The time stamping of all alarms shall be as per PLC processor time stamping .
- f) The system shall be able to store and display stored data wherever required. The minimum storage capacity shall be for 30 days at 1 minute sample rate for all the inputs specified, diagnostic alarms, process and first out alarms, manipulation data etc.
- g) The system shall be able to generate shiftily, hourly, daily, weekly and monthly reports. The log format shall be furnished during configuration.
- h) The system shall be supplied with first out alarm generation capability. The resolution of alarm shall be as per processor cycle time.

5.9.9.5 PLC Communication Subsystem

5.9.9.5.1 The PLC communication subsystem shall be a digital communication bus that provides a high speed data transfer rapidly and reliably between the processor, I/O sub-system, PLC console and other devices connected in the PLC system.

5.9.9.5.2 Redundancy in PLC communication subsystem shall be provided as follows unless otherwise specified.

- a) The communication subsystem between PLC processor and I/O subsystem shall be single unless otherwise specified. This shall include single communication bus and single interfaces/buffers.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 79 OF 137		

- b) For the triple redundant system, each processor shall have a separate set of PLC communication subsystem.
- c) For the QMR, VMR, FMR systems each I/O subset shall have separate communication interface and bus for connecting to respective CPU module.
- d) The communication subsystem between processor subsystem and PLC console shall be dual redundant, consisting of two separate communication interfaces and two buses, each one configured in redundant mode, unless this is only used as programming aid.

5.9.9.5.3 The mechanism used by the system for error checks and control shall be transparent to the application information / program. Error checking shall be done on all data transfers by suitable codes.

#### 5.9.9.6 Interface with Distributed Digital Control System

5.9.9.6.1 The PLC shall be required to be interfaced to the offered Distributed Digital Control System bus. A suitable interface shall be offered in order to achieve the following functions:

- a) Display of all input points under alarm/first out alarm connected to PLC or generated by PLC on the main operator console.
- b) Generate shutdown reports on the logging printer of Distributed Digital Control System.
- c) To receive certain operational commands from the operator console for the operation of certain output devices connected to PLC.
- d) To display diagnostic messages of PLC.

5.9.9.6.2 In general, PLC shall provide data in a well established protocol format preferably MODBUS protocol.


5.9.9.6.3 The interface shall be dual redundant unless otherwise specified meeting all requirements as specified under para 5.9.9.5.3 and 5.9.9.5.4 of this specification.

#### 5.9.10 System software


5.9.10.1 The system software shall include all programs for the PLC and PLC console which are required to perform all PLC functions including communication and self-diagnostics.

Whenever PLC is specified for shutdown application with SIL classification, the system shall be designed and engineered in full compliance with the requirement of IEC-61511.

Whenever different functional logics are combined within a common PLC, the safety related I/O's of each functionality shall be kept segregated within the system.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 80 OF 137		

- 5.9.10.2 Logic program shall be recorded on the CD which shall be delivered in duplicate together with the system.
- 5.9.10.3 The PLC programming language for implementation of logic operations shall be based on the following representations:
- Logic diagrams - Binary logic symbols such as AND, OR, NOT Gates, Timers and Flip-Flops.
  - Ladder diagram - Series parallel connection of relay contacts.
  - Combination of (a) & (b) above.
- 5.9.10.4 It shall be possible to print out the ladder/logic diagram on a dedicated printer. The printer shall also print out all diagnostic reports. Vendor must supply the off line software package to enable the owner to modify/add/delete any part of program and for documentation.
- 5.9.10.5 Software for the generation of various displays including dynamic graphics, whenever specified, to be provided as per para 5.4.3.5 of this specification.
- 5.9.10.6 The software for printing alarms, system as well as process and events on the PLC printer must be provided. All alarms must be printed as and when they appear.
- 5.9.10.7 Software package for displaying I/O map showing status of inputs and corresponding output as per logic shall be offered. The I/O map format shall be users definable.
- 5.9.10.8 The system shall have an extensive set of self diagnostic routines which shall be able to identify all permanent and transient system faults / failures at least up to module level including redundant components and power supplies through detailed VDU displays and report print out. Diagnostic software shall have the capability to provide information about the failed module/system either in the form of a system configuration display or provide information in the form of a statement.
- 5.9.10.9 System for the following functionalities shall be supplied when specified;
- Long storage historisation
  - Log report generation
  - First out alarm generation
- 5.9.10.10 System diagnostics shall be capable of identifying, locating and reporting the following faults, as a minimum;
- Processor fault
  - Communication fault
  - I/O module fault
  - Power supply fault
  - Over temperature monitoring

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 81 OF 137		

f) Permanently close / open (stuck on or off) fault

g) Scan time failure

h) Memory fault

i) Signal redundancy fault

Any other additional diagnostic alarm if available as standard shall also be provided by vendor.

5.9.10.11 Self diagnostic software shall have capability to detect faults which make the system permanently close/open in the I/O modules or I/O signal conditioning modules (incase of triple redundant system, whenever specified in the job specifications, this may be achieved by automatically running the testing software at cyclic intervals) The automatic cyclic testing feature shall also be provided for dual I/O configuration and dual I/O signal conditioning for triple redundant system. The testing software cycle time may be considered one in 30 minutes however this shall be field adjustable by engineer. However, system performance shall not be degraded whenever testing feature is specified.

5.9.10.12 In case of triple redundant system or quadruplicate system, whenever output module testing software detects any faulty channel, the power supply to that particular module in that particular bank is removed automatically and further testing on the corresponding module in the other mirror image bank is stopped. However, the testing continues uninterruptedly in other output modules.

5.9.10.13 Feedback must be provided in case of triple redundant system and quadruplicate system from the output voter system to detect any latest faults of the system in addition to other diagnostic software as per para 5.9.10.9 through 5.9.10.10 of this specification.

5.9.10.14 Diagnostic package and its related equipment and software shall be supplied. A list of additional diagnostic packages available and the packages provided, including the description and capabilities, shall be provided with separate quote.

5.9.11 Sequence of Event (SOE) Function Requirement


Sequence of Event for analog and digital inputs shall be generated and time stamped in PLC. The maximum resolution between two events shall not exceed specified PLC scan time unless specified otherwise. A separate SOE PC with 21" size TFT screen and laser printer shall be provided for each PLC sub-system unless specified otherwise.

## **5.10 Foreign Device Interface**

5.10.1 Foreign device interface shall be capable to transfer data from the foreign devices like analyser systems, gas chromatographs, gas turbine system etc. to other sub-systems connected to communication sub-system and vice-versa wherever specified in the job specifications.

5.10.2 Each device interface shall be redundant unless otherwise specified in job specifications.

5.10.3 Interface hardware and software shall be suitable to match the foreign device communication requirements like hardware interface, communication protocols etc.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 82 OF 137		

5.10.4 While writing software or mapping the input/output in the interface device it must be ensured that integrity of the data to be transferred like resolution, correctness etc. shall be maintained.

5.10.5 Redundant interface switchover shall be designed based on the type of redundancy available in the foreign devices.

5.10.6 The total responsibility of selection of hardware, writing of software, switchover of redundant interface etc. shall be of distributed control system vendor only. All necessary information, assistance and help shall be rendered by the Foreign device vendor.

5.10.7 The exact requirements of Input/outputs to be transferred shall be as per job specifications.


#### 5.11 **Interface with Smart Transmitters**

5.11.1 System shall be provided with suitable hardware and software to interface with the communication protocol of specified smart transmitters.


5.11.2 In case, smart transmitters are specified with 'HART PROTOCOL', the maintenance data related to these transmitters shall be made available on a separate Personnel Computer. The system shall meet the following requirements as a minimum :-

- a) The system shall allow the maintenance functions like configuration, calibration and monitoring of transmitter's data from the associated personnel computer in addition to Hand held terminal, whenever used.
- b) The hardware used shall allow unrestricted transfer of digital signal without degrading the analog data i.e process variable.
- c) The software supplied shall be 'CORNER STONE' OR EQUIVALENT compatible with the specified transmitter protocol. The software shall allow the following data to be displayed on the PC:-
  - (i) Complete configurational data base of all transmitters including data of commissioning, last calibration, next due calibration etc.
  - (ii) Historical data for calibrations and configuration changes.
  - (iii) Event and log reports.
  - (iv) Multiple authorisation levels for carrying out Configuration changes and Calibration adjustments.
  - (v) Manual editing of data base with Password and /or keylock protection.

#### 5.12 **Hard-wired Instrumentation**

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 83 OF 137		

- 5.12.1 Hardwired instruments shall be stand-alone type and shall meet their functional requirements fully without depending on DCS system. Even power supply and input/output circuits of hardwired instruments shall be totally independent of DCS system.
- 5.12.2 Hard wired instruments shall be microprocessor based. Each instrument shall have as a minimum the necessary firm-ware to meet its functional and operational requirements.
- 5.12.3 Each device shall have its own analog to digital/digital to analog converter.
- 5.12.4 The display of each device shall preferably be bar graph type.
- 5.12.5 Controller shall be digital type capable of performing automatic control based on the set points given locally or from a remote device like another controller or Distributed Control System or Supervisory computer. The controller as an instrument shall also have provision for manually controlling the process by means of a manual loader and cascade-computer auto-manual transfer switch. The operation of the transfer switch shall be procedure-less and bumpless while changing mode from computer to cascade to manual and from manual to auto to cascade to computer. During such a change the output shall not change by more than 1% of span. Controller shall have a facia giving continuous indication of process variable, set value, controller output, and controller mode. It shall be possible to remove an instrument for maintenance without upsetting the process by use of device like service station. Operation of the controller like set point change, manual control, controller mode change shall be possible from the front of the controller. Controller shall be flush panel mounting type on the panel/hard wired console. Configuration and tuning of controller shall be possible through a portable and pluggable configurator.
- 5.12.6 Recorder shall have independent circuit and pen drive assembly for each channel. Recorder shall have capability of continuous line marking or digitized marking of input value with high resolution. Recorder chart drives shall be of multi-speed type and shall be operator selectable. Recorders shall be flush panel mounting type on the panel/hard wired console.
- 5.12.7 Manual loader unit shall have continuous display of process variable and manual loader output. It shall be possible to manually change the output to control valve. Manual loaders shall be flush panel mounting type on the panel/hardwired console.
- 5.12.8 Temperature transducers and trip amplifiers shall accept inputs from standard industrial thermocouple and resistance temperature detector (RTD). Linearization of the thermocouple and RTDs shall be done inside each instrument. Transducers and amplifiers shall be suitable for rack mounting.
- 5.12.9 Alarm cards shall accept standard outputs and shall produce changeover contact output. Each alarm card shall have one continuously adjustable blind setting device. Alarm cards shall be suitable for rack mounting.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 84 OF 137		


#### 5.12.10 Alarm and annunciator system

- 5.12.10.1 The alarm logic shall be executed in single input plug-in type logic modules. Where integral logic has been indicated, the logic module shall be accessible from the front of the annunciator after opening the swing door. The design of each module shall be such that by simply jumpering suitable point, it may be changed from normally open mode of operation to a normally closed mode of operation and vice versa.
- 5.12.10.2 Lamps shall be replaceable from the front. The power consumption of each lamp shall be approximately 10 watts.
- 5.12.10.3 The initiation of alarm condition in the annunciator shall take place approximately 330 millisecond after the condition sensing contact have assumed the off- normal state.
- 5.12.10.4 Hooter, in general, shall be solid state type with audibility of the order of 100 dB at a distance of 3 metres.
- 5.12.10.5 An interruption of power supply for a duration of 20 milliseconds or less shall not affect the functioning of the annunciator.

### 5.13 Instrument Asset Management System (IAMS)

- 5.13.1 Instrument Asset Management System shall facilitate the maintenance management of all smart, field-bus based and conventional field instruments. Unless otherwise specified, the system shall manage the maintenance of following;
- All smart and field-bus based instruments connected to Distributed Control System or Programmable Logic Controller.
  - Conventional (non-smart / non field-bus) instruments connected to DCS or PLC or any other dedicated instruments.
  - Field Instruments other than (a) and (b) above eg. local gauges etc.
- 5.13.2 The system shall include all hardware and software to meet specified functional requirements. In general, IAMS shall be an integral part of Distributed Control System and shall acquire the data from the controller and data acquisition sub-system. Inputs, which are connected to programmable logic controller, shall be parallely connected to DCS in such a way that the hardware used shall allow unrestricted transfer of digital signal without degrading the analog signal.
- 5.13.3 A dedicated IAM console consisting of one video display unit along with a printer shall be provided;
- Display all data related to device diagnostics.
  - Provide historical data for calibration and device configuration / reconfiguration etc.
  - Generate event and other device reports.
  - Manual data entry with password / key lock.

The VDU shall be 21" colour TFT monitor along with a keyboard and a printer.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 85 OF 137		

5.13.4 The system shall support multiple authorisation levels for carrying out configuration charges and calibration adjustment.

5.13.5 The Instrument Asset Management System shall meet the following requirements:

a) Instrument Configuration

It shall be possible to configure, verify the configured parameters, reconfigure, re-range and calibrate / recalibrate the smart and field-bus devices from IAM console.

b) Device Status Monitoring

The system shall monitor the status of all field devices and shall report any maintenance alarm generated by these devices. In general, following shall apply;

- Diagnostic alarms from smart and fieldbus devices shall be classified into device failure and device diagnostic categories.
- Out of limit alarm shall be generated to indicate device failure alarm for conventional devices.

The system shall be capable of displaying and generating maintenance report listing all devices currently under alarm. The report may be generated unit-wise / area-wise or for complete plant.

c) Maintenance database

The system shall be able to maintain maintenance database for all the instruments which shall include date of commissioning, last calibration date, next due calibration. The system software shall have capability to manage and track scheduling of all such maintenance related activities.

The software shall also provide data as predictive maintenance such as list of transmitters experiences excessive drift, list of control valves loosing on shipping characteristics etc.

d) Audit Trail

The system shall have capability to provide an audit trail for a complete historical record of all configuration, calibration and device alert data. This shall include tracking of maintenance history for all instruments in the plant, typically recording the type of maintenance work done, smart and compilation times of activity, person responsible for the activity etc.


e) Advanced diagnostics

The system shall be able to provide advanced diagnostics such as device step response, device signature, dynamic error band etc. special device diagnostic software whenever required (like for smart / field-bus position) shall run in the system.

f) Documentation

System shall generate documentation like trend reports, diagnostic reports, pre-detective maintenance report, audit report, historical data and device specification sheet etc. Definition,



	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 86 OF 137		

engineering, configuration, loading and completion of all reports whether specifically indicated are available as standard and shall be supplied as part of vendor scope of supply.

#### **5.14 Alarm Information Management System (AIMS)**

5.14.1 The purpose of Alarm Information Management System (AIMS) is to provide a centralised Alarm information over and above the requirements specified in Clause 5.4.3.8 of this specification and shall be used for acquiring, sorting, add value and provide redistribution platform, so as to streamline and transform the raw alarm data into intelligent, add actionable information for plant operation personnel.

5.14.2 The system shall acquire inputs from various systems such as;

- Distributed Control System / Systems and Programmable Logic Controllers.
- ESD and F&G Systems
- Package unit control systems
- Machine monitoring and Analyser system
- Electrical control system / systems
- Electrical numerical relays
- Any other system defined specifically in the job specifications.


5.14.3 Unless otherwise indicated, the AIMS shall have a high speed data transfer OPC link connectivity with the systems. Where OPC link is not available, the data transfer shall be through dedicated serial links. In addition, AIMS shall also have capability to accept hardwired inputs.

5.14.4 Unless otherwise specified, the following type of data shall be acquired by the AIMS software for further analysis;

- Process and utility alarms
- System diagnostic alarm
- Sub system status alarms
- Operator activities
- Maintenance alarms

The AIMS shall offer a variety of alarm handling feature for processing, and presenting alarms in most efficient way. The package shall be a comprehensive tool with capabilities of;

- a) Logical filtration of alarms during normal and special operating conditions such as start-up, process upset and turndown conditions.
- b) Logical processing of events and sequence of events for facilitating quick assessment of normal or emergency situation based on pre-defined rule-sets.
- c) Generation of different levels of alerts, based on type of alarms, sequence of alarms,

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 87 OF 137		

logical processing of alarms etc. and propagation of the same to different groups and categories of personnel's, based on pre-defined alarm distribution matrix.

5.14.5 AIMS shall meet the following functional requirements, as a minimum;

5.14.5.1 Data Acquisition

The data acquired from the various sub-systems and other control systems shall be stored in a dedicated AIMS server. The data shall be stored in a structured format and shall contain tag number, time of occurrence, text information like service description, event type, alarm priority, alarm group priority etc.

5.14.5.2 Alarm Computing

The package shall have capability to generate / compute alarms based on a logical combination of states, conditions and events.


5.14.5.3 Information Analysis

The package shall have capability to analyse and present only the meaningful information. This shall include the following;

- a) Analyse the alarm frequency within the predefined period and its repetition period.
- b) Analysis of various alarms to identify nuisance, chattering and redundant alarms and eliminate them, if necessary.
- c) Analysis of various alarms to identify serious alarms and monitor their frequency of occurrence.
- d) Monitoring Operator actions.

5.14.5.4 Expert Alarming

- i) The system shall be able to carry out statistical analysis on the alarms data gathered and perform;
  - Real-time frequency analysis
  - Alarm frequency break-up
  - Alarm frequency monitoring
  - Standing alarms
  - Time elapsed between two alarms / events
- ii) The system shall have capability of implementing rule sets to analyse various alarms / data and inform plant operator the probable reason, make recommendations for the action to be taken and provide operational alternatives.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 88 OF 137		

iii) System shall also be capable of analysing and recommending maintenance requirements based on preset rules.

iv) The system shall have advanced search and sort features to provide quick access of alarm data to operator.

#### 5.14.5.5 Alarm Prioritisation

The system shall have the capability to segregate the alarms as per their criticality and operational importance, which may be defined as per the severity with respect to its;

- Production losses
- Human and equipment safety
- Environmental safety
- Process reaction time like run-down reactions

The alarms shall be differentiated in different displays by allocating different colour codes.


The system shall be able to be configured with different priority levels which shall be defined based on the process criticality and operational requirements. As a minimum following priority levels shall be definable;

- Level 1 - Alarms directly related to human safety – leading to heavy casualties
- Level 2 - Alarms directly leading to total plant shutdown – personnel, environmental and equipment safety hazard.
- Level 3 - Alarms leading to partial plant trip conditions.
- Level 4 - Maintenance alarms not leading to immediate plant trip.
- Level 5 - Status or low priority alarms for operator information.

Other priorities shall also be user definable. It shall also be possible to set priority for each and every alarm point. Assignment or change of level of priority shall be possible only under password protection.

Number of alarms under each level of priority shall be user definable. However, for the purpose of internal assignment, following numbers may be considered

Priority Level	No. of Alarms
Level 1	10 Nos.
Level 2	70 Nos.
Level 3	5% of Total
Level 4	20% of Total
Level 5	75% of Total

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 89 OF 137		

#### 5.14.5.6 Alarm Display

- a) AIMS shall display alarms gathered from all Nodes / subsystems seamlessly and shall be displayed on any display irrespective of source or location.
- b) Alarm display shall be sorted out in the form of alarms groups in the following categories;
  - Priority level sorting
  - Sorting as per type, frequency, unit-wise, area wise and operating area wise.
- c) AIMS displays shall be in graphic form with user friendly displays, color modifiers etc.
- d) The system shall process alarms using well proven analysis techniques, directly related to specific alarms, which are trendable.


The system shall have advanced Rule-based and latest abnormal condition management tool which shall provide prediction and anticipation of plant deterioration with sufficient lead time for operation action. The system shall also have real time root cause analysis.

#### 5.14.5.7 Operator Actions

The system shall be able to acquire and analyse operation action required during plant operation such as;

- Time to alarm acknowledge
- Controller mode changes
- Controller set point changes
- Analogue output changes (in manual mode)
- Discrete output changes (in manual mode)
- Alarm level of priority changes
- Range changes
- Tuning constant changes
- System configuration changes e.g. control algorithm, cycle time changes etc.
- Manual time adjustment
- Alarm acknowledgement
- ESD switch actuation (full or partial)
- Any other operator action not specifically indicated above but required during operation. The operator actions shall also be categorised based on their criticality in various levels.

Level – 1            - Most critical operator actions leading to plant shutdown in full eg.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 90 OF 137		

ESD switch action.

- Level – 2      - Configuration changes or set point changes which may lead to mal Operation or partial plant shutdown eg. set point changes, range Changes, time adjustment etc.
- Level – 3      - Changes which may effect control but rarely could lead to plant Shutdown full or partial eg. controller mode change, range changes, tuning constant changes etc.
- Level – 4      - Actions which are mere operation but does not lead to plant operation.

The system shall also able to provide information like;

- i) Time to acknowledge alarms
- ii) Alarm acknowledge time exceeding a pre-set value.

#### 5.14.5.8 Report Generation Printing

The package shall have capability to;


- a) Store alarm messages for a period of minimum one year and shall have facility for data archival on portable media.
- b) AIMS shall be capable of generating and printing reports in user defined formats. The data in each report shall be either raw, manipulated, calculated, compressed or analysed.
- c) The alarm shall be possible to be printed as and when required, as a user defined formats. These formats shall be defined during engineering.

#### 5.14.5.9 System Diagnostics

The AIMS shall have extensive set of diagnostic subroutines running in real time basis and shall provide at least the following diagnostic alarms;

- System software failure
- Disc / Disc drive failure
- Application software failure
- Network failure
- Communication software failure
- Disc full
- Power supply failure

These diagnostic alarms shall also be made available at DCS operator and engineering consoles.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 91 OF 137		

#### 5.14.5.10 Data Storage and Archival

AIMS shall store alarms and events indicated in Clause 5.4.6 for a period of minimum 1 (one) year in the hard disc. Multiple disc configuration, if required, shall be provided for the purpose of calculating data storage capacity consider occurrence of 30% of alarm and events per day apart from other system defined functionalities.

#### 5.14.5.11 Alarm Notification and Audio Messaging

The system shall be capable of performing following alarm notification and messaging functions;

##### a) Dial Telephone

In case of predefined alarm or alert condition the system shall automatically dial a telephone number and plays a pre-recorded message. All hardware and software for auto-dialing shall be included.

##### b) Dial a Cell phone

The system shall have facility to dial up mobile pager or mobile cell phone. When an alarm occurs, the system shall be able to send a test (SMS) message also.

##### c) E-mail

When a predefined alarm occurs, the system shall be able to send message through an e-mail to the predefined user. This facility shall also be utilised to send e-mails to the manufacturers of various system oriented items like DCS, PLC etc in case of occurrence of a critical system diagnostic alarm.

##### d) Audio Messages

The system shall be capable to play a pre-recorded message in case of predefined critical alarms on the plant public address system. For example, this shall be useful for alerting plant personnel's on gas / fire alarm in a particular area.


##### e) Emergency Hooters

The system shall be capable of generating input such that in case of an emergency condition emergency hooters can be initiated along with audio messages on the public address system.

#### 5.14.6 System Hardware & Software

##### 5.14.6.1 AIMS shall have all the hardware and software to meet the following major functional requirements;

- a) Efficient storage and archiving of acquired and manipulated data to allow retrieval of reports or alarm analysis information.
- b) Retrieval of important information on-line to a network drive disc or dedicated device.
- c) Remote access to more than one clients on the network.

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR <b>DISTRIBUTED CONTROL SYSTEM &amp; PLC SYSTEM</b>	GSTD-0201	1	
			Rev	
		SHEET 92 OF 137		


- d) Export alarm, events or other information to other applications, Excel or Access.
- e) Advanced diagnostic techniques for analysis of acquired data.
- f) Log the time between specified alarms / messages.
- g) Assignment of various level of pass-ports.
- h) Multiple client's displaying different data or data screens simultaneously.
- i) Disc mirroring for data storage over the network.
- j) Automatic Triggering of alarm reports and messages on devices like mobiles, telephones, computer networks etc.
- k) Data search facilities with efficient search engines like SQL.
- l) Data sorting facility as per defined rule-set.
- m) Time stamping of data as per AIMS clock wherever required.

5.14.6.2 AIMS can be realised on either the DCS platform or as a stand along system. In either case the offered solution shall meet all the requirements specified in MR without exception.

5.14.6.3 In case AIMS functionality realised on DCS platform a separate dedicated AIMS station shall be provided. This station shall have same hardware and software configuration as operator console and shall have redundant storage disks for bulk data storage.


5.14.6.4 In case stand-alone system is considered, the same shall meet the following requirements;

- a) The system shall be capable of interaction with DCS via a serial port or by OPC connectivity.
- b) The system shall have a minimum of one dedicated server with monitor and cursor control devices capable of meeting all functional requirements for AIMS. If the system demands more than one server to meet job requirements, the same shall be supported and provided.
- c) The AIMS console shall be server based machine and shall have 21" LCD display screen with keyboard, mouse and read / write DVD drive.
- d) The system shall support client server architecture with minimum of 4 clients. Detailed functionalities of these clients shall be finalised during engineering. The clients shall also meet hardware and software requirement specified in Clause 5.14.6.4(c).
- e) AIMS server shall have redundancy in storage discs for bulk-data storage.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 93 OF 137		

- 5.14.6.5 In general, all alarms and events shall be transferred to AIMS with time stamped by the originating devices. AIMS shall maintain this time for further analysis. AIMS shall time stamp the acquired data only when this data is not transferred by the originating device with time stamp.
- 5.14.6.6 The AIMS connectivity to third party devices and systems shall be either from the control network (i.e. communication sub system) or from the serial ports available in these devices. For third party systems direct connectivity from the station having master database is preferred.
- 5.14.6.7 When multi drop serial link connectivity, not more than four (4) devices shall be multi-dropped on one serial link to server.
- 5.14.6.8 AIMS shall have sufficient flexibility in hardware and software to interface a variety of peripheral devices, these include but shall not be limited to;
- Printer to be provided and attached to the server or client for printing reports and alarms.
  - Public Address system for automatic broadcasting of alert messages in pre-designated areas. (The package shall be supplied with a voice package, which shall automatically broadcast the message as the occurrences of the particular alarm).
  - Fixed line EPBAXs and Mobile telephones
  - Horn and / or beacons for Audio / Visual alarming.
- 5.14.6.9 AIMS server memory shall be sized suitably to display and printout the alarm history of all the tags of all the systems and sub-systems connected to it.
- 5.15 Unit History Node (UHN)**
- 5.15.1 UHN shall primarily used to carryout the following activities;
- a) Store automatically gathered data from control system (DCS, PLC, etc), other DCS systems over OPC and manually entered data.
  - b) Present data in a meaningful manner for performance enhancements and fault analysis.
  - c) Long term historisation of data for future reference and decision making.
  - d) Carryout calculations on the real time and stored data, as necessary.
- 5.15.2 The UHN shall be a high capacity data storage device where data from various process units shall be stored in a fast access database. The node shall support standard open system interfaces like OPC, SQL, OLE, DDE and shall provide active X facility.
- 5.15.3 UHN shall collect data from;
- a) Distributed Control system of which this UHN is a node.
  - b) UHN's of other control systems
  - c) Nodes other than UHN's connected on information network.
  - d) Manually entered data.



	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 94 OF 137		

The data collected shall be of various types like process variable, set point, computed variable, manipulated data, outputs, alarms, events, which shall be used for long term storage, trending and report generation.

5.15.4 UHN shall have capability of storing real time data in real time database and shall perform functions like;

- a) Identification of bad data (algorithm to run in UHN when necessary)
- b) Specify dead band and data sampling rate (or collection rate) as user definable parameter.
- c) Calculate maximum, minimum, average, summation, and, integrated values of collected data. The time period of calculating average shall be user definable.
- d) Specify high / low, high – high / low – low alarm limits for triggering an event or message or alarm as applicable.
- e) Specify damping parameter, delay parameter etc. to reject unwanted data.
- f) Specify data storage / sampling rate and period of storage necessary for historical storage of data.
- g) Mathematical functions and application program as specified in material requisition which are necessary for report generation. (This does not include advanced control functions but do include MIS reports)

All the parameters indicated or functions performed shall be definable tag number wise.

5.15.5 Data Management and data presentation

5.15.5.1 UHN shall act as a network server and shall support two way data communication between;

- a) DCS and UHN for real time data transfer. UHN shall acquire real time data from DCS and provide derived and calculated data to DCS.
- b) UHN and information network to transfer data from other systems on information network to UHN and vice versa.

5.15.5.2 UHN provides the user with current raw and calculated / manipulated data on predefined graphic screens or pre-defined report formats. The graphic screens and report formats are user configurable.

5.15.5.3 UHN perform long-term historization of raw and calculated / manipulated data.


5.15.5.4 The data received or sent from the UHN shall have time stamp associated with it from the originator of the data. The data update is effected in case the data value has changed by more than the configured dead band since the last update.

For manually entered data, the time stamp shall be time of entering data (by default) or the time entered with the data as applicable.

5.15.5.5 UHN time shall be synchronized with DCS time clock. For time synchronization refer clause 5.8 of this specification.

5.15.5.6 UHN shall maintain relational database and shall support oracle ROBMS tool.

5.15.5.7 All data raw, manipulated or manually entered acquired or calculated by UHN shall be stored, as unit-wide historian. Historian can be accessed to retrieve the data from specified period in the past.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 95 OF 137		

Historian should have capability to store data for a period of one year (365 days) with a sampling rate of 30 seconds, as a minimum. Other sampling rates such as 1 minute, 5 minutes, 10 minutes and 1 hour shall also be possible. The duration of on-line storage shall be controlled by the archiving facilities which in turn shall be dependent on specified sampling rate.

5.15.5.8 The data shall be presented to the user in a well structured hierarchically configured user displays. User shall be able to navigate down to any detailed data displays without any system configuration knowledge.

The display structure may include;

- a) Overview display or main menu display, displaying key process parameters and performance indicators like real time data, swap-shot, calculated variables, real time trend, historical trends, manual data entry, function block, alarm and events, reports etc.
- b) The reports generated shall include both tabular and graphical type (i.e. trend and bar graph). The reports as a minimum, shall include shiftily, daily, weekly, monthly and yearly reports. The report formats and specific data shall be finalised during system configuration stage.

5.15.6 System Administration and Security functions

5.15.6.1 The system shall perform the following administration functions;


- a) System start-up and shutdown
- b) System configuration and configuration changes
- c) System diagnostic alarm management
- d) Archiving and storing history data.
- e) System back-up and system restoration from back-up.
- f) Manning user and security files.
- g) Maintenance sub-routines and manipulation of data in the database with Audit.

5.15.6.2 UHN shall provide a full data security guarantee and shall be equipped with proper fire wall security features. For details refer clause 5.1.12 of this specification. Typically firewall shall be CISCO system appliance firewall (PIX) and software (IOS) or equivalent.

5.15.7 System Configuration

5.15.7.1 UHN shall be higher grade RAID 5 server machine with preferably Xeon CPU. The selected UHN hardware platform shall meet system throughput and capacity requirements. As a minimum, the system hardware shall meet the following requirements;

- a) VDU shall be 459.7 mm active matrix TFT type coloured LCD screen.
- b) QWERTY keyboard with SCSI interfaces
- c) Mouse or track-ball control
- d) Memory as 1GB RAM and 80GB hard disc (HDD) and shall support DAT and DVD / CD ROM.
- e) Clock speed as 2.4 GHZ
- f) Coloured laser printer

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 96 OF 137		

5.15.7.2 The system shall be supplied with a robust operating system and all supporting softwares necessary to meet functional requirements specified here in including RDBMS such as oracle or SQL with TCP / IP as network protocol.

#### 5.15.8 System Sizing

Following criteria shall be followed for sizing UHN;

- a) UHN shall interact concurrently with minimum 10 number of users in addition to DCS (of which UHN is the node) and clients main computer. Unless otherwise specified, ten concurrent user licenses shall be supplied along with UHN node. For the purpose of sizing consider at least 20 concurrent users.
- b) The data shall be accessed from remotely located data sources through information network or through auto-dialing with proper ID address and password protection. The rate of data access from / to this network shall be considered as 1000 tags per second.
- c) The data access from DCS shall be all 1.4 times the all analog (PV, MV, SV) and digital tags accessed at the rate of 1000 tags per second.
- d) UHN historian shall be sized considering following factors;
 

Storage data	:	2 times the total analog (PV, MV, SV) and digital data of all DCS connected tag number (through hardwiring, serial ports, fieldbus etc.
Storage time	:	1 year (365 days)
Storage rate	:	30 seconds for all data
Storage interval on RAM:		20 minutes

#### 5.15.9 System Performance

5.15.9.1 The response to all online enquiries and actions from any user shall be complied with 95% confidence level from any client with a maximum of 20 concurrent users as defined in clause 5.15.8(a) of this specification shall be as follows;


- a) A data query to display on graphic or report : 5 second
- b) Pre-defined trends up to 1hour data : 5 seconds
- c) A data query to present a 24 hours report : 10 seconds

5.15.9.2 Average loading shall not exceed 50% when averaged over 15 minutes with peak loading at any time not to exceed 70%.


5.15.9.3 All securities shall be positioned while evaluating system performance.

### 5.16 Sequence of Event Recorder (SER)

5.16.1 Sequence of event recorder shall be provided for recording sequence of alarms / events for shutdown inputs.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 97 OF 137		

- 5.16.2 The inputs for sequence of event recording shall be handled as follows;
- The maximum number of inputs for I/P module shall be 32.
  - The contact inputs (either open or close on alarm) shall be multiplied using dual output contact barrier one of which contact shall be connected to PLC while the other contact is routed to SER. Wherever necessary, fast response multiplying relays may be used (certified by SER manufacturer)
  - For analog input, the signal shall be connected in parallel across the conditioning resistance to PLC or dual output barrier and to a dedicated alarm card, the contact of which shall be routed to SER.
- In case analog input are to be routed to different physical locations or more than two devices, analog isolators shall be used.
- 5.16.3 SER shall be capable of providing demonstrable alarm resolution of 1millisecond between the events and shall also be able to print out the same with similar resolution.
- 5.16.4 The contacts or alarm may be close or open on failure and must be configurable for close / open on failure.
- 5.16.5 The SER system shall be capable of providing alarm monitoring, printing and inputs for management packages. The configuration of inputs and other functions mentioned above shall be carried out using a dedicated terminal, which is also provided with a printer. Once configured, the access to configuration shall be denied except with 3 level of password protection.
- 5.16.6 All the trip / alarm settings should be same as that of PLC in all respects. The accuracy and resolution of measurements and settings are to be equal or greater than that of PLC.
- 5.16.6.7 Vendor shall make a provision to connect PLC outputs to SER recorder whenever necessary and decided during engineering with proper isolation.
- 5.16.8 There must be 20% installed and wired spare input channels up to the marshalling cabinet for each type of input / output of DCS, PLC and other systems.
- 5.16.9 The system must have facility of keeping at least 96 hours of record at the time with last in and first out facility.
- 5.16.10 It shall be possible to configure / modify / reconfigure the system online through a dedicated programming unit. Engineering shall be possible to engineer the system using menu driven fashion. Any addition and deletion of inputs should be menu driven only and should be possible to be done during running condition.
- 5.16.11 It shall be possible to archive data from the SOE recorder on tape drive / CD drivt. CD driver and CD writer along with all necessary software shall be part of system supply by the vendor. The CD driver and CD writer must be with latest hardware and latest software.
- 5.16.12 The system shall have an extensive set of diagnostic package, which shall be able to provide the fault alarms up to the module level. The same shall be also printable on the laser printer.
- The system shall be able to generate an audit report, which can be printed on demand. The audit report shall be able to provide shutdown area, time of shutdown and reason for shutdown.
- 5.16.13 Sequence of events shall also record PLC shutdown outputs.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 98 OF 137		

## 5.17 Large Screen

5.17.1 The Giant Screen (Large screen) in the control room, is primarily used for:

- Display important operational data of the plant /unit for ready reference like daily production, shutdown required /requested etc.
- Display operational situations like start up or shutdown to enable managers / operators to discuss without disturbing the unit operator.
- Display any operator screen on the large screen.
- To provide real time clear luminous view of the unit to share information's between operators, unit managers and refinery manager.
- To hold demonstrations to visitors for ready impressive and effective plant overview and plant highlights.

5.17.2 The giant screen shall be installed in the control room wall. The size of the screen shall be approximately 3200mm(L) X 1300mm(H) as a minimum.


5.17.3 The giant screen system shall have the following specifications:

- The screen design shall be based on single chip DLP technology.
- Optical system shall have a resolution of 1024 pixels X 768 pixels Colour pixels per cubic. Each cube shall have a screen diagonal of 70 inches with 16.7 million colours

The lamp shall be pre-adjusted in lamp module, which shall not require any readjustment after replacement. The minimum operational time of lamp shall be 8000Hrs.

They shall be able to provide uniform brightness of 95% with a contrast 250:1, which shall be able to provide high contrast even in bright ambient light.

- The display screen shall be seamless and flicker less. It shall be black or grey in colour. The brightness and contrast shall remain uniform irrespective of the number of cubes used.
- The control of screen displays shall be carried out either from the operator console. The signal transfer shall provide guaranteed disturbance free operation, which shall not effect sharpness and colour quality.
- The giant screen shall be lightweight and low thickness type, which can be supported from the control room wall. Only the front access shall be provided for any maintenance.
- The system shall perform satisfactorily in ambient conditions with maximum temperature of +40 degree Celsius and 80% non-condensing humidity.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 99 OF 137		

vii) Provision of automatic switch off of Giant screen if temperature in the console room increases above the maximum permissible limit for Giant screen is required.

viii) VDU shall be provided with the Giant screen Control station.  
Ethernet card shall be provided in Giant Screen to connect it with Ethernet port for necessary functionality.

5.17.5 The Giant screen system shall be interfaced with the system such that any operator display of any screen could be displayed on the Giant screen suitably. It shall meet the following requirements;

- i) Any operator console display or all operator console displays shall be able to be displayed or switched as desired.
- ii) Screen areas should be protected for each console group.
- iii) Priority of displays should be assignable.
- iv) The system shall be supplied complete with all hardware and software as necessary for the specified application including interface software for DCS.

## **6.0 MISCELLANEOUS REQUIREMENTS**

### **6.1 Safety requirements**


6.1.1 Unless otherwise specifically indicated in job specification, all the equipment covered in this specification shall be located in general purpose non hazardous area, normally in control room or / and satellite rack room. However, transmitters, process switches and final control elements including smart positioners, solenoid valves etc. I/P converters (not forming part of this specification) shall be located in the field and shall be specified as per the electrical area classifications.

6.1.2 Unless otherwise specified, intrinsically safe certified transmitters, smart positioners, field-bus devices, and I/P converters shall be used when located in hazardous area.

#### **6.1.3 Intrinsic Safety Protection**

6.1.3.1 I/O modules of Distributed system shall have either built in intrinsic safety or shall use external barriers for intrinsic safety. Safety barriers shall also be used whenever intrinsic safety is specified for contact inputs and solenoid valves. Barriers shall not be required when protection other than intrinsic safety are specified.

6.1.3.2 The system as a whole shall be intrinsically safe based on entity concept. It may be noted that the field instruments are being bought separately and can be of different make and models by different recognised statutory body. These details shall be furnished during detailed engineering. Safety barriers selection shall be carried out based on the entity (safety) parameters which shall be properly matched. Field-bus segment terminator shall be considered for evaluating intrinsic safety of a segment. Any

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 100 OF 137		

limitation or special requirements for cables to meet the intrinsic safety requirements shall be brought out in the offer.

#### 6.1.3.3 Conventional or smart Instrumentation

- a) Whenever intrinsic safety is specified for conventional and smart instrumentation entity parameters of the elements in loop shall be matched with the barrier safety description parameters (i.e. loop design as per entity concept).
- b) In case of smart transmitter, the entity parameters of the hand held terminals shall also be considered while selecting proper barriers.
- c) Unless otherwise specified all intrinsically safe barriers shall be isolating type only providing isolation between;
  - i) Input and output (non-hazardous to hazardous side of barriers)
  - ii) Power supply and input
  - iii) Power supply and output

The minimum isolation level shall be 250V. In case of I/O modules have built in barriers, I/O modules shall also meet the requirements specified in Clause 6.1.3 of this specification.

- d) Unless specifically indicated, only single channel barriers shall be selected. Following shall apply;
  - i) Dual input barriers shall not be selected
  - ii) Single input and single output barriers shall be selected.
  - iii) Single input dual output shall be selected when specifically indicated.


#### 6.1.3.4 Field-bus instrumentation

- a) Whenever intrinsically safe field-bus system is specified with Entity concept, safety parameters of various items in the segment shall be matched with the selected barrier.
- b) Whenever FISCO system is specified, all components in the segment is FISCO complied, segment power supply selected shall also meet FISCO compliance. Segment design shall also meet FISCO requirements.
- c) Whenever non-incendive is specified, all components in the segment shall be FINICO complied including segment power supply.

6.1.4 All intrinsically safe barriers shall be of the isolating type only, shunt diode type of safety barriers shall not be used. Only single channel type of barriers shall be used.

## 6.2 Power supplies and distribution



	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 101 OF 137		

#### 6.2.1 System Power Supply

6.2.1.1 Unless specified otherwise, the system shall operate on uninterrupted power supply (UPS). However the system shall be capable of operating satisfactorily at the following power supply specifications :

Voltage	:	220 V AC $\pm 10\%$
Frequency	:	50 Hz $\pm 3$ Hz
Harmonic contents	:	Less than 5%
Power interruption	:	10 millisecond

Various main load centres of distributed control system may be sequentially started whenever the starting current are high. The requirement of sequential starting shall be specified in job specification. The sequential starting circuit shall be designed using hardware timers and contactors of adequate rating.

6.2.1.2 The system shall be supplied with dual DCS feeders each capable of handling 100% of the total power supply load requirements. The system shall be engineered such that;

- The redundant systems / sub-systems shall be powered such that main and redundant components are powered from separate UPS feeders.
- The non-redundant components / items shall be powered from either of the feeders, unless otherwise specified in the job specification.
- In case of failure of one feeders, redundant feeder shall supply the total load.

6.2.1.3 Each power feeder shall be monitored for its voltage and current in DCS, the transducers required for the measurement shall be located in power supply distribution cabinet/cabinets.

In addition to above, following indication / alarms shall also be provided for each feeder;


- Voltmeter, ammeter and power-on-lamp on the cabinet front of respective power supply distribution cabinet.
- Power failure Alarm contacts for such feeder for DCS monitoring.
- One common power failure alarm contact for alarm on hardwired console.

#### 6.2.2 DC Power Supply

6.2.2.1 DC supply shall be generally used for ESD devices and shall be 24V DC as specified in job specifications. In general, DC supply shall have the following specifications;

Voltage	:	24V $\pm 10\%$
Harmonic Contacts	:	...



	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 102 OF 137		

6.2.2.2 Each DC power supply feeder shall be monitored for its voltage. The voltage transducer shall be installed in the DC supply distribution cabinet.

6.2.2.3 In addition to above, following indications and alarms shall also be provided for each DC supply feeder;

- a) Voltmeter installed on the respective DC power supply distribution cabinet.
- b) Power failure alarm contacts for each feeder for DCS monitoring.
- c) One common power failure contact for alarm as hardwired console.

6.2.3 Non-UPS Power Supply

6.2.3.1 Non-UPS power supply shall be generally used for panel / cabinet / console lighting, power sockets. The voltage shall be 240V 50Hz power supply. In general, 240V 50Hz Non-UPS power supply shall follow the following specifications;

Voltage : 240V  $\pm$  10%

Frequency : 50Hz  $\pm$  3%

6.2.3 All cubicles lighting shall be on 240 V, 50 Hz normal power supply.

6.2.4 Power supply shall be made available at one point. Further power distribution network shall be designed such that a single power fault in any instrument branch system shall not cause a trip of the entire system. Each consumer shall be provided with a separate switch and fuse for isolation and protection of the system.


6.2.5 Each transmitter shall preferably be powered with individual power supply. However when several transmitters are powered by a common DC source, each power supply branch shall have a separate switch and fuse. The distribution network shall be designed in such a way that overload in any branch shall not trip the main power supply. Enough redundant power supplies/battery banks shall be provided which shall take over automatically in case of main common power source failure. All power supplies shall have one to one redundancy and shall be sized for full load.

### **6.3 Equipment assembly**

6.3.1 General

6.3.1.1 All system equipment like instruments, electronic modules, power supplies, barriers, relays etc shall be installed in either of the following enclosures / cubicles as specified in purchaser's job specifications. The layout of these enclosures shall be prepared considering proper accessibility and maintainability;

- a) Control Panels

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 103 OF 137		

All indicating types of dedicated instruments like single loop controllers, indicators, recorders, alarm annunciators, manual loading station manual switches etc shall be installed on control panel when control panel is the operator interface or when specifically indicated in the job specifications.

b) Hardwired Console

All indicating type of dedicated instruments like single loop controllers, indicators, recorders, alarm annunciators manual switches shall be installed on hardwired console when hardwired cosole is the operator interface or whenever specifically indicated in the job specifications.

Hardwired consoles form the part of main operator console and shall have same design, dimensions, colour, and shape as operator consoles.

c) System cabinets

All system hardware (excluding consoles) shall be installed in system cabinets. This shall include system racks, system modules, communication modules, power supply modules etc.

System cabinets shall be pre-standing type and shall be freely accessible from front and / or back as required. Following system cabinets shall be required, in general;

- i) Power distribution cabinet (for AC and DC distribution).
- ii) Safety barrier mounting cabinet (when field instrument is intrinsically safe).
- iii) Controller and data acquisition sub-system cabinet.
- iv) Temperature converter trip amplifier and other auxiliary card mounting cabinet.
- v) Shutdown system cabinets (PLC processor and I/O cabinets)
- vi) SER Cabinet
- vii) Marshalling cabinets


Free issue items mounting cabinet (for mounting items which are free issued to vendor)

6.3.1.2 In general, control panels and hardwired consoles supplement the operator consoles for plant operation. Those instruments which provide direct operating interface to the plant operator are installed on these enclosures / cubicles.

In contrast, system cabinets generally house back and items / equipments / instruments which are not required by the plant operator for direct operation.

6.3.1.3 Mechanical Design

6.3.1.3.1 As far as possible, panels / cabinets / consoles shall be manufactured using standard modular design and standard equipment. Vendor may follow their standard manufacturing procedures, however following points must be ensured;

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 104 OF 137		

- a) All nuts, bolts, screws, washers (lock or flat) and hinges shall be of stainless steel. All fastening links shall also be of stainless steel.
- b) Document pocket / wallet shall be provided on the inner side of front and rear doors of each cabinet and on the inner side of the door of each panel. Similar arrangement shall also be made on the inner side of doors of console.

#### 6.3.1.3.2 Control Panels

- a) Control panels shall have self-supporting free standing cubical construction with back doors made up of sectional steel panels. Two doors shall be provided for each panel, as standard.
- b) Each panel section shall have the following dimensional details;

Height : 2000mm

Width : 1200mm


Depth : 1000mm

Panel shall be rigidly mounted on 100mm high channel base.

- c) The panel shall be fabricated using angle iron frame section of minimum 50mm x 50mm x 4.0mm size. The control panel front shall be fabricated preferable from 3.0mm cold rolled carbon steel sheet.
- d) Unless otherwise specified the panel shall be straight face type. Desk type panel shall be supplied where specified. Case shall be taken to ensure that the face of the panel is truly float and smooth.
- e) Panel painting procedure shall include sand blasting, grinding, chemical cleaning, surface finishing by suitable filler and two coats of high grade lacquer with wet sand blasting between coats. Two coats of paint in the panel colour shall be provided. Final coat shall be given after assembly at site of non-glossy high satin finish when specified in the job specifications. Colour of the panels shall be as per job specifications.
- f) Normal mounting heights of instruments (centre lines of instruments to floor) on panel shall conform to the following, with minor adjustments depending upon instruments selected.

1	Miniature and sub-miniature instruments. (3 rows)	Bottom Row Middle Row Top Row	1100 mm 1350 mm 1600 mm
2	Annunciators		1950 mm
3	Electrical push buttons		700 mm

- d) Door locking arrangement

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 105 OF 137		

All doors of cabinets / panels / consoles shall have flush mounted handles with key operated mechanical door locking arrangement. The locking arrangement shall be interchangeable and shall have common key for locking / unlocking all locks (master keying arrangement).

e) Internal lighting arrangement

Internal illumination shall be provided for all panels / cabinets / consoles to ensure proper illumination level of 250 lux for performing maintenance activities.

Fluorescent lamps shall be provided in each cabinet / console / panel which shall be activated individually by door operated magnetic switches. The lamps shall activate when door is opened and deactivate when the door is closed. The magnetic switches selected shall have undergone life cycle cyclic test of at least 10,00,000 operations. A manual over-ride switch shall be provided inside the panel / cabinet / console which shall keep the lamp deactivated even when the door is open. Panels / cabinets / consoles housing memories, which are likely to be effected by fluorescent light, shall have incandescent lamps.

The cabinet / panel / console lighting shall operate on 240V AC emergency power supply.

f) Utility Sockets

Each cabinet / panel / console shall have at least one number each of 240V AC (emergency power) and 220V AC, (UPS) power socket. The sockets shall be rated for 10A as a minimum.

g) Ventilation


In order to effectively remove dissipated heat from the cabinets / panels / consoles, ventilation fans along with vent louvers backed by wire fly screen shall be provided as required. Ventilation fans shall be provided in all cabinets / panels / consoles where the temperature rise with all doors closed and all internal and external loads energised shall exceed 10°C above the ambient temperature. A temperature element (resistance temperature detector) shall be provided in each cubicle for temperature measurement. Ventilation fans shall be provided in dual configuration, as a minimum.

Each fan shall have a separate dedicated assembly and shall be replaceable on-line without shutting down any equipment / panel / cabinet / console in part or in complete.

Ventilation fan assembly shall operate at 240V AC emergency power supply. Each fan shall have its own dedicated circuit breaker.

Each ventilation fan shall be fitted with a protection type finger guard. Whenever, the number of panels / cabinets / consoles are compacted (supplied in mechanical joined conditions), each panel / cabinet / console shall be provided with separate ventilation fan assembly.

The maximum noise level with all fans operating and cubicle doors open shall not exceed 85dBA.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 106 OF 137		

Following signals and alarms shall be provided for each panel, cabinet and console separately;

- i) Fan failure alarm for each cubicle in DCS.
- ii) Temperature indication of each cabinet or compacted combination, as applicable in DCS.
- iii) A common alarm each for high temperature and fan-failure on hardwired console.
- h) Earthing

Each cubical (panel / cabinet / console) shall be provided with earth bus bars of at least 15 x 5 square mm cross-section for the following;

- i) Electrical earthing (non-isolated earth) where all metal components like all cabinet panels, doors etc shall be connected.
- ii) System earthing (isolated earth) where cable shielding of all cables shall be earthed. System earth bus bar shall be isolated from electrical earth and also from metallic doors, panels etc.
- iii) DC earth (isolated earth) where cable shielding of all 110V DC shall be earthed. DC earth shall be isolated from electrical earth, system earth and also from metallic doors, panels etc.
- i) Lifting lugs

All control panels and system cabinets shall be provided with removable lifting lugs to permit lifting of panels / cabinets. The panel structure / frame shall be designed to permit panel / cabinet lifting without deformation. The normal working load of the lifting lugs shall be more than 1.5 time the panel / cabinet load. The eye bolts shall be certified for their normal working load.

Panels / cabinets shall also be supplied with plugs which can be fitted after the lifting lugs are removed after their placement.

- j) Name Plates

All panels / consoles / cabinets shall have name plates fixed on the front, back and inside with following details;


Front and Back : Tag number and description

Inside : Manufacturer's name, purchase order number and year of manufacture, port number of manufacture.

All other details shall be as per clause 5.1.22 of this specification.

#### 6.3.1.3.3 System cabinets

- a) All the cabinets shall be free standing, enclosed type and shall be designed for bottom entry for cable connection. Cabinets structure shall be sound and rigid.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 107 OF 137		

- b) Cabinets shall be equipped with front and rear access doors. Doors shall be equipped with lockable handles and concealed hinges with pull pins for each door removal.
- c) Each cabinet shall have the following dimensional details;

Height : 2000mm  
Width : 600mm / 1200mm  
Depth : 800mm

Cabinets shall be rigidly mounted on 100mm high channel base. Construction shall be modular preferably to accommodate 19" standard electrical racks. All racks shall be of same height. Maximum swing out for doors and drawers shall be limited to 600 mm.


- d) Cabinets shall be fabricated from cold rolled steel sheet of minimum 2 mm thickness suitably reinforced to prevent warping and buckling. Doors shall be fabricated from cold rolled steel sheet of minimum 1.6 mm thickness. Cabinets shall be thoroughly deburred and all sharp edges shall be grounded smooth after fabrication.
- e) Equipment, within the cabinet, shall be laid out in an accessible and logically segregated manner. All metal parts of the cabinet including doors shall be electrically continuous and shall be provided with a common grounding lug.
- f) Cabinet painting procedure shall include sand blasting, grinding, chemical clearing, surface finish by suitable filler and two coats of high grade lacquer with wet sand blasting between the coats. Two coats of paint shall be provided. Colour of the cabinet shall be as per job specifications.

#### 6.3.1.3.4 Electrical Wiring

All the cabinets, consoles and panels shall be completely wired and/or tubed, as required. Interconnections shall preferably be done with the help of pre-tracked cables. Vebdir may follow their standard wiring practices, however the requirements specified herein must be complied.

#### 6.3.1.4.1 Terminals and Terminal Blocks

- a) All terminal / terminal blocks shall be DIN Rail mounted type and shall be easily removable. The size of the terminal blocks / terminals of different types shall be consistent and identical.
- b) All terminal blocks shall be mounted on suitable anodised metallic or plastic stand-off.
- c) Terminal strips shall be arranged group-wise for incoming and outgoing cables separately. Terminal blocks for intrinsically safe wiring shall be separate. 20% spare terminals shall be provided, as a minimum, preferably in each terminal strip.
- d) Terminal housing shall be strictly sized with considerations for accessibility and maintenance. Minimum distance required between various components are listed below. These distances are clear distances, and are excluding the width of the raceways or any other component / item mentioned herein. Following clearances should be considered;

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 108 OF 137		


- i) Distance between terminal strip and side of the cabinet parallel to the strip, up to 50 terminals, shall be minimum 50mm.
- ii) Distance between terminal strip and, top and bottom of the cabinet shall be minimum 75mm.
- iii) Distance between two adjacent terminal strips shall be minimum 100mm.
- iv) Additional distance for each additional 25 terminals shall be minimum 25mm.
- v) Distance between cable gland plate and the bottom of the strip shall be minimum 300mm.

#### 6.3.1.4.2 Terminals

- a) Terminals shall be non-hygroscopic type made up of unbreakable fire-retardant, safe extinguishable, halogen free polyamide compound of VO grade of 960°C. These shall be manufactured as per IEC-60947-7-1.
- b) Terminals shall be suitable for wires up to 2.5 sq. mm base solid or standard conductor in general. For power cables, higher size terminals shall be used.
- c) The metal parts of terminals shall be of high quality (pure electrolytic) copper and shall be tin or nickel plated (of thickness up to 15 micron). The contact terminal resistance shall be of the order of 0.3 multi ohm.
- d) The spring material for all terminals shall be chrome nickel spring steel of high tensile strength and of excellent corrosion resistance.
- e) Voltage withstand capacity of the terminals shall be up to 4KV for 60 seconds as per IEC/EN-60664-1.
- f) Field side terminal blocks in marshalling cabinet shall be cage clamp interruptable (i.e. disconnect) terminals providing necessary polarity distribution, protection, test point and earthing.

#### 6.3.1.4.3 Wiring Requirements

- a) All wiring shall conform to SPI RP 550 Part-I, Sections 7 and 12. Different signal level cables shall be routed under false flooring with separation distances as recommended by API RP 550 Section 7.
- b) All wiring inside racks, cabinets, and back of the panels shall be housed in covered, non-flammable plastic raceways arranged to permit easy assembly to various instruments for maintenance, adjustments, repair and removal.
- c) All wiring in the raceways shall be properly clamped. All incoming cable shall be terminated by vendor at marshalling rack with cable glanding including supply of cable glands. Total wiring cross-sectional area shall not exceed 50% of the raceway cross sectional area.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 109 OF 137		

- d) Separate wiring raceways shall be used for power supply wiring, DC and low level signal wiring, and intrinsically safe wiring. Parallel runs of AC and DC wiring closer than 300mm shall be avoided.
- e) Vendor can alternately offer prefabricated cables for interconnection between different cabinets and panels.
- f) Wire termination shall be done using self-insulating crimping lugs. More than two wires shall not be terminated on one side of single terminal. The use of shorting links for looping shall be avoided.
- g) No splicing is allowed in between wire / cable straight run.

#### 6.3.1.3.5 Hardwired console


- a) Hardwired console shall be non-graphic self supporting, free standing cubicle with back doors and shall be designed for batter cable entry for connections. Console structure shall be sound and rigid.
- b) The design and dimensions of hardwired console shall strictly match with the operator consoles. For designing hardwired console, following points must be ensured;
  - No instrument or switch shall be installed on the horizontal portion of console.
  - Horizontal portion of console shall be spill proof, as well as scratch proof. Materials other than metallics can also be accepted for horizontal portion provided this can provide rigid, hard, flat and smooth surface. This shall require the purchaser's approval prior to deciding the material.
  - In order to reduce number of hardwired consoles, vendor may utilize back-lighted switches and miniature instrumentation and annunciator windows.
- c) Whenever the operator consoles are specified with table top design instead of console type of design, the hardwired console shall be identical and symmetrical to the operator console design.
- d) Panels/hard wired console shall be fabricated preferably from 3 mm thick cold rolled steel sheet. Angle iron frame shall use a minimum section of 50 x 50 x 4 mm angle.
- e) Cabinet paint procedure shall include sand blasting, grinding, chemical cleaning, surface finish by suitable filler and two coats of high quality lacquer with wet sand blasting between two coats. Two coats of paint shall be provided. Colour of hardwired console shall be as specified in job specification.

## 6.4 Earthing

6.4.1 All system equipments such as panels, marshalling cabinets, system cabinets and other powered equipments shall be provided with following type grounding system;

- a) Protective Earth / Electrical Earth
- b) System earth / signal earth



	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 110 OF 137		

c) Safety earth / ZB earth (when required)

d) SPD Earth


Both system earth and safety earth shall be totally separate from protective earth.

#### 6.4.2 Protective earth / Electrical earth

- a) Earth metallic enclosure / cabinet / panel / console etc shall be provided with electrical earth lug, as a minimum. Door hinges, flexible conduits or self-detachable connectors shall not be considered path for earth connectivity/earth return paths. Separate earth lug or permanent connectivity shall be considered.
- b) Unless recommended otherwise by vendor, all earthing lugs of metallic equipments indicated in Clause 6.4.2(a) above shall be connected individually to electrical protective earthing system bus-bar / earthing station using a maximum of 10sq mm solid copper conductor PVC installed wires.
- c) Where multiple cabinets are multiplexed together, earth looping with permanent shorting link cables shall be acceptable. Two earthing connection wires as indicated in Clause No.6.4.2(b) above shall be used for connecting multiplexed cabinets to protective earth station / bus-bar.

#### 6.4.3 System Earth

- a) System earth shall be totally noise free dedicated earthing system and shall be fully isolated from electrical protective earth. This earth must be very high integrity system and shall be used to ground zero volt references and signal cable grounds.
- b) System earth shall be less than one (1) ohm grounding system with its own dedicated earthing pits. These earth pits shall be away from any heavy noise plant equipment. Outside the control room building is the most appropriate location.
- c) The earth pit design shall be as per IS-3043 code of practice for earthing. A minimum of four (4) number of earth pits shall be provided for grounding system integrity. In case number of pits required to meet 1 ohm resistance are more than (2), the number of earth pits shall be two times the actual number of pits required to meet resistance criteria. All these pits shall be security connected with each other to form a one homogeneous system earth grid.
- d) Each marshalling / system cabinet / panels etc shall be provided with system earth bus-bar which shall be insulated from the metallic body frame. This bus-bar shall be used to earth also signal zero volt references and signal cable screens. Terminals used for termination of

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 111 OF 137		

spare conductor pairs / cores of multi-pair signal / control cables shall be connected to system earth bus-bar. Shorting links shall be used for spare terminal looping.


- e) System bus-bars in the multiplexed cabinets can be joined together by permanent shorting links. System bus-bars of other cabinets can also be connected together provided they are permanently joined using 35 sq mm stranded copper conductor cable in a looped both ends except for the following exceptions;

#### 6.4.4 Safety earth / Zener barrier earth

- Whenever Zener barriers are selected or used to meet intrinsically safe requirements, the earthing terminal of the zener barriers shall be connected to a separate earth bus bar.
- This earth shall meet all the requirements specified in Clause 6.4.3 of this specification.
- Safety earth bus bar shall be directly connected to earth pits using dual insulated cable. Cable conductor size shall be minimum 95 sq. mm (copper).

#### 6.4.5 SPD Earth

- SPD earthing terminals are connected to separate earthing bus bar in the cabinets.
- This earth shall meet all the requirements specified in Clause 6.4.3 and 6.4.4(c) of this specification.


	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 112 OF 137		

## **PART - II**

**TESTING, INSTALLATION, COMMISSIONING**


**AND ACCEPTANCE OF**

**DISTRIBUTED CONTROL SYSTEM**

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 113 OF 137		

## CONTENTS

Sr.NO.	TITLE	PAGE NO.
1.0	SCOPE	117
2.0	FACTORY TESTING AND ACCEPTANCE	118
2.1	General	118
2.2	Testing details	118
2.2.1	Phase - I	118
2.2.2	Phase - II	120
3.0	INSTALLATION, TESTING AND COMMISSIONING	127
4.0	SYSTEM ACCEPTANCE	131
5.0	FINAL ACCEPTANCE TEST	132
6.0	TESTING / CALIBRATION EQUIPMENTS	132

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 114 OF 137		

## 1.0 SCOPE

- 1.1 This specification defines the basic guidelines to Distributed Control System vendor for factory testing and acceptance, installation, commissioning and field acceptance of the fully integrated system.
- 1.2 These guidelines shall also be applicable to all sub-systems and hardware bought by DCS vendor.
- 1.3 On the basis of this specification, vendor shall submit detailed testing and acceptance procedures specifically applicable for their system. The procedure shall include both hardware as well as software testing and acceptance methodology covering following details;

### a) Hardware Testing;

The procedure shall include;

- i) Test name
- ii) Purpose of Test
- iii) Test equipment
- iv) Test set-up (Block diagram)
- v) Input definition
- vi) Test procedure
- vii) Results expected
- viii) Acceptance criteria.

### b) Software Testing;

The procedure shall include;


- i) Test name
- ii) Purpose of Test
- iii) Test equipment
- iv) Test set-up
- v) Sequence of Execution
- vi) Results expected
- vii) Acceptance criteria

The procedure shall not omit any column as indicated above in the procedure submitted. Indicate 'NA' whenever any column is not applicable. Additional requirement, if any may be include, as applicable.


- 1.4 The testing and acceptance of the system shall be carried out on the approved testing procedures and criterion based on this specification and vendor's standard testing requirements and procedures.

## 2.0 FACTORY TESTING AND ACCEPTANCE

### 2.1 General

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 115 OF 137		

- 2.1.1 Vendor shall test and demonstrate the functional integrity of the system hardware and software. No material or equipment shall be transported until all required tests are successfully completed and certified “Ready for Shipment” by the owner/consultant.
- 2.1.2 The purchaser reserves the right to be involved and satisfy himself at each and every stage of inspection. The purchaser shall be free to request any specific test on any equipment considered necessary by him although not listed in this specification, as a part of approval of factory testing procedure. The cost of performing all tests shall be borne by the vendor.
- 2.1.3 Vendor to note that acceptance of any equipment or the exemption of inspection or testing shall in no way absolve the vendor of the responsibility for delivering the equipment meeting all the requirements specified in Material Requisition.
- 2.1.4 It shall be vendor’s responsibility to modify and/or replace any hardware and modify the software if the specified functions are not completely achieved satisfactorily during testing and factory acceptance.
- 2.1.5 Failure of components/ modules/ sub-systems during Testing
- 2.1.5.1 Vendor shall not replace any system component/module/sub-system unless it is failed. A log of all failed components/modules in a sub- system shall be maintained which shall give description of the failed component/module, effect of failure on the sub-system, cause of failure and number of hours of operation before it failed.
- 2.1.5.2 If malfunction of a component/module in a sub-system repeat, the test shall terminate and vendor shall replace the faulty component/module. Thereafter the test shall commence all over again. If even after this replacement, the sub-system fails to meet the requirements, vendor shall replace the full sub-system to the one meeting the requirements and the system shall be tested all over again.
- 2.1.5.3 If a sub-system fails during the test and is not repaired and made operational within four hours of active repair time after the failure, the test shall be suspended and restarted all over again only after the vendor has replaced the device in the acceptable operation.
- 2.2 The factory testing and acceptance shall be carried out in two phases i.e. Phase I and Phase II. The schedule for the testing shall be submitted by the vendor for both Phase I and Phase II separately. The minimum requirements for testing during these two phases are as follows:
- 2.2.1 Phase-I
- 2.2.1.1 Vendor shall perform tests at his works to ensure that all components function in accordance with their respective specifications. A test report shall be submitted to the owner/consultant for review within one week of completion of testing giving details. Phase II testing (witness inspection) shall start only after.
- 2.2.1.2 All sub-systems shall undergo a minimum of 30 days (720 hours) burn-in period. The system shall be offered for factory acceptance only after it has completed the specified burn-in period. The requirements shall be as follows;
- a) The burn-in time shall start after the sub-system is fully assembled and is powered up. It may include any such time for which the system has been kept powered on even for system generation and Phase I testing.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 116 OF 137		

- b) Burn-in period log report shall be maintained by the vendor clearly recording sub-system (Tag No. / Identification No.), date and time of power-on, date and time of power-off, failed component (if any) with identification, communicative power-on time and sign-off. In case power to the sub-system is switched off because of any reason, the same shall be recorded in this log report.
- c) Vendor shall submit burn-in period log report as part of Phase I test report for purchaser's review.

2.2.1.3 All the test results shall be recorded in the test log report. The test logbook shall contain the following information about the tests:

- a) Date/time
- b) Assembly /loop tag number
- c) Test input
- d) Test results and sign off with personnel name
- e) Action required (if deficiency is detected)
- f) Action taken, date of completion and sign off
- g) Special test methods (including special equipment requirement, bypasses used etc.)

2.2.1.4 Test details

Following tests shall be performed by the vendor and report shall be forwarded to the owner/consultant.


2.2.1.4.1 Quality control test

- a) Quality control tests shall be carried out to assure quality of all components and modules in accordance with vendor's quality control and assurance procedures. QA / QC test methodology shall be in accordance with relevant international standards and practices. Vendor shall forward the details of these procedures for purchaser's review.
- b) The sampling procedures for all purchased components or components manufactured by the vendor shall be in accordance with the vendor standard quality assurance / quality control procedures.
- c) All assemblies shall be aligned and adjusted before conducting tests. All tests shall be carried out as per manufacture's published / established testing methods and shall be recorded in a test logbook. The test logbook shall be duly signed by the QA / QC manager.

2.2.1.4.2 System power-up tests

All sub-systems shall undergo complete functional testing as part of Phase I power-up testing. Testing shall include, but not limited to, the following;

- a) System hardware functional testing including redundancy, wherever applicable, as per vendor standard testing procedures
- b) System software testing as per vendor standard testing procedure including builder functionality.
- c) System performance on power supply variations as per vendor standard procedures.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 117 OF 137		

d) Application, Software testing;

Complete application programme generated by the vendor specific to the job shall be tested by simulating inputs. This shall include the following, as a minimum;

- Database verification including loop configuration as per approved functional schematics.
- Display verification including dynamic graphics and hierarchical displays.
- Trending, real time and historical, functionality and assignment.
- Logging and report generation
- Serial port assignment and its proving
- Security functionalities, as applicable e.g. password functionalities, fire-wall protection
- Testing of third party equipments (if applicable)
- Verification of logic diagrams
- Alarm management verification
- Any other software verification necessary for the offered system, as per vendor standard.

e) System Diagnostic verification

All the test results shall be recorded as per Clause 2.2.1.3 of this specification.

## 2.2.2 Phase II (Witness Inspection)

### 2.2.2.1 During Phase II testing, all the hardware and software shall be systematically, fully and functionally tested in the presence of purchaser representative.

All the sub- systems shall be interconnected to simulate, the totally integrated system as close as possible. Vendor purchased items (third party equipment) e.g. programmable logic controller, sequence of event recorder, alarm information management system etc shall also be integrated with the system. Free issue item, if any supplied by purchaser to the vendor for integrated factory acceptance test, shall also be integrated with the system. Barrier cabinets shall be used as the connecting points for the test inputs and outputs.


### 2.2.2.2 The duration of Phase II testing shall be communicated by the vendor along with day wise testing schedule to the purchaser. System shall be shipped to site only after the successful completion of this testing and the system is certified 'ready for shipment' by purchaser.

### 2.2.2.3 Data review:

Purchaser shall review the following documents before starting the witness Inspection (Phase II));

- a) The latest document revisions, based on which vendor has generated the system, to the current data. Any revision or changes required shall be informed to the vendor before starting the witness inspection.
- b) Test reports of all bought-out items by their respective manufacturers.



	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 118 OF 137		

- c) The test report/log book forwarded by vendor after Phase-I testing. Owner / consultant has right to witness any test performed in Phase I, if found necessary.

#### 2.2.2.4 Testing record

- a) During testing of Phase II, each test carried out shall be recorded. Any deficiency or problem observed during testing shall be clearly recorded and corrected thereafter.
- b) Vendor shall prepare a punch list report listing out all the action points. All punch list actions must be completed before system dispatch.
- c) Any change in the data or configuration etc informed to the vendor during testing by purchaser shall be recorded and modifications required shall be carried out by the vendor.

#### 2.2.2.5 Visual and mechanical testing.

Visual and mechanical testing shall be carried out in principle to assure correct, proper, good and neat workmanship by the vendor. This testing shall include the following, as a minimum;

- i) Dimensional verification
- ii) Sheet thickness
- iii) Layout verification as per approved GA drawings
- iv) Quality of painting (outer and inner)
- v) Nameplates, identifiers and tag plates
- vi) Adherence to ferruling philosophy.
- vii) Dressing of wires / prefabricated cables and clearances
- viii) Locks and handles

#### 2.2.2.6 Verification of Bill of Material (BOM)


Hardware and software including bought-out items shall be available for verification with the bill of material (BOM) document submitted by the vendor during engineering. Vendor must obtain purchaser's prior approval if any sub-system or bought-out equipment / item can't be made available during Phase II testing i.e. witness inspection. The verification of BOM shall include the following;

- a) Hardware verification

The verification shall include verification of all hardware including mandatory spares as per the model numbers and quantities indicated in bill of material document. Items which can't be identified with model numbers, shall be verified with manufacturer's serial numbers. In all such cases, vendor must ensure that the serial number has been indicated against all such items in the BOM document.

- b) Software verification

The verification shall include verification of licenses and their numbers for all softwares as listed in bill of material document. All licenses shall be in the client's name. Number of copies of as built application programmes shall be verified at the time of site acceptance test and not during factory acceptance test.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 119 OF 137		

All system hardware including network interfaces and all software including operating system, console software, network software, complete application software etc. shall be installed and tested as part of function testing.

#### 2.2.2.7 Functional testing

All system hardware including network interfaces and all software including operating system, console software, network software, complete application software etc. shall be installed and tested as part of function testing.

Functional testing shall include the simulation of inputs and outputs to verify proper system response for both analog and discrete signals. Unless otherwise specified, at least 20% of I/O's shall be simulated in controller and data acquisition sub-system while all I/O's shall be simulated and corresponding logics shall be verified in case of Programmable logic controllers. The I/O sampling shall be at random and shall be selected by the purchaser during testing. The testing, as a minimum, shall include the following:-

a) Complete system configuration loading.

b) Controller and Data acquisition Sub-system

Demonstration of all controller functionalities verification and data acquisition sub-system functions from local as well as from central level including;

- Changing control algorithms
- Changing control mode and controller action
- Changing alarm limits
- Controller tuning using tuning trend.
- Controller tuning using auto-tuning package and change in tuning package and change in tuning parameters either automatically or manually.
- Output status on controller failure.
- Setting of macro-cycle time for fieldbus segment.

c) Scan time verification of scan time values for controllers and data acquisition sub-system and PLC testing shall be carried out by simulating the inputs as follows;


- i) Open or close the contact input as per logic execution requirements.
- ii) Step input or slow ramp input (typical frequency of 4 cycles / second) with amplitude corresponding to 16mA (4mA to 20mA or vice versa) for all conventional analog and smart (HART) inputs from a signal generated.

The processor cycle time setting and the processor loading shall not exceed the specified limits while verifying scan time.

Checking of scan time values for controllers and data acquisition sub-system and PLC;

The inputs to the system shall be;

- Step input i.e. 0 or 1 for all contact inputs.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 120 OF 137		

- Step input or ramp input for all analog inputs

The processor cycle time setting and the processor loading shall not exceed the specified limits while verifying scan time.


Control cycle time shall be measured by simulating a segment with transmitters and positioners in the worst case fieldbus segment (w.r.t number of transmitters and positioners) and scheduled activities.

- d) Checking of correct change-over of the back-up units in case of main unit failure. This shall include the following:-
  - i) Uninterrupted controller operation shall be verified even during and after switchover of back-up device. The failed controller Database, point records, inputs and outputs of the failed main controller shall be transferred to the back up controller without any interruption. The same shall be repeated for transfer back from back up controller to the main controller. Maximum transfer time shall not exceed the specified value. The test shall be repeated for controller all redundant devices including input /output modules.
  - ii) Uninterrupted data transfer from main communication network and communication interfaces to the redundant ones shall be checked. The transfer back from back-up device or back-up communication network to main network or interface shall not be automatic (automatic transfer from back-up device / network to main device / network shall also be acceptable in case the changeover procedure is flawless and smooth). This test shall be repeated for all interface units in the system including foreign device interfaces.
  - iii) Uninterrupted operation of system shall be checked on failure and resumption of any of the power supplies where redundant power supplies are provided.
  - iv) Uninterrupted operation of the system incase of redundant H1 module, power supply conditioners and LAS functionality.
- e) Checking of controller loading
 

Controller loading shall be verified as displayed by the system by simulating as many as inputs to simulate worst case data transfer condition.
- f) Simulation of fieldbus segment
 

At least one fieldbus segment of each type (e.g. foundation fieldbus, profibus etc) shall be simulated as applicable. The segment shall include at least one device of each make and model number being used in the project (purchaser shall identify and provide the device to vendor for segment simulation). Following minimum tests shall be carried out;

  - i) Inter operability test to ensure correct data transfer between devices of different makes and host (i.e. DCS).
  - ii) Control cycle time verification as per specifications.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 121 OF 137		

- iii) Control loop functionality when control algorithm is configured in DCS and in a field device i.e. positioner and in transmitter.
  - iv) Verification of functionality of control input data transfer along with fieldbus converter by simulating inputs.
- g) Functional verification of cursor movement devices
 

Verification of correct functioning of all keyboards, mouse, touch screens, light pen etc shall be carried which shall include;

  - i) Smooth functioning of all devices.
  - ii) Functional commands verification
  - iii) Dual function key configuration.


The devices shall include those attached to operator console, engineering console, PLC console, personal computers, other sub-systems / accessories.
- h) Verification of loop configuration
 

Data base and the configuration of all the loops shall be verified for their correctness with respect to range, limits, engineering units, alarm set points, software configuration, output status of controller / control block failure etc with respect to latest revisions of instrument details and functional schematics / P&ID's supplied by purchaser.
- i) Verification of Displays
 

All types of displays, process as well as system, configured on operator console, engineering console and PLC console shall be verified with respect to correct display configuration, colour scheme, colour modifiers, engineering units, windowing feature, alarms, flags, restricted operation etc.
- j) Verification of functionality of accessories
 


All the accessories like printers and hard copiers shall be verified for their proper operation by printing either test data or actual data.
- k) System Diagnostics
 

System diagnostics shall be thoroughly checked for all sub-systems on local level as well as on operator/engineering console. These shall include diagnostics of failure of main as well as redundant items such as a sub-system, sub-system module, HI module, LAS functionality, power supply, interface unit, network and network module, consoles, third party device interfaced with DCS, printers, hard copier, server failures, key-board / cursor movement devices, disc and disc drives, field-bus devices, field-bus segment, network devices etc. and other detailed diagnostics and their corresponding displays. Diagnostic alarms for any ventilation fan failure, cabinet temperature high and corrosion monitor shall also be verified.
- l) Verification of Application programme

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 122 OF 137		

Following application programming shall also be verified thoroughly in addition to the complete loop operation by simulation;


- i) Verification of trending and trend displays.
- ii) Verification of historisation functionalities
- iii) Verification of alarm management
- iv) Verification of data retrieval functionalities.
- v) Verification of all dynamic graphics.
- vi) Verification of interchangeability between various video screens of a console.
- vii) Synchronisation of system clocks.
- viii) Verification of various log formats and log reports including MIS reports as applicable.
- ix) Complete (100%) verification of interlock and shutdown logic by simulating inputs and verifying outputs preferably using simulator, other related functions like forcing, first out shall also be verified.
- x) Verification of third party device (like PLC, analyser system, computers, MMS, F&G systems etc) interfaces for complete data transfer between device and DCS and vice versa. Where third party devices are not supplied by vendor (and cannot be provided by purchaser for conducting factory testing), the complete address mapping shall be verified and the link shall be proved using third party device simulation.
- xii) Verification of data and reports related to instrument asset management system.
- m) Verification of other specific requirements when specified like;
  - i) Large screen functionality and display solution shall be verified along with large screen controller. Where large screen is not available during factory acceptance test, vendor may utilize a PC in place of display unit for application verification.
  - ii) Verification of all functionalities of alarm information and management system including report generation.
  - iii) Verification of functionalities of unit history node and its verification. The verification shall include configuration verification, sample rate versus storage time verification (by extrapolated method for extended time period), throughput, report formats and report generation.
  - iv) OPC node verification with respect to its configuration, data structure and throughput.
  - v) Sequence of Event Recorder functionalities verification by verifying identification of events with the specified resolution. The input shall be generated using pulse generator of suitable frequency.
  - vi) Functionalities of other items when specified shall also be verified.
- n) Verification of hardwired console and its functionality. All functions shall be 100% verified such as operation of hardwired instruments, hardwired annunciator, switches, ramps, pushbuttons, instruments like controllers, indicators, recorders etc. Hardwired consoles must be present during

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 123 OF 137		

factory acceptance test and shall be interconnected for functional verification. All hardwired instruments like alarm cards, barriers and relay shall also be verified for their proper operation.

- o) Verification of all system builder functions and engineering console functionalities.
- p) Verification of fieldbus simulator functionalities when specified and purchased along with the system.
- q) Verification of display update rate and call-up time under worst loading conditions. Network performance shall also be verified by verifying display update rate of an analog tag number when all other inputs in the system are under varying conditions.

2.2.2.8 The vendor shall notify the owner/consultant at least three weeks prior to final system testing. In the event that representatives arrive and the system is not ready for testing, the vendor will be liable for back charges for any extra time and expenses incurred.

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 124 OF 137		


- 2.2.2.6.4 Checking of loop configuration for correctness with respect to ranges, limits, alarm points, engineering units etc.
- 2.2.2.6.5 Checking of all types of VDU displays including process and system displays on operator Engineering and PLC console.
- 2.2.2.6.6 Checking of correct functioning of key-board operation for operator, Engineering and PLC console.
- 2.2.2.6.9 Testing of proper functioning of all printers and hard copy units.
- 2.2.2.6.10 Testing of system features like interchangeability between VDUs of a console, synchronisation of system clocks, selective tuning from Engineering console, key-lock functions etc.
- 2.2.2.6.11 Checking of various log formats, shut down reports, I/O mapping and other MIS formats printing.
- 2.2.2.6.12 Checking of shutdown and interlock configuration and proper operation thoroughly.
- 2.2.2.6.13 Proper system operation at power supply specifications specified in the Material Requisition.
- 2.2.2.6.14 Checking of proper operation of all interfaces with the system like interface with PLC, computer, analyzer system etc as specified in Material Requisition.
- 2.2.2.6.15 Checking of bus-degradation while loading the bus from 10% to 100%.
- 2.2.2.6.16 Simulation of power failure and restarts.
- 2.2.2.6.17 Checking of all hardwired instrumentation including all alarm cards, alarm annunciator system, switches and other indicating instruments.

### **3.0 INSTALLATION, TESTING AND COMMISSIONING**

- 3.1 Vendor shall offer the services of the installation team which would install the equipment in the control room, lay the interconnecting cabling inside the control room, check out, test and commission the system.

All technical personnel assigned to the site by the vendor shall be fully conversant with the supplied system and software package, and shall have both hardware and software capability to bring the system on line quickly and efficiently with a minimum of interference with other concurrent construction and commissioning activities.

- 3.2 Vendor's responsibility at site shall include all activities necessary to be performed to complete the job as per material Requisition including:
- a) Receipt of hardware/software and checking for completeness of supplies.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 125 OF 137		

- b) Installation of the system including free supply equipment and field cable termination in the system.
- c) Check out of the equipment installation.
- d) Checking of interconnection, hardware & software configuration, overall system functioning etc.
- e) Loop checking.
- f) Liaison with vendor's home office.
- g) Field tests
- h) Commissioning and on-line debugging of the system.
- i) Performance of final acceptance test.

3.3 The only exclusion from vendor's responsibility shall include the following:


- a) All civil works in the control room including false flooring, control room lighting and air conditioning ducting.
- b) Laying and identification of field cables.
- c) Field instrument installation and calibration.

### 3.4 Field Inspection


3.4.1 All equipments shall be inspected thoroughly by vendor after its receipt at site. The tests, as a minimum, shall include;

- (a) Hardware verification as per packing list.
- (b) Visual and mechanical checking.
- (c) Complete System Configuration loading.
- (d) Functioning of all VDUs, keyboards, disc drives, printers, hardcopy units etc.
- (e) Checking of correct change-over of redundant devices.
- (f) Checking of hardwired instruments.
- (g) Any other checking.



	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 126 OF 137		

- 3.4.2 The testing defined in para 3.4.1 shall be carried out to ensure functional integrity of all hardware being supplied. Vendor must initiate the remedial action in case unsatisfactory operation of any equipment or item is observed during this testing with an intimation to Engineer-in charge.
- 3.4.3 Vendor must document all observations including details of malfunctions observed, if any. Items/ equipments requiring total replacement must document reasons for the same.
- 3.5 **Loop Checking**
- 3.5.1 Vendor shall be responsible for loop checking which shall also include checking of the interconnection, at control room end, configuration and ensuring over all system functioning.
- 3.5.2 Calibration and installation of field instruments, installation of junction boxes, interconnection between instruments and junction boxes, laying of single, multi pair cables upto control room, tagging all field cables, performing continuity/ insulation test of cable, core identification of field cables etc. shall not be in the vendor scope. This work shall be carried out by the field contractor.
- 3.5.3 Vendor's scope of work, as a part of system installation and loop checking shall include termination of all field cables in control room, checking of interconnection between instrument glanding and equipment, ferruling and tagging of interconnecting cables in control room, ferruling of field cables in control room and performing overall loop performance check.
- 3.5.4 Loop checking shall be carried out to check the functional performance of all elements comprising the loop and thereby ensuring proper configuration, functioning and interconnection.  
For fieldbus devices the loop checking shall include the checking of complete fieldbus segment connectivity with its devices including noise, device configuration, waveform checking. The complete device configuration shall be downloaded to all field devices from DCS prior to the start of loop checking.
- 3.5.5 Vendor shall co-ordinate with the field contractor for smooth and proper loop checking. Any discrepancy found during checking shall be brought to the notice of Engineer-in-Charge. Complete loop checking shall be performed in the presence of Engineer-in Charge or his authorised representative. All readings shall be recorded on a suitable format which shall be handed over to the vendor by the field contractor after completing calibration record of each field device. On the completion of loop checking, remaining information related to loop checking shall be filled by the vendor. Completely filled format duly signed shall be submitted for approval, to Engineer-in Charge.
- 3.5.6 a) All the components of the loop shall be checked for proper functioning. All field instruments connected to control room shall be loop checked at 0%, 50% & 100% of FS (for both increasing and decreasing signals). The mode of generating signal from the field by field contractor shall be as follows for different instruments types:-


	<b>GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM &amp; PLC SYSTEM</b>	GSTD-0201	1
			Rev
		SHEET 127 OF 137	

	Type of Instrument	Mode of Signal Generation
a)	Differential pressure/ flow instruments/ DP type level instruments	By applying impulse to the primary by squeeze bulb or regulator at field
b)	Pressure instruments	By applying impulse to the instrument using instrument air, regulator & standard gage or using portable hydraulic pump and standard gage.
c)	External Displacer	Cage shall be filled with water for different levels and specific gravity correction shall be applied
d)	Other type of tank level instruments	By lifting the float of the level instruments for 0% and 100% of range
e)	Temperature loops with thermocouple	Appropriate mV signals shall be fed from thermocouple head
f)	Temperature loops with RTD	Appropriate resistance shall be fed from RTD head
g)	Field switches for Alarm & Shutdown	Abnormality shall be simulated by disconnecting and connecting the wires at field instruments end
h)	Owner supplied items	As per Engineer-in-Charge's Instructions
i)	Special instruments & any other type of instruments	As per Engineer-in-Charge's Instructions

- b) Receiver alarm cards shall be checked by the vendor for different settings on both increasing and decreasing signals.
- c) Shutdown schemes shall be checked for proper functioning, configuration and actuation.
- d) Performance of individual loops may be accepted for an overall accuracy of  $\pm 1.0\%$  unless otherwise specified. Where deviation exists, re-calibration of instruments, based on the scope of work, shall be carried out either by field contractor or by vendor.
- e) Signal from controllers/shutdown schemes to control valves/shutdown valves shall be checked at the respective valves. The stroke checking including checking of time of operation of control valves/shutdown valves also forms a part of loop checking. Vendor shall coordinate this activity with field contractor and record the same in the loop checking format.
- f) For the loop checking of loops connected to substation, vendor shall be responsible to coordinate with the Electrical Contractor.
- g) After loop checking is completed, vendor shall connect back any terminals and connections removed for loop checking.

## 4.0 SYSTEM ACCEPTANCE

- 4.1 The owner shall provisionally takeover the system from vendor after System acceptance test. System acceptance test shall be started only after the satisfactory performance of loop checking and verification of all loop checking records by Engineer-in-charge.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 128 OF 137		


4.2 The system acceptance test shall be carried out in the presence of owner's representative and Engineer-in-charge or his authorised representative. The tests carried out in System acceptance test shall be fully recorded and duly signed by all representatives participating in the System Acceptance Testing.

4.3 Vendor shall carry out the following functional tests on the fully integrated system as a part of System acceptance test, as a minimum;

- a) Hardware verification as per final Bill-of-material.
- b) Visual and mechanical checking for proper workmanship, identification, ferruling, nameplates, etc.
- c) System configuration as per approved configuration diagram.
- d) Checking of correct functioning of all keyboards and dual function keys.
- e) Checking of proper operation of hardcopy unit and all printers including printing of Alarms and Events on the Alarm & Event (A&E) printer.
- f) Demonstration of all system diagnostics.
- g) Checking of correct changeover of redundant devices.
- h) Checking of redundancy for LAS functionality for fieldbus segments.
- i) Checking of communication between DCS, PLC and other foreign devices.
- j) Checking of proper functioning of all disc drives, historical trend-points, alarm summary and alarm history.
- k) Verification of proper functioning of assignable trend recorder
- l) Printing of Configuration and Configuration changes on C&M printer.
- m) Proper information transfer on the information network by verifying system displays and printouts.


## **5.0 FINAL ACCEPTANCE TEST**

5.1 The owner will take over the system from the vendor after the final acceptance test, which is defined as successful uninterrupted operation of the integrated system for three weeks for all units of the plant. Vendor's personnel shall be present during the test. Any malfunctioning of the system components shall be replaced/repared as required. Para 2.1.6 of this specification shall be applied for failure of components & readjustments. Once the system failure is detected, the acceptance test shall start all over again from the beginning. The warranty period commences from the day owner takes over the system.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 129 OF 137		


## 6.0 TESTING/CALIBRATION EQUIPMENTS

- 6.1 Vendor shall make available all consumable, instruments, and equipments necessary for testing, calibration, maintenance etc. as required by the defined scope of works. All instruments and equipments used for the above purpose shall be of standard make with accuracy better than the accuracy expected from the calibrated/tested instruments, and certified by National Physical Laboratory or other equivalent agencies. These instruments/equipments are necessary only during testing/calibration/maintenance.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 130 OF 137		


## **PART - III**

# **GENERAL REQUIREMENTS OF DISTRIBUTED CONTROL SYSTEM**

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 131 OF 137		

## CONTENTS

<u>SR.NO.</u>	<u>TITLE</u>	<u>PAGE NO.</u>
1.0	SCOPE	135
2.0	LOGISTIC SUPPORT SERVICES	135
3.0	DOCUMENTATION	137
4.0	WARRANTY	139
5.0	MAINTENANCE CONTRACT	139
6.0	PACKING AND SHIPPING INSTRUCTIONS	140

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 132 OF 137		

## **1.0 SCOPE**

1.1 This specification defines the general requirements expected to be fully complied by Distributed Control System vendor including logistic sup ports, documentation, warranty, maintenance contract and shipping instructions etc.

1.2 The requirements defined in this specification shall also be applicable for all sub-system and hardware bought and supplied by vendor from manufactures other than his own.

## **2.0 LOGISTIC SUPPORT SERVICES**

2.1 The hardware maintenance engineers shall be trained for module level nd optionally component level diagnostics of the system. Vendor is required to quote separately for these training facilities. It is also necessary to include in the proposal the details of diagnostic software package for isolating the fault at module level for all the sub- system of Distributed Control System.

### **2.2 Training**

2.2.1 The requirements of training for owner/consultant personnel (one group consisting of operators and other group consisting of hardware/software maintenance engineers) in the operational software and diagnostic programs, are set forth herein.

2.2.2 Vendor shall be responsible for furnishing details of course outlines, manuals of training, equipment necessary to conduct the training, exercises to evaluate trainees' progress. Vendor shall also be responsible for any other requirements necessary to train the engineers deputed by owner within a time limit so that they acquire the necessary expertise to operate and maintain the programs and the equipments supplied.

2.2.3 Owner/ consultant or his authorised representatives shall select personnel for training on the basis of his requirements and will review all materials furnished for adequacy of teaching aids and time tables.

2.2.4 Training Personnel.

Each instructor-designate shall have the following minimum qualifications for his area of instructions:


- a) Six months of formal class-room instructor experience.
- b) Complete and thorough technical knowledge of the equipment and system supplied under the contract and skilled experience in their programming, maintenance and operation.
- c) Complete and thorough knowledge of the test and laboratory equipment maintaining, diagnosing, programming, operating and trouble shooting the hardware software system.

### **2.2.5 Course contents**

2.2.5.1 The outline of each course shall give the subject matter, a short resume of the pre-requisite subjects (if applicable), the position of the course in the training programme, the aim and yardsticks for evaluation and other topics which will add to the usefulness of the program. In order that the selected trainees shall have time to participate in the course, sufficient advance notice of minimum 8 weeks shall be given by the vendor. The course outlines shall be submitted 10 weeks ahead for review.

2.2.5.2 The training exercise shall be designed to be objective in nature and shall include trouble shooting exercises on similar equipments.

### **2.2.6 Training manuals**

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 133 OF 137		

2.2.6.1 All training manuals shall be prepared by the vendor and submitted for review 10 weeks ahead of the commencement of the course. After course completion, these manuals shall become the property of the owner. Any change in equipment, manuals and other material shall be informed to the owner during the guarantee period. In addition to vendor documentation, the following minimum requirements shall be adhered to for the training manuals:

- a) Functional flow-charts, descriptive material, program source listings applicable to all operating and application software and diagnostics programs.
- b) Schematic drawings of each assembly of the hardware for the course on maintenance.
- c) All manuals pertaining to procedures, specifications and operation for each equipment.

## 2.2.7 **DCS hardware and software maintenance training**

2.2.7.1 Vendor shall conduct a course in hardware (module level and optional component level) maintenance, software maintenance and diagnostic of the system for owner at vendor's facility. The course shall be conducted prior to the factory system performance tests so that trained personnel can participate effectively in the final testing.

2.2.7.2 The hardware maintenance training course shall cover every equipment item supplied as part of the Distributed Control System. This course shall include:

- a) Actual operation, detection and correction of faults in equipments.
- b) Familiarisation with maintenance procedures for the system offered.

2.2.7.3 Some of the topics covered in the course shall include:

- a) Fundamentals of the system
- b) Equipment logic diagrams
- c) Diagnostic procedures
- d) Peripherals maintenance
- e) Preventive maintenance procedures

2.2.7.4 Software maintenance training shall cover all software supplied with the system. The trained personnel shall be able to write and debug the application and system software.

2.2.7.5 The vendor is required to quote for in-house and on-site training separately and manhour rate for additional training, if required by the owner.

## 2.2.8 **Site training facility and training kit**


2.2.8.1 The training kit shall essentially be used for refresher and training courses for process engineers, operating and instrument maintenance staff. The training kit shall be simple control system with process simulator for a group of loops and shall include:

- a) An operator console with a VDU, operator key board and engineering keyboard.
- b) Controller with auto backup facility.
- c) One each of the varieties of PCBs used in data acquisition.
- d) Signal simulator.

2.2.8.2 Vendor to provide the details of the kit offered alongwith the proposal.

2.2.8.3 Training kit system shall be stand alone with respect to hardware and software and in no way be lined with the main system.



	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 134 OF 137		

### 2.3 Spare parts

2.3.1 Vendor shall include in the proposal, provisions for special tools, test equipments and initial stock of maintenance spares for a period of two years after commissioning as are essential for proper maintenance and operation of the equipment. In addition, estimated requirements of spares consumption per annum should also be indicated. Full particulars of the tools, test equipments and spare parts shall be provided separately. The list should also include the item wise price.

2.3.2 The successful vendor shall warrant that spare parts for the system would be available for a minimum of fifteen years. After this period, if vendor discontinues the production of spare parts, vendor shall give at least twenty four (24) months notice prior to such discontinuation so that the owner may order his requirements of spares in one lot.

## 3.0 DOCUMENTATION

Vendor shall furnish all the manuals necessary to test, operate and maintain Distributed Control System hardware and software.

### 3.1 Hardware documentation


3.1.1 The following documentation for all hardware supplied and as built under this contract shall be submitted for review two months before the start of factory acceptance testing.

- a) The specifications for all off-the-shelf hardware manufactured by vendor, his sub-contractors or suppliers.  
Supplier's name and identification of ordered hardware and expected delivery data to vendor's premises shall also be supplied along with this.
- b) Documentation relating to off-the-shelf hardware and hardware developed by vendor including description, specifications, theory of operation, maintenance procedures, installation information and drawings. This information shall exclude all non-applicable information.
- c) Where more than one size, rating or type of construction appears on the submitted catalogue data, those characteristics applicable shall be identified. Non applicable information shall be suppressed.
- d) Test plans and test reports as specified in Part II of this specification for each item of hardware, to be supplied.
- e) Bill of material listing all hardware to be supplied including manufactures part numbers, name plates data, approximate volume, weight and overall dimensions.
- f) Spare parts catalogue for all items (at component level) to be supplied.
- g) Recommended spare parts for two years.

### 3.2 Software documentation

The following documents shall be submitted for review before 90 days of the shipment of the system, for the software packages included in the supply:

- a) The specifications for all software to be obtained in-house or from subcontractors or suppliers. The details supplied shall also include the name of the suppliers, software identification including latest modification data.
- b) Reference manuals, operating manuals, programming manuals and other software manuals (if any).

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 135 OF 137		

c) Description of the function of each program. This shall include the logic, configuration requirements and constraints and sub-programs used,, memory map and special characteristics.

d) Input and output details for each program.

e) Listing of assembled programs with label and symbol tables in assembler/compiler language.

### 3.3 **System manuals**

3.3.1 Manuals shall be submitted for assuring satisfactory operation and maintenance of the system. Detailed literature for installation and maintenance of all hardware should be provided to the owner.

3.3.2 All system manuals shall be supplied in hard cover loose ring folders in A size i.e. 216 x 279 mm. All drawings and sketches shall be in multiple of 'A' size like 'B' (279 mm x 432 mm) or 'C' type (406 mm x 518 mm) etc. but folded to 'A' size.

#### 3.3.3 **Instruction Manual**

The information submitted shall preferably be in three parts.

##### **I Part**

First part shall give the following information:

- A general functional description of the whole system.
- General software description.
- General Instructions and start up procedures.

##### **II Part**

Second part shall describe the system software in detail including its interaction with application programs and other programs used as supporting software.

##### **III Part**

The third part shall include detailed maintenance information including all data pertaining to equipment required for maintenance of the system.

#### 3.3.4 **Maintenance manuals**

3.3.4.1 The maintenance manual shall include details of


- Preventive maintenance procedures.
- Trouble shooting procedures including failure analysis.

3.3.4.2 A section on repairs shall provide enough information on repairs including removal, repairs, adjustment and replacement.

3.3.4.3 The maintenance manuals shall contain a list of all maintenance parts to facilitate quick identification of the parts for replacement and ordering. Standard hardware structural parts, or other parts not requiring maintenance shall not be included here. At the end of the list of parts requiring maintenance, a list of special tools required for the maintenance of each unit shall be given. List of manufacturers of each part shall also be included.

3.3.5 The final system manuals shall be furnished to owner within a month of completion of final satisfactory field testing. All field modifications shall be incorporated and system as built drawings and documents shall be included. Fifteen copies of each manuals shall be submitted to the owner/consultant.

#### 3.3.6 **Engineering drawings**

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 136 OF 137		

- 3.3.6.1 The vendor shall provide a complete set of drawings covering each art of the supply for the owner/consultant record. The vendor is required to include owner's project number on each of his drawings in order to ease owner/consultant's record keeping.
- 3.3.6.2 Functional schematics and logic diagrams are furnished by owner/consultant to provide an idea of system hardware and software requirements to the vendor. Functional schematics shall be furnished in two parts.
- Part-I, containing all system hardware and software requirements is furnished along with Material Requisition.
  - Part-II, containing the field devices details like transmitter, junction box details, final actuating device single and multi cable/core details, shall be furnished later.  
Vendor shall develop loop wiring diagrams, containing full information of each loop (one drawing per loop) including field termination, junction box details, cables numbering, rack number, bus address code, device address code, power supply connections, final actuating device details including positioner and air supply etc and furnish these before the installation of system.
- 3.3.6.3 All field modifications shall be carefully recorded by the vendor's commissioning personnel and change shall be incorporated into final drawings. Fifteen copies of each drawing shall be submitted with one reproducible.

#### **4.0 WARRANTY**


- 4.1 Vendor shall be fully responsible for the manufacture in respect of proper design, quality, workmanship and operation of all the equipment, accessories etc. supplied by the vendor for a period of 18 months from the date of taking over by the owner at the site as mentioned in this specification or 24 months from the shipment date whichever is later.
- 4.2 It shall be obligatory on the part of vendor to modify and/or replace any hardware and modify the operating, application and diagnostic software free of cost, in case any malfunction is revealed even during on line operation after taking over within the warranty period.
- 4.3 Vendor shall also provide the total maintenance of the system during warranty period. The cost for warranty maintenance, if any, shall be included in the proposal separately in 'vendor proposal outline and pricing details'.

#### **5.0 MAINTENANCE CONTRACT**

- 5.1 Vendor shall quote separately for maintenance contract after warranty period for two years based on per day rate for each category of personnel required. The personnel deployed shall have thorough knowledge of the system and atleast two years of experience on the maintenance of similar system. Any other conditions of contract required by vendor shall be explained in the offer.

#### **6.0 PACKING AND SHIPPING INSTRUCTIONS**

- 6.1 All the material used for packing, wrapping, sealers, moisture resistant barriers and corrosion preventers shall be of recognised brands and shall conform to the best standards in the areas for the articles which are packaged.
- 6.2 Workmanship shall be in accordance with best commercial practice with the requirement of applicable specifications. There shall be no defects, imperfections or omissions which would tend to impair the protection offered by the package as a whole.

	GENERAL SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM	GSTD-0201	1	
			Rev	
		SHEET 137 OF 137		

6.3 The package shall be suitable for storing in tropicalised climate, the ambient conditions being specified in the job specifications.

6.4 Shipment shall be thoroughly checked for completeness before final packing and shipment.


	PROJECTS & DEVELOPMENT INDIA LTD	GSTD-0202	0	
			Rev	
		SHEET 1 OF 39		

# GENERAL SPECIFICATION


## FOR

### PROGRAMMABLE LOGIC CONTROLLER (PLC)


0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 2 OF 39		

#		
AC	:	Alternating Current
API	:	American Petroleum Institute
SIS	:	Bureau of Indian Standards
CCOE	:	Chief Controller of Explosives
CPU	:	Central Processing System
DC	:	Direct Current
DCS	:	Distributed Control System
DGMS	:	Director General of Mines Safety
DMR	:	Dual Modular Redundant
DVD	:	Digital Versatile Disc
EMI	:	Electromagnetic Interference
ERTL	:	Electronic Regional Testing Laboratory
ESD	:	Emergency Shutdown System
FAT	:	Factory Acceptance Test
FMEDA	:	Failure Modes, Effects and Diagnostic Analysis
HART	:	Highway Addressable Remote Transducer
HW	:	Hardware
HWC	:	Hardwired Console
I/O	:	Input / Output
IEC	:	International Electrotechnical Commission
IEEE	:	Institute of Electrical and Electronic Engineers
IS	:	Indian Standards
ISA	:	International Society of Automation
ISO	:	International Organization for Standardization
LAN	:	Local Area Network
LCD	:	Liquid Crystal Display
LCIE	:	Laboratoire Central Industries Electriques
LED	:	Light Emitting Diode
MTBF	:	Mean Time Between Failure
MTTR	:	Mean Time to Repair
OPC	:	OLE for Process Control
P&ID	:	Piping and Instrumentation Diagram
PC	:	Personal Computer
PESO	:	Petroleum and Explosives Safety Organisation
PID	:	Proportional, Integral and Derivative
PLC	:	Programmable Logic Controller
PTB	:	Physikalisch Technische Bundesanstalt
QMR	:	Quadruple Modular Redundant
RFI	:	Radio Frequency Interference
SAT	:	Site Acceptance Test
SER	:	Sequence of Event Recorder
SIL	:	Safety Integrity Level
SIS	:	Safety Instrumented System
TCP / IP	:	Transmission Control Protocol / Internet Protocol
TFT	:	Thin Film Transistor
TMR	:	Triple Modular Redundant
TUV	:	Technische Überwachungsvereine
UHF	:	Ultra High Frequency


 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR  PROGRAMMABLE LOGIC CONTORROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 3 OF 39		

UL : Underwriter's Laboratories  
UPS : Uninterrupted Power Supply  
VDU : Video Display Unit  
VHF : Very High Frequency  
Triple Modular redundant (TMR), Quadruple Modular Redundant (QMR)configuration, Flexible Modular Redundant (FMR) configuration, Virtual Modular Redundant (VMR)

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTORROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 4 OF 39		

1.0	GENERAL	5
2.0	DEFINITIONS	11
3.0	SPARES PHILOSOPHY	14
4.0	DESIGN AND CONSTRUCTION	16
5.0	TESTING, INSTALLATION, COMMISSIONING AND ACCEPTANCE	36
6.0	GENERAL REQUIREMENTS	42
7.0	SHIPPING	42




	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 5 OF 39		

## 1.0 GENERAL

### 1.1 Scope


1.1.1 This specification, together with the Material Requisition defines the minimum functional requirements for the design, hardware, software and firmware specifications, nameplate marking, testing and shipping of Programmable Logic Controllers (PLC) designed for reliable effective and optimum control and monitoring of a process plant 1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the purchaser's enquiry:

APIRP 552	Transmission Systems
EEMUA 191	Alarm System -A Guide to Design, Management and Procurement
EN 10204	Metallic Products -Types of Inspection Documents
EN 50039	Electrical Apparatus for Potentially Explosive Atmospheres: Intrinsically Safe Electrical System 'I'
IEC 60079	Electrical Apparatus for Explosive Gas Atmosphere
IEC 60529	Degree of Protection Provided by Enclosures
IEC-60584	Thermocouple Part 2: Tolerances
IEC 60617	Graphical Symbols for Diagram
IEC-60751	Industrial Platinum Resistance Thermometers and Platinum Temperature Sensors
IEC 61000-4-3	Electromagnetic Compatibility (EMC) -Testing and Measurement Techniques - Radiated, Radio Frequency, Electromagnetic Field Immunity
IEC-61000-4-4	Electromagnetic Compatibility (EMC) -Testing and Measurement Techniques - Electrical Fast Transients / Bust Immunity Test
IEC-61000-4-5	Electromagnetic Compatibility (EMC) -Testing and Measurement Techniques – Surge Immunity Test
IEC-61000-6-2	Electromagnetic Compatibility (EMC) -Generic Standards -Susceptibility - Industrial
IEC 61508	Functional Safety of Electrical/Electronic / Programmable Electronic Safety-related Systems
IEC 61131	Programmable Logic Controllers
IEC 61511	Functional Safety -Safety Instrumented Systems for the Process Industry Sector
IEEE 802.3	Telecommunication and Information Exchange between Systems -Local and

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTORROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 6 OF 39		

Metropolitan Area Networks -Specific Requirements -Part 3: Carrier Sense Multiple Access with Collisions Detection (CSMA / CD) Access Method and Physical Layer Specifications


- |            |   |
|------------|---|
| IS 2148    | Flameproof Enclosures of Electrical Apparatus   |
| IS-3043    | Code of Practice for Earthing   |
| IS 13947   | Specifications for Low Voltage Switchgears and Control Gears  |
| ISA 5.1    | Instrumentation Symbols and Identification  |
| 5.2        | Binary Logic Diagrams for Process Operations  |
| 5.3        | Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer System.  |
| 5.4        | Instrument Loop Diagrams  |
| 5.5        | Graphic Symbols for Process Displays  |
| 18.1       | Annunciator Sequences and Specifications  |
| 71.01      | Environmental Conditions for Process Management and Control Systems: Temperature and Humidity   |
| 71.04      | Environmental Conditions for Process Measurement and control Systems: Airborne Contaminants   |
| ANSI/ISA   | Security Technologies for Industrial Automation and Control Systems TR 99.00.01 Manufacturing and Control System  |
| ISO 216    | Writing Paper and Certain Classes of Printer matter-Trimmed Sizes-A & B Series  |
| ISO 9241-5 | Workstation Layout and Postural Requirements  |
| ISO 9241-7 | Display Requirements with Reflections   |
| 1.1.3      | In the event of any conflict between this specification, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern: <ul style="list-style-type: none"> <li>a) Design Basis / Statutory regulations</li> <li>b) Data Sheets</li> <li>c) Standard Specifications</li> <li>d) Codes and Standards</li> </ul> |
| 1.1.4      | In addition to meeting purchaser's specifications in totality, vendor's extent of responsibility shall also include the following:  |

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 7 OF 39		

- a) Purchaser's data sheets specify the minimum acceptable functional requirements for the programmable logic controllers. It shall be vendor's responsibility to select proper hardware, software and firmware to meet the specified functional requirements.
- b) Purchaser's data sheets specify the scan time / cycle time / response time and loading requirements. Vendor shall be responsible for sizing and selecting their standard product i.e. hardware, software and firmware to meet the requirements specified in the purchaser's data sheets.
- c) Selection of proper and adequate hardware, software and firmware to meet system requirements specified in the purchaser's specifications, keeping the integrity of functional blocks specified in the configuration 'diagram attached with the material requisition.
- d) Adequacy of Bill of Material selected to meet purchaser's requirements. Vendor to note that bill of material shall not be verified by the purchaser during evaluation stage. Any hardware, software and firmware required to meet the purchaser's specified requirements shall be provided by the vendor without any implication.
- e) Providing adequate mandatory spares including consumable spares as specified in the purchaser's specifications. Vendor shall be responsible to meet mandatory spare requirements specified by the purchaser.

## 1.2 Bids

- 1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to vendor attached with the material requisition. Vendor's quotation shall enumerate and include the detailed specification of each subsystem and each module of programmable logic controller, detailed system configuration, hardware and software capabilities, programming aids, display facilities and other relevant information.
- 1.2.2 Whenever a detailed technical offer is required, vendor's quotation shall include the following:
  - a) Compliance to the specifications.
  - b) Detailed specification sheets for each sub-system. The specification sheet shall provide information regarding hardware specifications, software specifications, redundancy requirements, capacity, power consumption etc. of the programmable logic controllers and its accessories. The material specifications and unit of measurement for various items in vendor's specification sheets shall be to the same standards as those indicated in purchaser's data sheets.
  - c) System security features and design details.
  - d) Proven references for each offered model in line with clause 1.2.4 of this specification whenever specifically indicated in the purchaser's specifications.
  - e) A copy of approval for flameproof enclosure, intrinsic safety etc whenever specified, from local statutory authority, as applicable, like Petroleum and

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 8 OF 39		

Explosive Safety Organization (PESO) / Chief Controller of Explosives (CCOE), Nagpur or Director General of Mines Safety (DGMS) in India along with:

- i) Test certificate from recognized house CIMFR (Central Institute of Mines & Fuel Research) / ERTL (Electronics Research and Test Laboratory) etc. for specified protection class as per relevant Indian Standard for all Indian manufactured equipments or for equipments requiring DGMS approval.
- ii) Certificate of conformity from agencies like LCIE, Baseefa, PTB, CSA, UL etc., for compliance to ATEX or other recognized standards for all equipments manufactured outside India.
- f) Deviations on technical requirements shall not be entertained. In case vendor has any valid technical reason to deviate from the specified requirement, they must include a list of deviations item wise, summing up all the deviations from the purchaser's data sheets and other technical specification along with the technical reasons for each of these deviations.
- g) Certificate for specified SIL requirement (e.g. SIL-3) from Independent Testing Agency.
- h) Catalogues giving detailed technical specifications, model decoding details and other related information for each item / sub-system covered in the bid.

1.2.3 Vendor shall offer only their standard proven product i.e. system hardware, system software and firmware, which shall be configured to meet the functional requirements specified in the material requisition. Moreover, the equipment being offered / supplied shall be of latest proven version available in the current manufacturing range and meeting the requirements specified in clause 1.2.4 of this standard specification.

1.2.4 The system hardware, software and firmware as offered, shall be field proven and should have been completed trouble free satisfactory operation for a period of minimum 4000 hours on the bid due date in the similar application with equal or higher than the proposed system size with respect to number of inputs and outputs specified in the purchaser's data sheet. Items with prototype design or items not meeting proneness criteria specified above shall not be offered or supplied.


1.2.5 The detailed scope of work, specific job requirements, exclusions, deviations, additions etc. shall be indicated in the job specifications which shall be part of material requisition.

1.2.6 Whenever specified, vendor shall furnish tested values of failure rates, probability of failure on demand and test intervals for safety integrity level analysis.

1.2.7 All documentation submitted by the vendor including their quotation, catalogues, drawings, installation, operation and maintenance manuals shall be in English language only.

1.2.8 Vendor shall also quote for the following:


- a) Two year's operational spares for each sub-system and their accessories which shall include the following as a minimum:

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTORROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 9 OF 39		

- i) All type of electronic modules e.g. I/O modules, processor modules, communication modules, memory modules, disc controller module, power supply modules etc.
  - ii) All type of auxiliary items e.g. barriers / isolators, hardwired instruments, annunciator modules, receiver switches, trip amplifiers, temperature element converters etc.
  - iii) Switches, lamps, fuses, connectors, terminals, pre-fabricated cables, circuit breakers, relays etc.
  - iv) Video display units, keyboards, disc drives, PC's, network items (e.g. switches, hubs etc.) etc. \
- b) Any special tools and test equipments needed for the maintenance of PLCs and other items being offered by vendor. Vendor must confirm in their offer if no special tools or test equipments are needed for maintenance other than those specifically indicated in purchaser's data sheet.

### 1.3 Drawing and Data

- 1.3.1 Detailed drawings, data, catalogues and manuals required from thy vendor are indicated by the purchaser in vendor data requirement sheets. The required number of prints and soft copies shall be dispatched to the address mentioned, adhering to the time limits indicated.
- 1.3.2 Final documentation consisting of design manuals, installation manual, operation and maintenance manual etc., submitted by the vendor after placement of purchase order shall include the following, as a minimum:
- a) Specification sheet for each sub-system, auxiliary instrument and bought out item.
  - b) Certified drawings for complete system including the following:
    - i) GA drawings for panels, cabinets, marshalling racks, hardwired consoles, operator console, programming terminal etc with complete dimensional details, internal construction and weight in kilograms.
    - ii) Control room layouts e.g. console room, rack room and engineering room layout with all dimensions in millimetres.
    - iii) Channel base frame drawing for console room, rack room and engineering room.
    - iv) Input / output assignment.
    - v) Logic / Ladder diagrams.
    - vi) Loop wiring diagram.
    - vii) Power supply distribution diagram.

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 10 OF 39		

- viii) Memory loading calculations/Scan time calculation.
- ix) Protocol/Pin Details.
- x) Dynamic graphic diagrams.
- xi) System grounding drawing.
- c) Design manuals and functional design specifications which shall include hardware design manual, software design manual and special software specifications.
- d) Copy of type test certificates.
- e) Copy of test certificates for all tests indicated in this specification.
- f) Installation manual containing installation procedure for programmable logic controllers and other items covered in the material requisition.
- g) Power-on, start-up and internal testing procedures.
- h) Software debugging and system configuration procedures.
- i) Calibration and maintenance manual containing maintenance procedures including replacement of parts, application modification etc.
- j) Any other drawings and documents specifically indicated in job vendor data requirement enclosed with the material requisition.

All system manuals and documentation shall be supplied in hard cover loose ring folders in 'A4' size as per ISO 216 i.e. of size 210mm x 297mm. All drawings and sketches shall be in multiple of 'A4' size like 'A3' (297mm x 420mm) or 'A2' type (420mm x 594mm) etc. but folded to 'A4' size.

## 2.0 DEFINITIONS

The various terms used in this specification are defined as follows:

### 2.1 Programmable Logic Controller


The class of control systems which can be programmed to execute plant shutdown and / or interlock / sequence logics to the specified safety integrity levels.

### 2.2 Accessible

A system feature that is viewable by and interactive with the operator and allows the operator to perform user permissible control action e.g. set point change, auto-manual transfers or on-off actions.

### 2.3 Assignable

A system feature that permits an operator to direct a signal from one device to another without the need for change in wiring, either by means of switches or via other data entry

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTORROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 11 OF 39		

devices like keyboard commands to the system.

#### 2.4 Configurable

The capability to select and connect standard hardware modules to create a system or the capability to change functionality or sizing of software functions by changing parameters without having to modify or regenerate software.

#### 2.5 I/O

Input / Output with respect to process / operator

#### 2.6 PLC Console (Operator)

PLC console (Operator) is the operator's main plant interface device through which operator can view, monitor and control the plant and can give instructions to peripherals to execute commands, and shall have protective access to configure and maintain the system.

#### 2.7 PLC Console (Programming Terminal)

PLC console (Programming Terminal) shall be the engineer's main interface device through which engineer can configure / program and maintain the system, and shall have protective access to monitor and control the plant, give instructions to peripherals to execute commands.

#### 2.8 Local Level

All those sub-systems; which directly interface with field devices shall be referred to as local level.

#### 2.9 Central Level

Operator Console and Programming Terminal, which present data acquired from local level devices shall be referred as Central Level.

#### 2.10 Database


Database shall be defined as the information stored temporarily or permanently in the system which can be accessed by various programs to meet all its functional requirements.

#### 2.11 Loop Integrity

A system shall be said to have loop integrity if the failure of one component in the system/ sub-system does not affect more than one loop.

#### 2.12 System Loading

System loading for a sub-system is defined as the percentage of time a sub-system spends in carrying out various activities referred to the use of memory, CPU time and communication capacity in the worst case of high sub-system operation out of the designed / designated cycle time of the sub-system.

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 12 OF 39		

### 2.13 Redundancy

A system component shall be termed as redundant if it takes over automatically the operation in the event of the failure of the main component without causing any interruption in the system and upsetting the process. The repaired or replaced device shall be brought in-line only through operator action without upsetting system operation.

### 2.14 Switchover Time

Time required for a back up instrument / system to come on-line automatically in case of the failure of the main instrument / system.

### 2.15 Processor Cycle Time (tpc)

Processor cycle time is the measure of the processing speed of a processor. Processor cycle time for a sub-system of the programmable logic controller shall be defined as follows:

Processor cycle time for programmable logic controller shall be defined as the total time taken by the processor to read input supplied by input module, execute all computations (analog as well as logic as configured) and write the outputs for the output module.

### 2.16 Scan Time (ts)

Scan time of a logic loops is the end-to-end response time of a sub-system and shall be defined as follows:

The scan time for a logic loop shall be defined as the total time taken by a sub-system e.g. programmable logic controller to read input from the input terminal, process input, execute logic, updating logic output and write output at the output terminal for all the logics configured within the subsystem.

### 2.17 User's Memory

Free memory space available after utilisation of memory required for system operation, configuration and implementation of application and other system related functions for implementation of user defined specific programs such as plant calculations, process optimization or MIS (like free formatting of certain logs). The programs shall either be written in high level language or system specific language.


### 2.18 Event

An event shall be defined as any action taken by the operator via operator keyboard or switches on hardwired console like change of set point, change of control mode, start/stop of motor, open/close of shut down valves, alarm acknowledge etc.

### 2.19 Sequence of Event (SOE)

Arranging events in the sequence of their occurrence in time with a specified time resolution by a program is defined as sequence of event.



	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 13 OF 39		

## 2.20 Sequence of Event Recorder (SER)

System or sub-system which presents and / or records the events in the sequence of their occurrence in time with a specified time resolution utilizing its hardware and software capabilities is termed as sequence of event recorder.

## 2.21 Real Time Trend

Real time trend shall be defined as a continuously progressing graphical record showing updated parameter with most recent value and a past record of minimum of 10 minutes without pressing any additional key for moving backward in time.

## 2.22 Plant Information Network

High-level communication network which serves various users within a plant and transfer information for the purpose of unit / plant monitoring. This network is different than control network and is generally realised using open communication protocol network e.g. OPC etc.

## 2.23 Tag

A Tag is a collection of attributes that specify either a control loop or a process variable, or a measured input, or a calculated value, or some combination of these, and all associated control and output algorithms. Each tag is unique.

## 3.0 SPARES PHILOSOPHY

3.1 The system including sequence of event recorder, hardwired instruments etc. shall meet the following spare philosophy. This philosophy shall also be applicable for items like barriers, relays, terminals, lamps, push buttons etc.


### 3.1.1 Mandatory Spares

Vendor shall include following mandatory spares in their scope of supply:

#### 3.1.1.1 Installed Engineering Spares

Installed engineering spares shall be provided in each sub-system for each type of module to enhance the specified" system functional requirements by 20%. The basis of offering installed engineering spares shall include:

- For a system with conventional and / or smart analog input / output, discrete (contact) input / output, 20% spare input / output of each type shall be considered for calculating I/O modules and all other related accessories.
- For all serial input / outputs to the system, 20% spare serial I/O ports of each type of serial input / output shall be provided.
- 20% spare accessories like relays, switches, lamps, fuses, circuit breakers, barriers, isolators, terminals etc.
- The engineering spares shall be wired up to the field cable interface and shall be

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 14 OF 39		

in ready-to-operate condition when field cable is connected to spare assigned terminals.

- e) Spare pairs of the incoming cables shall be terminated on spare terminals in the marshalling / barrier cabinets as applicable.
- f) The system shall be fully engineered considering 20% installed engineering spares including processor loading.

#### 3.1.1.2 Spare Space Requirement

In addition to installed engineering spares specified in Clause 3.1.1.1 of this specification, the system shall be provided with following spare space:


- a) I/O racks of programmable logic controller shall have 10% usable spare space for installing additional I/O cards of each type in future. However internal wiring for the same shall be connected up to the I/O terminals.
- b) Processor system of programmable logic controller shall have capability to execute additional 20% logics.
- c) Each operator console shall contain 20% usable spare group and related display capability in addition to as specified in para 3.1.1.1 of this specification.
- d) The system shall have capability to extend its historical trending, logging and user's memory by 20% to meet future expansion with/without adding additional memory modules.
- e) The communication sub-system shall have sufficient capacity to handle additional data contributed by addition of 20% I/O over and above installed engineering spares.
- f) Usable spare space in panels and cabinets to install 10% spare hardwired items like relays, switches, lamps, fuses, circuit breakers, barriers, isolators, terminals, panel mounted instrument etc. in future.

#### 3.1.1.3 Spare Memory Requirement

- a) The system shall be provided with a minimum of 40% spare memory capacity, as required for application program and data base to meet specified functional requirements.
- b) It shall be possible to extend the memory by at least 20% over and above the actual requirement at a later date.

#### 3.1.1.4 Spare Software Capability

- a) Sufficient additional software capacity shall be available in the system to take care of spares requirement as specified in para 3.1.1.1 and 3.1.1.2 of this specification to meet all functional requirements as per para 4.0 of this specification.

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 15 OF 39		

- b) Unless specifically indicated otherwise, the offered system shall have software licenses to cover all the tag numbers indicated in the material requisition, including installed engineering spares and spare space indicated in clause 3.1.1.1 and 3.1.1.2 of this specification.

### 3.1.1.5 Predefined Mandatory Spares

- a) Mandatory spares shall be ware-house spares and shall be supplied as loose items.
- b) Mandatory spare module of 5% or one module of each type, whichever is higher, must be supplied for each type of modules being used excluding modules used in consoles, servers, Personal Computers.
- c) For items like, Video Display Units, keyboards, disc drives, network components, hardwired instruments like barriers, lamps, fuses and circuit breakers, complete item limited to 5% or minimum one of each type shall be supplied' as predefined mandatory spare. But this shall not include hardware like hard discs, terminals.

### 3.1.1.6 Consumable Spares

Any paper, ribbon, printer heads, toner and ink required for printers, video copier or any other consumable item shall be supplied along with system required for minimum of six months duration after system acceptance.

### 3.1.1.7 Commissioning Spares

Unless otherwise specified, vendor shall be responsible to supply all spares which are found necessary to replace failed modules, failed sub-systems, or corrupted / faulty softwares while performing pre-commissioning and commissioning activities.


### 3.1.2 Two Years Operational Spares

Two years operational spares shall be as per Clause 1.2.8(a) of this specification and shall be quoted separately.

## 4.0 DESIGN AND CONSTRUCTION

### 4.1 Design Requirements

- 4.1.1 Programmable logic controller shall be microprocessor based system which shall be used to execute all the process and safety shut-down logic of the plant. When specified, it shall also execute plant interlock logics and sequence operation. Programmable logic controller shall be an independent unit and shall not depend on any of its functionality on any other system including Distributed Control System.
- 4.1.2 The system shall be of modular construction and expandable in future by adding additional modules which shall be easily accessible for maintenance and repair. The type of modules shall be kept to the minimum possible in order to have interchangeability and low inventory.
- 4.1.3 System Availability

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 16 OF 39		

- a) The system shall be designed 'fault avoidant' as a minimum by selecting high grade components of proven quality and proper design of system electronics.

Redundancy shall be provided, as a minimum, as per this specification to improve system availability and reliability. Due considerations shall be given to the environmental conditions particularly for field mounted sub-system, if specified in job specifications, during system design.

- b) The system shall have a high MTBF value and shall have well proven record of operating in hydrocarbon plants.
- c) The system shall be designed with 99.995% or greater availability. The availability shall be defined as follows:

Availability =  $\frac{\text{Mean Time Between Failure (MTBF)}}{\text{MTBF} + \text{Mean time to repair (MTTR)}}$

MTBF + Mean time to repair (MTTR)


For the purpose of calculations, consider mean time to repairs as four (4) hours unless the manufacturer recommends higher value for MTTR. It is therefore necessary that:

- i) Vendor covers all necessary spare parts in 2 years recommended operational spares which shall be necessary to meet specified MTTR time.
- ii) Vendor provides adequate training to owner's personnel and cover all necessary maintenance related topics in their training programmes to ensure specified MTTR time.

#### 4.1.4 Operating Environmental Conditions

##### 4.1.4.1 Environmentally Controlled Location Installation

- a) All subsystem of Programmable Logic Controllers located in Control Room, Local Control Room or in Satellite Rack Room shall be able to operate satisfactorily from 15°C to 30°C and 20% to 80% non condensing humidity.
- b) In addition to above, all such sub-systems shall also be able to operate satisfactorily in case of air conditioning failure with ambient temperature of 50°C and 90% no condensing humidity until the system safe operating limits are exceeded. The minimum period of continuous operation in such condition shall be 48 hours at least once in a month without any damage or degradation of system performance. Vendor, therefore, shall provide continuous temperature monitoring for each enclosed cabinet housing items / equipments generating heat, such as system cabinets, barrier cabinets, relay cabinets etc and also provide alarm for operator alert in case the safe operating temperature limits are exceeded.
- c) Chemical filters have been provided in the incoming air conditioning air to limit the concentration of contaminants below following limits:
- |                   |               |
|-------------------|---------------|
| Contaminants      | Concentration |
| (Corrosive Gases) |               |

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTORROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 17 OF 39		

SOx	< 0.01 ppm by volume
NOx	< 0.05 ppm by volume
H2S	< 0.003 ppm by volume
Cb	< 0.001ppm by volume
NH3	< 0.5 ppm by volume
SPM	< 200 ugm/m'
RSPM	< 100 ugm/nr'

All sub-systems and system components shall be suitable for operating continuously in the above mentioned corrosive environments

#### 4.1.4.2 Outdoor Installations


- a) Sub-systems or system components which are installed outdoor shall be suitable to continuously operate at ambient temperature and humidity specified under ambient conditions. The heat generation effect of current carrying for the electronic modules shall also be considered. For this purpose the system shall be rated for minimum 5 deg C more than the maximum ambient temperature specified. In case the system is not suitable for the above conditions, necessary cooling arrangement shall be provided.
- b) Unless otherwise specified, all PLC sub-systems or system components installed outdoor shall have corrosive environmental protection coating meeting the environmental classification class G3 as per ISA-S71.04.

#### 4.1.5 Transient, Static and EMI / RFI Protection

##### 4.1.5.1 The system shall be internally protected against system errors and hardware damage resulting from:

- a) Electrical transients on power wiring.
- b) Electrical transients on signal wiring.
- c) Connecting and disconnecting devices or removing or inserting printed circuit boards in the Programmable Logic Controller (PLC).

##### 4.1.5.2 All sub-systems and system components shall be capable of accepting various signal inputs for its direct use while preventing noise errors due to electromagnetic interference (EMI) or radio frequency interference (RFI) including nearby radio stations, hand held two way radios, solenoids, relays or contactors carrying heavy currents as per levels of Environmental electromagnetic phenomenon defined in IEC-61000-6-2. The system shall have total noise immunity from UHF / VHF radio communication equipments, (RFI) and (EMI) noise generating equipments as per IEC-61000-4.

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 18 OF 39		

4.1.5.3 For interplant, inter unit and other system cables routed in the field, the level of surge immunity required for equipment signal ports shall be increased to level 4 as defined in IEC-61000-4-5 and the system shall operate according to performance criterion B as defined in IEC-61000-6-2.

#### 4.1.6 On-line Replacement

4.1.6.1 On-line replacement of any module of programmable logic controller shall be possible in such a way that removal and addition of the module shall be possible and safe without de-energising the system. Furthermore, there shall not be any interruption of the system while replacing a faulty module wherever redundant modules are provided.

4.1.6.2 Apart from system modules, power supply units shall be replaceable on-line without disrupting the process and without affecting the system redundancies. It shall be possible to hot swap any faulty system module without degrading the system safety or operation or freezing the output status. The switchover to the healthy module shall be bumpless. The swapped module shall take over the function of the failed module without any manual programming.

#### 4.1.7 Electrical Isolation

Galvanic or optical isolation shall be provided for all field signals. The isolation levels shall be as follows:

Analog I/O channel to system ground 1500V AC

Discrete I/O channel to system ground 500V AC

External isolator shall be provided, if necessary to meet the above.

Isolation shall also be provided between Engineering / operator console/PLC programming terminal and related sub-systems connected to it if there is any possibility of high voltage being transmitted to the sub-systems.

#### 4.1.8 Design Requirements of Equipments in Hazardous Area


4.1.8.1 Unless specifically indicated, the field devices are beyond the scope of this specification. However vendor shall be fully responsible for integrating these devices with their system.

##### 4.1.8.2 General requirements

- Unless otherwise specified, all instruments in hazardous area shall be intrinsically safe type. Other concepts shall be used when specified.
- For conventional instrumentation, entity concept shall be used for selecting proper barriers / isolators.

#### 4.1.9 Repeat Signals

4.1.9.1 Unless otherwise specified in the job specifications, following philosophy shall be followed for repeat signals:

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR  PROGRAMMABLE LOGIC CONTORROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 19 OF 39		

a) Whenever repeat contact outputs are required as per job specifications following philosophy shall be followed:

- i) For intrinsically safe input contacts, isolating barrier with dual contact output shall be utilized.
- ii) For all other contact inputs, repeat contact shall be provided using electro-magnetic relays.

4.1.10 The system shall be designed fault tolerant and shall utilize high quality components of proven quality. Any single system fault shall not degrade the system safety or functionality or affect operation. The system shall have certified Safety Integrity Level as per IEC61508/ 61511 as applicable and specified in job specification. Unless otherwise specified, it shall meet the availability requirement specified in Clause 4.1.3 of this specification.

4.1.11 Unless otherwise specified, the scan time of programmable controller shall be of the order of 250 milliseconds for SIL certified PLCs. Scan time for a PLC shall be as defined under para 2.16 of this specification.

4.1.12 Operation of the PLC shall be completely unaffected by a momentary power loss of the order of 20 milliseconds.

1.1.13 The system shall be programmed in principle as per the logic diagrams furnished during detailed engineering. Vendor shall prepare their own Logic/Ladder diagrams depending upon the capability of the programmable logic controller offered by them. Owner / Consultant reserve the right to revise or review the logic diagrams even after acceptance of any offer. The programming language of offered PLC shall be as per IEC 61131.


1.1.14 Whenever the requirement of SIL is specified for the PLC, it shall meet the requirements of SIL level specified and shall be certified by an independent body (e.g. TUV) for complying requirements of IEC-61508 / 61511 as specified. For shutdown application requiring SIL certification, PLC shall always meet SIL 3 requirements.

1.1.15 The system shall have extensive set of self diagnostics hardware and software for easy and fast maintenance of PLC. Routine checks should run automatically at frequent intervals for identifying any fault in software or hardware. Diagnostics shall be required at local as well as console level. \

1.1.16 Safety barriers shall be provided by the vendor for intrinsically safe input/output circuits wherever specified. In such cases, the system shall be designed intrinsically safe based on entity concept. The barriers shall be certified by a statutory authority like Baseefa, LCIE, CSA, UL, PTB, CIMFR etc., for the use in the area classification as specified elsewhere in the job specifications. The proper selection of the safety barriers shall be the vendor's total responsibility. In case of smart transmitter, the entity parameters of the hand held terminals shall also be considered while selecting proper barriers.

1.1.17 Unless otherwise specified all intrinsically safe barriers shall be 3 port isolating type only providing isolation between;

- i) Input and output (non-hazardous to hazardous side of barriers)

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0
			Rev
		SHEET 20 OF 39	

ii) Power supply and input

iii) Power supply and output

The minimum isolation level shall be 250V.

## 4.2 System Configuration

### 4.2.1 General

- PLC system configuration / architecture shall be as specified in the job specification. For emergency shutdown system application specified with SIL classification, the system configuration shall be TMR or QMR or DMR or VMR as per the job specification and shall be certified by independent agency e.g. TUV.
- Regardless of the action feature selected (except for single architecture), the failure of single component shall not result in a failure of correctly executed safety function. The degradation mode for the selected configuration e.g. 4-2-0 or 3-2-0 or 3-2-1-0, etc. shall be documented in SIL certification report.
- In general, the PLC system shall comprise of various sub-systems as described in the subsequent clauses of 4.2.

### 4.2.2 Input/ Output Subsystem

4.2.2.1 Each I/O module shall have its own processor. I/O modules configured in redundant configuration, shall have their processors properly synchronised.


4.2.2.2 Unless otherwise specified, system shall accept analog 4 -20mA inputs and contact inputs. The maximum number of Input/Output per I/O module shall be limited as per the following table.

SI No.	Type of Configuration	Maximum No. I/O s
1	Single I/O system	8
2	Dual I/O system	16
3	Triple Modular Redundant system (TMR)	32
4	Quadruple Modular redundant System (QMR), Flexible Modular Redundant (FMR) configuration, Virtual Modular Redundant (VMR)	16

4.2.2.3 Each I/O shall be galvanically isolated from external control circuit by suitable means. The minimum isolation level between I/O and logic circuit shall be 1000 volts DC.

4.2.2.4 Each I/O shall be protected against the reversal of polarity of the power voltage to I/O.



	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 21 OF 39		

4.2.2.5 Each input shall be provided with filters to filter out any noise in the input line and contact bouncing noise, as applicable.

2.2.2.6 All the inputs / outputs shall be double ended i.e. two wires per input / output and not with common return for all inputs.

4.2.2.7 The interrogation voltage to the inputs and power supply for 2-wire instruments shall be powered from separate redundant power supply / supplies and shall not be a part of PLC, unless otherwise specified. This power supply shall be supplied at one point and shall be distributed by the vendor.

4.2.2.8

- a) Each module shall have a LED per channel to indicate the status of each input output.
- b) When specified, input module shall be capable of monitoring the input contacts for any wire open fault and short circuit.

4.2.2.9 Analog Input Module

- a) Input module shall be able to accept 4~20 mA DC input from smart transmitters (e.g. 4 -20mA HART).
- b) The module shall have 12 bit Analog to Digital resolution accuracy of  $\pm 0.25\%$  of full scale over the entire range, unless otherwise specified.

4.2.2.10


- a) Output contacts from the PLC shall be potential free dry contacts with contact rating as per para 4.2.2.10 b) of this specification. Vendor must provide arc suppression device for each output contact.

- b) The output contact rating shall be as follows:

SL.No.	APPLICABLE FOR	VOLTAGE RATING	CURRENT RATING
1	All output cards driving solenoid valve and alarm annunciator system unless otherwise specified Category -I Category -II	<b>110 V DC</b> <b>24VDC</b>	0.5 A 2A
2	All motors/pumps/compressor output cards unless otherwise specified. Category –I Category -II	<b>240 V AC</b> <b>220 V DC</b>	5.0A 0.2 A


- c) The category of contacts shall be specified in the material requisition. Each output shall be short circuit proof and protected by fuse. Visual indication of fuse blown must be provided for each module.

- d) When specified contact output module shall have monitored\ output features like

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 22 OF 39		

wire open and short circuit.

- 4.2.2.11 Where inputs or outputs have multiple field devices for the same measurement or device, the corresponding inputs / outputs shall be configured in separate I/O modules.
- 4.2.2.12 Where single input signal is available for QMR or TMR or FMR or VMR configuration, inputs shall be multiplied to feed inputs to each input modules / channels.
- 4.2.2.13 PLC shall be provided with Auto I/O testing facility as a standard diagnostics features. PLCs which do not have auto I/O testing facility, manual testing facility shall be provided to detect any system fault. For manual testing, manual switches shall be provided to bypass each input at a time and its effect on the output shall be monitored.
- 4.2.3 Processor System
- 4.2.3.1 The processor shall have capability to implement all the control functions required to implement the logic scheme as logic/ladder diagram.
- 4.2.3.2 The size of the memory shall be sufficient for storage of the program instructions required by the logic schemes and other functional requirements. Offer shall indicate the amount of memory capacity occupied by the actual program and spare capacity available for future program modifications or additions.
- 4.2.3.3 Memory shall be non-volatile. However in case volatile memory is provided, battery backup shall be provided with a minimum of 3 months lifetime to keep the program storage intact. A battery drain indication shall be provided at least one week before the battery gets drained.
- 4.2.3.4 Watchdog timer shall be a software device. The healthiness of processors shall be continuously monitored by watchdog timer. Any hardware or software problem in the processor system, which shall include, CPU, memory, power supply, communication interface etc. shall cause the watch dog timer to report processor failure.
- 4.2.3.5 Wherever dual redundant processor is specified, redundancy shall be provided in such a way that in case of failure of the main processor, the standby shall take over automatically. The changeover shall be bump less. Redundancy shall be provided for complete processor system including processor, power supply and communication sub system.
- 4.2.3.6 In case of triple modular redundant system all the three processors shall execute the same instructions/program and check their results and vote to correct any faulty result. The faulty processor diagnostic shall be made available.
- 4.2.3.7 In case of QMR system, individual processor shall execute the same instructions/ programs and check their results within same CPU module and majority vote to correct any faulty result. The faulty processor diagnostic shall be made available.
- 4.2.3.8 Failure of a single processor in dual redundant, triple redundant system and two processors in QMR system shall not affect the system. In case of failure of complete processor system
- i.e. both processors in case of dual configuration, two or more in case of triple redundant system and more than two in case of QMR system, outputs shall take failsafe state automatically unless otherwise specified in the data sheets.

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 23 OF 39		

4.2.3.10 It shall be possible to generate the first out alarm contact by the PLC in case where a group of parameters are likely to trip a system.

#### 4.2.4 PLC Console (Programming Terminal)

4.2.4.10 The PLC console (Programming Terminal) shall be used for programming, program storing, fault diagnostics and alarm monitoring. Whenever specified, it shall also be possible to use this console for plant operation. The functionality to operate as engineering / programming terminal or operator terminal or both shall be as specified in the job specification.

4.2.4.2 It shall consist of at least one coloured 21" Flat screen LCD monitor with TFT technology and one programming / operating keyboard, mouse and printer unless specified otherwise.

4.2.4.3 PLC console when used for plant operation shall also meet the functional requirements as per clause 4.2.5 of this specification

4.2.4.4 The keyboard shall preferably be touch sensitive sealed type, easy to operate with each key clearly identified.

4.2.4.5 All illegal entries shall be rejected by the terminal and shall be identified by warning signal on VDU.

4.2.4.6 Manual forcing of any input or output contact connected to PLC shall be possible from keyboard. Forced functions shall have an associated audit trail.


4.2.4.7 It shall be possible to modify, add or delete the application program on line without affecting the outputs.

4.2.4.8 PLC Console shall display logic and/or ladder diagram indicating power flow and shall show description and status of each contact. It shall also be possible to display process alarms and diagnostic messages as and when they appear. Further it shall also be able to display I/O map in a user defined format.

4.2.4.9 It shall be possible to print out the ladder/logic diagram on the dedicated PLC printer. The printer in addition shall also print out:

- a) The diagnostic messages as and when generated and diagnostic reports, when called for.
- b) Process alarms connected to the programmable logic controller as and when they appear and alarm report whenever initiated. The choice of printing alarms on this printer shall be operator selectable from a key lock / password protected switch on PLC console.
- c) The I/O maps showing status of all inputs and corresponding outputs in a user defined format.

4.2.4.10 The PLC console shall be provided with self diagnostics feature which shall display error messages and initiate an audible alarm if the fault is detected. Wherever specified, a potential free contact for diagnostic group alarm shall be provided which shall be connected to the hardwired alarm 'annunciator system.

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 24 OF 39		

4.2.4.11 The system shall be able to identify the failure at least up to the module level including I/O system and redundant processor and report print out.

#### 4.2.5 PLC Console (Operator)

4.2.5.1 Where dedicated PLC operator console is specified, it shall be used for operation of plant, fault diagnostics, alarm monitoring and report generation.

4.2.5.2 It shall consist of coloured 21" Flat screen LCD monitor with TFT technology, operator keyboard and printer unless specified otherwise.

4.2.5.3 At least two number cursor control devices shall be provided in addition to keyboard which may include touch screen, mouse, track ball etc.

4.2.5.4 PLC operator console shall have complete graphic capability and shall be able to display process dynamic graphics, overview and group view displays. It shall be possible to operate the plant i.e. start and stop of rotating machinery, opening and closing of valves, Pill function etc. from dynamic graphics and group displays available on PLC operator console.

4.2.5.5 It shall be possible to monitor, historise and print out all process alarms, diagnostic alarms and alarm reports.

4.2.5.6 Unless otherwise specified, the time stamping of all alarms shall be as per PLC processor time stamping.

4.2.5.7 The system shall be able to store and display stored data wherever required. The minimum storage capacity shall be for 30 days at 1 minute sample rate for all the inputs specified, diagnostic alarms, process and first out alarms, manipulation data etc.

4.2.5.8 The system shall be able to generate shiftly, hourly, daily, weekly and monthly reports. The log format shall be furnished during detailed engineering.


4.2.5.9 The system shall be supplied with first out alarm generation capability. The resolution of alarm shall be as per processor cycle time, as a minimum.

#### 4.2.6 Communication Subsystem

4.2.6.1 The PLC communication subsystem shall be a digital communication bus that provides a high speed data transfer rapidly and reliably between the processor, I/O sub-system, PLC console and other devices connected in the PLC system.

4.2.6.2 Redundancy in PLC communication subsystem shall be provided as follows unless otherwise specified:

- a) For single architecture, the communication subsystem between PLC processor and I/O subsystem shall be single unless otherwise specified. This shall include single communication bus and single interfaces/buffers.
- b) For dual I/O configuration, each I/O sub set shall have separate communication interface and bus for connecting to PLC processors.

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 25 OF 39		

- c) For the triple redundant system, each processor shall have a separate set of PLC communication subsystem.
- d) For the QMR systems each I/O subset shall have separate communication interface and bus for connecting to respective CPU module.
- e) The communication subsystem between processor subsystem and PLC console shall be dual redundant, consisting of two separate communication interfaces and two buses, each one configured in redundant mode, unless this is only used as programming aid.

4.2.6.3 In case of redundant PLC communication sub system, on the failure of the active device, the redundant device shall take over automatically without interrupting the system operation. Information about the failed device shall be displayed at local as well as on PLC console. It shall be possible to manually switch over the communication from main bus / device to redundant bus / device without interrupting any system function.

4.2.6.4 The mechanism used by the system for error checks and control shall be transparent to the application information / program. Error checking shall be done on all data transfers by suitable codes.

4.2.6.5 In general, PLC shall provide data in a well established protocol format preferably MODBUS protocol.

#### 4.2.7 System Power Supplies

4.2.7.1 Unless specified otherwise, the programmable logic controller shall operate on uninterrupted power supply (UPS). However the system shall be capable of operating satisfactorily at the following power supply specifications:

Voltage 220 V  $\pm 10\%$

Frequency 50 Hz  $\pm 3$  Hz


Harmonic contents less than 5%

Power interruption 10 millisecon

4.2.7.2 The power supply system shall be supplied with dual PLC feeders each capable of handling 100% of the total power supply load requirements. In case of failure of one feeder, redundant feeder shall supply the total load.

4.2.7.3 Each I/O rack shall be provided with separate power supply unless otherwise specified in job specifications. Each power supply shall be sized to take full load of the I/O rack/signal conditioning panel. Each rack shall be provided with dual redundant power supply.

4.2.7.4 Processor subsystem shall be provided with separate power supply, as a minimum, unless otherwise specified in job specification. Failure of one power supply shall not affect the system operation/processor switchover in case of dual processor system. Wherever triple redundant system is specified each processor shall preferably be provided with a separate power supply. Also separate power supply must be provided for each multiplied process I/O

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTORROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 26 OF 39		

channel.

#### 4.2.8 Self Diagnostics

4.2.8.1 The system shall have an extensive set of self diagnostic routines which shall be able to identify all permanent and transient system faults / failures at least up to module level including redundant components and power supplies through detailed VDU displays and report print out.

4.2.8.2 At the local level, failure of a module in any subsystem shall be identified by an individual LED.

4.2.8.3 Diagnostic software shall have the capability to provide information about the failed module/system either in the form of a system configuration display or provide information in the form of a "statement".


4.2.8.4 Self diagnostic software shall have capability to detect faults which make the system permanently close/open in the I/O modules or I/O signal conditioning modules (in case of triple redundant system, whenever specified in the job specifications, this may be achieved by automatically running the testing software at cyclic intervals), The automatic cyclic testing feature shall also be provided for dual I/O configuration and dual I/O signal conditioning for triple redundant system. The testing software cycle time may be considered once in 30 minutes however this shall be field adjustable by engineer. However, system performance shall not be degraded whenever testing feature is specified.

4.2.8.5 System for the following functionalities shall be supplied when specified:

- a) Long storage historisation
- b) Log report generation
- c) First out alarm generation

4.2.8.6 System diagnostics shall be capable of identifying, locating and reporting the following faults, as a minimum:


- a) Processor fault
- b) Communication fault
- c) I/O module fault
- d) Power supply fault
- e) Over temperature monitoring
- f) Permanently close / open (stuck on or off) fault
- g) Memory fault
- h) Signal redundancy fault

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 27 OF 39		

Any other additional diagnostic alarm if available as a standard shall also be provided by vendor.

- 4.2.8.7 Testing software shall be capable of detecting faults in case of normally closed system as well as in normally open system.
- 4.2.8.8 Feedback must be provided in case of triple redundant system and QMR system from the output voter system to detect any latest faults of the system in addition to other diagnostic software.
- 4.2.9 System Software
- 4.2.9.1 The system software shall include all programs for the PLC and PLC console which are required to perform all the PLC functions including communication and self-diagnostics. Whenever PLC is specified for shutdown application with SIL classification, the system shall be designed and engineered in full compliance with the requirement of IEC-61511. Whenever different functional logics are combined within a common PLC, the safety related I/O's of each functionality shall be kept segregated within the system.
- 4.2.9.2 Logic program shall also be recorded on the external electronic media like DVD which shall be delivered in duplicate together with the system.
- 4.2.9.3 The PLC programming language for implementation of logic operations shall be based on the following representations:
- Logic diagrams -Binary logic symbols such as AND, OR, NOT Gates, Timers and Flip-Flops.
  - Ladder diagram -Series / parallel connection of relay contacts.
  - Combination of (a) & (b) above.
- 4.2.9.4 Diagnostic package and its related equipment and software shall be supplied. A list of additional diagnostic packages available and the packages provided, including the description and capabilities, shall be provided with separate quote, wherever asked.
- 4.2.9.5 It shall be possible to print out the ladder/logic diagram on a dedicated printer. The printer shall also print out all diagnostic reports. Vendor must supply the off line software package to enable the owner to modify/add/delete any part of program and for documentation.
- 4.2.9.6 Software for the generation of various displays including dynamic graphics wherever specified to be provided as per given below:
- 4.2.9.6.1 It shall be possible to display dynamic graphic of plant on the operator console VDU screens. Graphic displays shall be field configurable only through PLC Console (Programming terminal) with standard / user defined graphic symbols. Dynamic graphic displays of different sections of the plant shall be displayed on different pages.
- 4.2.9.6.2 The system shall have graphic symbol library as per ISA-5.1 and 5.3. In addition standard industrial symbols like distillation columns, heat exchangers, pumps, compressors, tanks etc. shall also provided as a standard.



	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 28 OF 39		

4.2.9.6.3 Graphic displays shall be interactive type through which it shall be possible to control the process. It shall also be possible to send motor start/stop and shutdown valve open/close commands, as specified in job specifications, from this display

4.2.9.6.4 It shall be possible to view the process variable and alarm points and view and change set point value, manipulated variable, controller mode etc. from the graphic display. Also rotating machinery (i.e. compressor / pump) status and valve status shall be displayed on the graphic display with different colours

4.2.9.6.5 Various colours used in the generation of graphics like colour of the process lines, utility lines, Instrument signal lines and event modifier conditions shall be finalised during detailed engineering. The colours used to identify event modified conditions shall generally be as follows unless otherwise indicated during detailed engineering

Red -	All points alarm
Blue-	Valve open, pump running
Green -	Valve closed, pump stopped
Flashing green -	Shut down valve transition state

4.2.9.6.6 It shall be possible to go from any graphic page to related graphic pages or any group view or alarm summary in single key stroke using soft key function.

4.2.9.7 The software for printing alarms, system as well as process, and events on the PLC printer must be provided. All alarms must be printed as and when they appear.

4.2.9.8 Software package for displaying I/O map showing status of inputs and corresponding output providing tag numbers as per logic diagram shall be offered. The I/O map format shall be user definable.

#### **4.2.10 Power Supply Distribution**

4.2.10.1 All type of power supplies shall be made available at one point. Further distribution of power supply shall be in vendor's scope.


4.2.10.2 In general, all output contacts and solenoids shall be powered with 110V±10% DC/ 24V±10% DC power supply. However, the actual interrogation voltages shall be as per job specifications and logic diagrams.

4.2.10.3 The distribution network for interrogation voltage shall be designed such that a single fault in any branch shall not cause trip of the logic other than where the fault has occurred.

4.2.10.4 Sequential starting of various load centers shall be provided whenever specified.

4.2.10.5 Power distribution network must use bus bars of adequate capacity with DPDT (Double Pole Double Throw) switches and HRC (High Rupture Capacity) fuses in each branch network. Vendor may select circuit breaker if short circuit characteristics do not match the HRC fuse.



	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 29 OF 39		

4.2.10.6 All cubicles lighting shall be on 240 V, 50 Hz AC normal power supply.

#### 4.2.11 PLC System Cabinets

4.2.11.1 All PLC system cabinets shall be completely wired with all modules in place. Inside cabinet wiring shall preferably be done using ribbon type pre-fabricated cables.

4.2.11.2 All the cabinets shall be free standing, enclosed type and shall be designed for bottom entry of cables. Cabinet structure shall be sound and rigid. Cabinet shall be provided with removable lifting lugs to permit lifting of the cabinets.

4.2.11.3 Cabinet shall be fabricated from cold rolled steel sheet of minimum 2 mm thickness suitably reinforced to prevent warping and buckling. Doors shall be fabricated from cold rolled steel sheet of minimum 1.6 mm thickness. Cabinets shall be thoroughly deburred and all sharp edges shall be grounded smooth after fabrication.

4.2.11.4 Cabinet finish shall include sand blasting, grinding, chemical cleaning, surface finishing by suitable filter and two coats of high grade lacquer with wet sanding between two coats. Two coats of paint in the cabinet colour shall be given for non-glossy high satin finish. Colour of the cabinets shall be as per job specification. Final coat shall be given after assembly at site when specified in the job specifications.

4.2.11.5 Each cabinet shall be maximum 2100 mm high (excluding 100 mm channel base), 800 mm wide and 800 mm deep, in general. Construction shall be modular preferably to accommodate 19" standard electrical racks. All cabinets shall be of same height.

4.2.11.6 Cabinets shall be equipped with front and rear access doors. Doors shall be equipped with lockable handles and concealed hinges with pull pins for easy door removal.

4.2.11.7 In order to effectively remove dissipated heat from the cabinets, ventilation fans along with vent louvers backed by wire fly screen shall be provided as required. Ventilation fans shall be provided in all cabinets where the temperature rise with all doors closed and all internal and external loads energised shall exceed 10° C above the ambient temperature. A temperature element (resistance temperature detector) shall be provided in each cubicle for temperature measurement. Ventilation fans shall be provided in dual configuration, as a minimum.


Each fan shall have a separate dedicated assembly and shall be replaceable on-line without shutting down any equipment / panel/cabinet / console in part or in complete. \

Ventilation fan assembly shall operate at 240V AC power supply. Each fan shall have its own dedicated circuit breaker.

Each ventilation fan shall be fitted with a protection type finger guard. Whenever, the numbers of cabinets are compacted (supplied in mechanical joined conditions), each cabinet shall be provided with separate ventilation fan assembly.

The maximum noise level with all fans operating and cubicle doors open shall not exceed 85dBA.

Following signals and alarms shall be provided for each cabinet:

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 30 OF 39		

- i) Fan failure alarm for each cubicle in PLC.
- ii) Temperature indication of each cabinet or compacted combination, as applicable in PLC.
- iii) A common alarm each for high temperature and fan-failure shall be made available.

4.2.11.8 Internal illumination shall be provided for cabinets to ensure proper illumination level of 250 lux for performing maintenance activities. Illumination shall be provided for all cabinets by incandescent lamps, which shall be activated individually by door operated magnetic switches. The lamps shall activate when door is opened and deactivate when the door is closed. The magnetic switches selected shall have undergone life cycle cyclic test of at least 1000000 operations. A manual over-ride switch shall be provided inside the cabinet which shall keep the lamp deactivated even when the door is open.

4.2.11.9 Equipment within the cabinet shall be laid out in an accessible and logically segregated manner. Cable glands shall be provided and supplied by vendor for incoming and outgoing cables to prevent excessive stress on the individual terminals. All metal parts of the cabinet shall be electrically continuous and shall be provided with a common grounding lug.

#### **4.2.12 Control Panels/ Hardwired Console**

4.2.12.1 Control panels, if required, shall be non-graphic self supporting, free standing cubicle with back doors made up of sectional steel panels. Each section shall be maximum 2100 mm high, 1200 mm wide and 1000 mm deep and shall be mounted on 100 mm high channel base. Care shall be taken to ensure that the face of the panel is truly flat and smooth.

4.2.12.2 Panels / hardwired console shall be fabricated from 3.0 mm thick cold rolled steel sheet. Angle iron frame shall use a minimum section of 50x50x4mm angle.

4.2.12.3 Front of panel/console instrument nameplates shall be black laminated plastic with white core. Nameplate shall be provided on the rear of the panel also for each instrument.


4.2.12.4 Document pocket / wallet shall be provided on the inner side of front and rear doors of each cabinet and on the inner side of the door of each panel. Similar arrangement shall also be made on the inner side of doors of console.

#### **4.2.13 Wiring Requirements'**

4.2.13.1 All wiring shall conform to API RP 552-Transmission Systems. Different signal level cables shall be routed with separation distances as recommended by this code.

4.2.13.2 All wiring inside racks, cabinets, and back of the panels shall be housed in covered, non-flammable plastic raceways arranged to permit easy assembly to various instruments for maintenance, adjustments, repair and removal. \


4.2.13.3 All wiring in the raceways shall be properly clamped. All incoming cable and outgoing cables shall be terminated by vendor at marshalling rack. Total wiring cross-sectional area shall not exceed 50% of the raceway cross sectional area.

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 31 OF 39		

- 4.2.13.4 Separate wiring raceways shall be used for power supply wiring, DC and low level signal wiring, and intrinsically safe wiring. Parallel runs of AC and DC wiring closer than 300mm shall be avoided.
- 4.2.13.5 Vendor can alternately offer prefabricated cables for interconnection between different cabinets and panels.
- 4.2.13.6 Wire termination shall be done using self insulating crimping lugs. More than two wires shall not be terminated on one side of single terminal. The use of shorting links for looping shall be avoided.
- 4.2.13.7 Terminal housing shall be strictly sized with considerations for accessibility and maintenance. Minimum distance required between various components is listed below. These distances are clear distances and are excluding the width of the raceways or any other component / item mentioned herein. Following clearances should be considered:
- Distance between terminal strip and side of the cabinet parallel to the strip, up to 50 terminals, shall be minimum 50 mm.
  - Distance between terminal strip and, top and bottom of the cabinet shall be minimum 75mm.
  - Distance between two adjacent terminal strips shall be minimum 100 mm.
  - Additional distance for each additional 25 terminals shall be minimum 25 mm.
  - Distance between cable gland plate and the bottom of the strip shall be minimum 300 mm.
- 4.2.13.8 All terminal/terminal blocks shall be DIN Rail mounted type and shall be easily removable. The size of the terminal blocks / terminals of different types shall be consistent and identical. All terminal blocks shall be mounted on suitable anodised metallic or plastic stand-off.
- 4.2.13.9 No splicing is allowed in between wire/ cable straight run.
- 4.2.13.10 Terminal strips shall be arranged group-wise for incoming and outgoing cables separately. Terminal blocks for intrinsically safe wiring shall be separate. 20% spare terminals shall be provided, as a minimum, preferably in each terminal strip. Terminals shall be suitable for wires up to 2.5 sq. mm base solid or stranded conductor in general. For power cables, higher size terminals shall be used.
- 4.2.13.11 Cabinet and rack layout shall be made considering proper accessibility and maintenance.

### 4.3 Earthing

- 4.3.1 All system equipments such as panels, marshalling cabinets, system cabinets and other powered equipments shall be provided with following type grounding system:
- Protective Earth/ Electrical Earth
  - System Earth! Signal Earth

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTORROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 32 OF 39		

- c) Safety Earth! Barrier Earth (when required)


Both system earth and safety earth shall be totally separate from protective earth.

#### 4.3.2 Protective Earth / Electrical Earth

- a) Each metallic enclosure / cabinet / panel/console etc. shall be provided with electrical earth lug, as a minimum.
- b) Unless recommended otherwise by vendor, all earthing lugs of metallic equipments indicated in Clause 4.3.2 (a) above shall be connected individually to electrical protective earthing system bus-bar / earthing station using ,a maximum of 10sq mm solid copper conductor PVC insulated wires.
- c) Where multiple cabinets are multiplexed together, earth looping with permanent shorting link cables shall be acceptable. Two earthing connection wires as indicated in Clause NoA.3.2 (b) above shall be used for connecting multiplexed cabinets to protective earth station / bus-bar.

#### 4.3.3 System Earth

- a) System earth shall be totally noise free dedicated earthing system and shall be fully isolated from electrical protective earth. This earth must be very high integrity system and shall be used to ground zero volt references and signal cable grounds.
- b) System earth shall be less than one (1) ohm grounding system with its own dedicated earthing pits. These earth pits shall be away from any heavy noise plant equipment. Outside the control room building is the most appropriate location.
- c) Wherever supply of earth pit is kept in vendor's scope in the Material Requisition, the earth pit design shall be as per IS-3043 code of practice for earthing. A minimum of four (4) number of earth pits shall be provided for grounding system integrity. In case number of pits required to meet 1 ohm resistance are more than (2), the number of earth pits shall be two times the actual number of pits required to meet resistance criteria. All these pits shall be securely connected with each other to form a one homogeneous system earth grid.
- d) Each marshalling / system cabinet / panels etc shall be provided with system earth bus-bar which shall be insulated from the metallic body frame. This bus-bar shall be used to earth also signal zero volt references and signal cable screens. Terminals used for termination of spare conductor pairs / cores of multi-pair signal/control cables shall be connected to system earth bus-bar. Shorting links shall be used for spare terminal looping.
- e) System bus-bars in the multiplexed cabinets can be joined together by permanent shorting links. System bus-bars of other cabinets can also be connected together provided they are permanently joined using 35 sq mm stranded copper conductor cable.

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 33 OF 39		

#### 4.3.4 Safety Earth / Zener Barrier Earth

- a) Whenever Zener barriers are selected or used to meet intrinsically safe requirements, the earthing terminal of the zener barriers shall be connected to a separate earth bus bar.
- b) This earth shall meet all the requirements specified in Clause 4.3.3 of this specification.
- c) Safety earth bus bar shall be directly connected to earth pits using dual insulated cable. Cable conductor size shall be minimum 95 sq. mm (copper).

#### 4.4 Interface with DCS

The PLC shall be required to be interfaced to the Distributed Control System bus whenever specified. A suitable interface shall be offered in order to achieve the following functions:

- a) Display of all input points under alarm/first out alarm connected to PLC or generated by PLC, continuous indication for analog signal on the main DCS operator console.
- b) Generate shutdown reports on the logging printer of Distributed Control system.
- c) To receive certain operational commands from the operator console for the operation of certain output devices connected to PLC
- d) To display diagnostic message of PLC.

In general, PLC shall provide data in a well established MODBUS protocol format.

The interface shall be dual redundant unless otherwise specified.

The speed of data transfer shall be such that any change in I/O which is to be updated on the operator console shall not exceed 3 second from the time event to update on the operator console screen considering one second standard update rate in DCS operator console.


#### 4.5 Sequence of Event (SOE) Function Requirement

Sequence of Event, whenever specified, for analog and digital inputs shall be generated and time stamped in PLC. The maximum resolution between two events shall not exceed specified PLC scan time unless specified otherwise. A separate SOE PC with 21" size TFT screen and printer shall be provided for PLC sub-system unless specified otherwise.

### 5.0 TESTING, INSTALLATION, COMMISSIONING AND ACCEPTANCE

#### 5.1 General

- 5.1.1 This specification defines the basic guidelines to vendor for factory testing and acceptance, installation, commissioning and field acceptance of the complete PLC system. On the basis of


	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 34 OF 39		

this specification, vendor shall submit their own detailed testing, installation, commissioning and acceptance procedure. For hardware, the procedure shall include test name, purpose of test, test equipment / set up, definition of input, test procedure, results expected and acceptance criteria. Similarly for software, it shall include test name, details of the method, list of tests, sequence of execution, results expected and acceptance criteria. For PLC system with SIL 3 requirement, certificate for hardware & software (Like TUV etc.) shall be verified.

- 5.1.2 The testing and acceptance of the system shall be carried out on the approved testing procedures and criteria based on this specification and vendor's standard testing requirements and procedures.

## 5.2 Factory Acceptance Tests (FAT)

- 5.2.1 Vendor shall test and demonstrate the functional integrity of the system hardware and software. No material or equipment shall be transported until all required tests are successfully completed and certified "Ready for Shipment" by the owner/consultant.
- 5.2.2 The purchaser reserves the right to be involved and satisfy himself at each and every stage of inspection. The purchaser shall be free to request any specific test on any equipment considered necessary by him although not listed in this specification, as a part of approval of factory testing procedure. The cost of performing all tests shall be borne by the vendor.
- 5.2.3 Vendor to note that acceptance of any equipment or the exemption of inspection or testing shall in no way absolve the vendor of the responsibility for delivering the equipment meeting all the requirements specified in Material Requisition.
- 5.2.4 It shall be vendor's responsibility to modify and/or replace any hardware and modify the software if the specified functions are not completely achieved satisfactorily during testing and factory acceptance.
- 5.2.5 Schedule of FAT shall be included in the Vendor's proposal.
- 5.2.6 Vendor shall not replace any system component/module/sub-system unless it is failed. A log of all failed components/modules in a sub-system shall be maintained which shall give description of the failed component/module, effect of failure on the sub-system, cause of failure and number of hours of operation before it failed. If malfunction of a component/module in a sub-system repeats, the test shall terminate and vendor shall replace the faulty component/ module. Thereafter the test shall commence all over again. If even after this replacement, the sub-system fails to meet the requirements, vendor shall replace the full sub-system by the one meeting the requirements and the system shall be tested all over again. If a sub-system fails during the test, which is not repaired and made operational within four hours of active repair time after the failure, the test shall be suspended and restarted all over again only after the vendor has replaced the device in the acceptable operation.
- 5.2.7 Testing and FAT shall be carried out in two phases. The minimum requirements for testing during these two phases shall be as follows:
- 5.2.7.1 Under the first phase, vendor shall perform tests at his works to ensure that all components function in accordance with the specification for each type of test. A test report shall be submitted for purchaser review within one week of completion of this test. Phase II testing

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 35 OF 39		

(witness inspection) shall start only after this.

All subsystem shall undergo a minimum of 30 days burn in period. The burn-in time shall start after the sub-system is fully assembled and is powered up. It may include any such time for which the system has been kept powered on even for system generation and Phase I testing.

Following tests shall be performed by the vendor and reports shall be forwarded to purchaser:

- a) Quality control test which shall be carried out to assure quality of all components and modules in accordance with vendor's quality control and assurance procedures.
- b) System pre-test which shall be physical check of all modules, racks, cabinets etc.
- c) System power-up test which shall test functionally all hardware and software. This shall include testing of redundancy, System performance on power supply variations, application software testing and system diagnostic verification.


5.2.7.2 The second phase of testing shall systematically, fully and functionally test all hardware and software in the pre-ence of purchaser representatives. All subsystems shall be interconnected to simulate, as close as possible, the total integrated system. Following minimum tests shall be carried out:

- a) Visual and mechanical testing, which shall be carried out in principle to assure correct, proper, good and neat workmanship by the vendor This testing shall include dimensional verification, Layout verification as per approved GA drawings, Verification of Sheet thickness / Quality of painting (outer and inner) / N-meplates, identifiers and tag plates / Adherence to ferruling philosophy / Dressing of wires / prefabricated cables and clearances / Locks and handles as a minimum.
- b) Verification of Bill of Material. The Bill of material verification shall include both hardware and software.
- c) Functional testing:

This shall include the simulation of each input and output to verify proper system response. The testing as a minimum shall include:

- i) Complete system configuration loading.
- ii) Demonstration of all PLC system builder functions including addition/deletion of an input/output, addition/ deletion of a rung or an element in a rung, generation of dynamic graphics and other views, report generation etc.
- iii) 100% checking of logics configured in the PLC by connecting switch/lamp at input/output, by simulating inputs and verifying outputs preferably using simulator, other related functions like forcing, first out shall also be verified.



	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 36 OF 39		

- iv) Checking of scan time. Scan time verification shall be carried out using high resolution storage oscilloscope during Factory Acceptance Test based on the specified requirements considering discrete input by given step change. The scan time values so observed shall be within 90% confidence level. In case of analog inputs, input shall be ramp or minimal step, however such reading for analog inputs should be noted only for reference.
- v) Checking of all PLC console displays, keyboard and touch-screen operation (wherever specified), printer/hard copier functions etc.
- vi) System redundancy check including correct change over of the back-up unit in case of failure of main unit.
- vii) System diagnostic checking for all subsystems on local level as well as on console, including checking of the testing software for I/O modules/signal conditioning modules, when specified.
- viii) Checking of output status on processor failure.
- ix) Checking of first-out alarm generation.
- x) Simulation of power failure and system restart auto boot-up of system configuration and program after power restoration.

5.2.8 Vendor shall notify the purchaser at least three (3) weeks prior to factory acceptance test. In the event that representative arrives and the system is not ready for testing, vendor shall be liable for back charges for any extra time and expenses incurred.

### 5.3 Installation, Testing and Commissioning


5.3.1 Vendor shall offer the services of an installation team which would install the equipment in the control room, lay the interconnecting cables inside control room, check-out, test and commission the system.

All technical personnel assigned to the site by the vendor shall be fully conversant with the supplied system and software package, and shall have both hardware and software capability to bring the system on line quickly and efficiently with a minimum of interference with other concurrent construction and commissioning activities

5.3.2 Vendor's responsibility at site shall include all activities necessary to be performed to complete the job as per material requisition including:

- a) Receipt of hardware/software and checking for completeness of supplies.
- b) Installation of the system including for free supply equipment, if any.
- c) Field cable termination and inter-cabinet cabling and termination.
- d) Check out equipment installation.
- e) Checking of interconnections, hardware and software configuration, overall system



	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 37 OF 39		

- f) Loop checking.
- g) Field tests.
- h) Commissioning and on-line debugging of the system.
- i) Involvement during plant commissioning and performance of final acceptance test.
- j) Co ordination for integration with DCS / other third party system.

### 5.3.3 Field Inspection


- 5.3.3.1 All equipments shall be inspected thoroughly by vendor after its receipt at site for completeness and proper functioning. Vendor must initiate the remedial action, in case unsatisfactory operation of any item is observed, with intimation to Engineer-in-charge.
- 5.3.3.2 Vendor must document all observations including details of any malfunction observed. Items/ equipments requiring total replacement must document the reasons for the same.

### 5.3.4 Loop Checking

- 5.3.4.1 Loop checking shall be carried out by vendor including checking the interconnections, configuration and overall system functioning.
- 5.3.4.2 Vendor's scope of work as a part of system installation and loop checking shall include termination of field cables in the control room, checking of interconnection between instrument/equipment, glanding, ferruling/tagging of interconnecting cables in control room, ferruling of field cables in control room and performing overall loop performance check.
- 5.3.4.4 The input signals shall be simulated by disconnecting/connecting the field wires for all field switches connected to 'PLC. All field transmitters connected to control room shall be loop checked at 0%, 50% & 100% of full scale (for both increasing and decreasing signals). Wherever receiver cards are used, the set point shall be generated by giving the input signal to receiver card. All outputs shall be checked in field, either for actual operation of solenoid valve or actual pick-up of electrical contractor for rotary equipments. Shutdown schemes shall be checked for proper functioning, configuration and actuation.
- 5.3.4.5 After loop checking is completed, vendor shall connect back any ~erminals and connections removed for loop checking.

### 5.4 System Acceptance

- 5.4.1 The owner shall provisionally takeover the system from vendor after System acceptance test. System acceptance test shall be started only after the satisfactory performance of loop checking and verification of all loop checking records by Engineer-in-charge.
- 5.4.2 The system acceptance test shall be carried out in the presence of owner's representative and Engineer-in-charge or his authorised representative. The tests carried out in System acceptance test shall be fully recorded and duly signed by all representatives participating in the System Acceptance Testing. .

	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 38 OF 39		

5.4.3 Vendor shall carry out the following functional tests, as a part of system acceptance test, as a minimum.

- a) Hardware verification as per final Bill of Material.
- b) Visual and mechanical check-up for proper workmanship, identification, ferruling, nameplates etc.
- c) System configuration as per approved configuration diagram.
- d) Demonstration of all system function, display and diagnostics.
- e) Checking of correct change-over of redundant devices.
- f) Checking of various peripheral devices like printers and printing of all reports.
- g) Complete checking of logic system, loading of user's program and checkout of results.
- h) Checking of proper functioning of all disc drives, alarm summary, alarm history etc.
- i) Proper information transfer on the information network by verifying system displays and printout.

## 5.5 Final Acceptance Test

The owner will take over the system from the vendor after the final acceptance test, which is defined as successful uninterrupted operation of the integrated system for three weeks. Vendor's personnel shall be present during the test. Any malfunctioning of the system components shall be replaced / repaired as required. Once the system failure is detected, the acceptance test shall start all over again from the beginning. The warranty period commences from the day owner takes over the system.


## 6.0 GENERAL REQUIREMENTS

6.1 Vendor shall comply fully with the general requirements of PLC system including logistic support services, documentation, warranty, maintenance contract and shipping instructions.

### Post Warranty Maintenance Contract

Vendor shall quote separately for post warranty maintenance contract after warranty period for five years for the complete system as per commercial terms and condition of the requisition and the type (i.e. comprehensive or non-comprehensive) of post warranty maintenance shall be as specified in job specification. The personnel deployed during post-warranty maintenance shall have thorough knowledge of the system and at least two years of experience on the maintenance of similar system. Any other conditions of contract required by vendor shall be explained in the offer.

## 7.0 SHIPPING


	GENERAL SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC)	GSTD-0202	0	
			Rev	
		SHEET 39 OF 39		

- 7.1 All the materials used for packing, wrapping, sealers, moisture resistant barriers and corrosion preventers shall be of recognised brands and shall conform to the best standards in the areas for the articles which are packed
- 7.2 Workmanship shall be in accordance with best commercial practices and requirements of applicable specification. There shall be no defects, imperfections or omissions which would tend to impair the protection offered by the package as a whole.
- 7.3 The packing shall be suitable for storing in tropicalised climate, the ambient conditions, being specified in job specifications.
- 7.4 Shipment shall be thoroughly checked for completeness before final packing and shipment. Vendor shall be responsible for any delay in installation or commissioning schedule because of incomplete supply of equipments.

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			Rev	
		<b>SHEET 1 OF 8</b>		

# GENERAL SPECIFICATION FOR MACHINE MONITORING SYSETM

0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	GENERAL SPECIFICATION FOR MACHINE MONITORING SYSETM	GSTD-0210	0	
			Rev	
		SHEET 2 OF 8		

As a minimum, all steam turbines/motor driven compressors (i.e. Process air compressors, N2 compressor, Refrigeration compressor, CO2 compressor and Syngas Compressor, Gas Turbine, Lean/Semi-lean pumps, LTS blower, HP Ammonai Pump, Carbamate Pump, ID Fa, Purifier/Expander, GTG , etc.) shall be provided with highly reliable, continuous monitoring, vibration monitoring system as per minimum requirements given below. For all the machines, the identical MMS system, including central parts, probes, proximeters and panels, all power supply, isolators and wiring philosophy; shall only be used.

There shall be separate racks of T T S for each of these machines. Also there shall be separate racks of T T U for both machines, if two machines are running in parallel or one running one standby mode in the same section/plant.


The requirement of measurement point and location for axial and radial vibrations, casing vibrations and various bearing temperature measurement points shall be as per vendor's recommendation.

#### 1. Instrumentation for Compressor and Rotating Equipments

1..1 Compressor vendor shall be completely responsible for providing adequate instrumentation for safe and efficient operation of the machine. The commonly used instruments are being detailed out in the following clauses, however this does not absolve the vendor of providing additional instrumentation, if required.


##### 1..2 Anti surge and performance control system (ASC).

- a) Vendor shall be fully responsible for the complete design of Anti surge/performance control system (ASC) including selection of type of flow element, controller Algorithm, type of explosion protection, type and operating timings of final control element. Vendor shall guarantee the performance of machine with the offered ASC system. Wherever required, ASC system shall be designed in such a way that it is capable of correcting the compressor operating point so as to avoid surge in order to protect machine from possible damage, to minimize process upsets and to minimize recirculation.
- b) ASC system shall typically consist of but not limited to flow element, flow transmitter, differential pressure transmitter, ASC controller, control valve and other accessories as felt necessary by the Vendor.
- c) Vendor shall supply all the hardware and software related to the operation and safety of the compressor. This shall include but not limited to the following:
  - Design and operation of surge control loop scheme based on offered compressor, performance.
  - Supply of all hardwares in antisurge control loop including dedicated controller, transmitters, measuring elements, final control element etc.

	GENERAL SPECIFICATION FOR MACHINE MONITORING SYSETM	GSTD-0210	0	
			Rev	
		SHEET 3 OF 8		

- Fast response transmitter and control valve etc. as required.
  - Algorithm required for antisurge/Performance control application.
- d) The ASC shall be a dedicated single loop controller on proprietary Hardware Platform or single/multi loop controllers of common hardware platform such as PLC. The single loop controller shall be dedicated controller for each Anti-surge or Performance control application/Tag. Dedicated panel mounted facia shall be provided. The ASC system when provided on common hardware platform shall be with redundant configuration as minimum viz-dual processor, dual input/output, redundant communication & dual power supply system. The multiloop controller/system shall be dedicated for Antisurge/Performance applications/Tags of each machine/each machine tag. Unless specified otherwise dedicated panel facia for each application shall be provided to mount on hardwired console in control room
- e) It should be able to accept 4-20 mA signal from field or from HIC at purchaser DCS or at LCP as a manual override to anti-surge control system with bump less transfer.
- f) Auto-manual operation with bump less transfer shall be provided.
- g) The controller response time (total time to read input, processing time and output) shall be as per the machine dynamics and safety and shall be of the order of max. 40-mililsec. Any faster response required based on machine dynamics shall be considered by vendor. The input sampling interval shall be as per machine dynamics within the controller response time as above. The processor cycle time shall be considered to meet the overall response time.
- h) The ASC shall be field proven, specific to the make of machine and for the similar application in hydrocarbon industries. Bidder shall provide the proven track record for the offered ASC meeting the above.
- i) The Anti surge/Performance control algorithm shall be implemented using standard firmware in the controller/Processor system.
- j) The Algorithm developed by vendor shall be specific for given application, surge control, performance, load sharing etc. and shall be field proven for the compressor make.
- k) The algorithm implemented in the system shall be protected against any modifications/changes.
- l) The configuration shall be stored in non-volatile memory or battery back-up for configuration shall be provided (min 72 hours) in case of volatile memory along with battery drain indication.
- m) In case of ASC on common hardwired platform separate configurator with necessary hard ware/ soft ware shall be provided for application programming.
- n) Anti surge controller shall not be used for performing any other machine related inter locks/logics.
- o) All the instruments (transmitters, I/P converters and temperature elements and / or transmitters) connected with anti-surge control loop shall be flame proof "EExd" type suitable for the area as specified. The suitability of smart transmitter shall be confirmed by vendor and to be provided accordingly.

### 1..3 Machine Monitoring System (MMS):

 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR MACHINE MONITORING SYSETM	GSTD-0210	0	
			Rev	
		SHEET 4 OF 8		

Machine Monitoring system shall be provided for continuous monitoring and indicator of machine parameters like vibration & axial displacement, bearing and winding temperature, keyphasor etc.

#### 1..3.1 Vibration and Axial Displacement Monitoring

1..3.1.1 The system shall be provided with built in intrinsically safe barrier and shall be duly mounted in separate panel. No external barrier shall be provided for the same.

1..3.1.2 For MMS the display unit shall be provided at local control panel with necessary statutory certification. Alternately purged enclosure is also acceptable with necessary certification.

1..3.1.3 Vibration and displacement monitoring system shall be as per API-670. The extent and type of monitoring shall be as defined elsewhere. However, vendor shall furnish any additional requirements for monitoring deemed essential by them with reasons. Two probes at 90 degree apart for each location shall be provided and connected to same dual channel monitor for vibration monitoring.

1..3.1.4 The sensing probe shall be accessible for adjustment, repair and replacement without dismantling the machine.

1..3.1.5 Vendor shall provide continuous 4-20 mA dc isolated output for each channel of measurement for remote indication and potential free contacts for alarm/shutdown setting from the monitors.


1..3.1.6 In addition to this, it shall be provided with necessary hardware (communication Gateway Module) (including the cable for serial data communication from monitoring system to purchaser's DCS) for machine monitoring through purchaser's DCS via redundant serial data interface between this system and purchaser's DCS. Bidder shall furnish all details like pin configuration and tag number wise MODBUS address mapping list etc. for smooth interfacing of this communication link with DCS.

1..3.1.7 Bidder shall also supply one common laptop based configuration unit with required configuration software and hardware for configuration of MMS system including the serial communication cable required between configuration unit (laptop) & MMS monitors.

1..3.1.8 Monitors shall be dual channel type and shall meet the following specifications as a minimum:


- a) Continuous two channel monitoring with each channel input from one probe. Readout scale shall read higher of the two sensors.
- b) Each channel shall have two independent alarm levels one for pre trip alarm and one for each trip, settable continuously over measurement range. Two relay contacts for each pre trip alarm and trip alarm per channel shall be provided.
- c) Broken sensor failure detection without causing shut down.
- d) LED lamps on monitor front for each channel to indicate pre-trip alarm, trip-alarm and circuit not OK conditions.
- e) Selector switches on monitor front to read vibration/ displacement pre-trip alarm and trip set points for each channel shall be provided.
- f) Analog output 4-20 mA dc isolated signals shall be provided for each channel for remote indication.

#### 1..3.2 Bearing & Winding Temperature Monitoring


 पी डी आई एल <b>PDIL</b>	GENERAL SPECIFICATION FOR MACHINE MONITORING SYSETM	GSTD-0210	0	
			Rev	
		SHEET 5 OF 8		

- 1..3.2.1 In general, bearing temperature shall be measured at the points which are under maximum loading.
- 1..3.2.2 Sensor shall be three wires RTD element of platinum having 100 ohms resistance at 0°C. Calibration shall be to DIN 43760 standards.
- 1..3.2.3 The temperature sensor, cables, terminal heads, junction boxes etc. should be capable of withstanding the mechanical vibration and environment of a rotating machinery atmosphere.
- 1..3.2.4 Bearing and Winding temperature shall be monitored by means of a temperature monitor. The temperature monitors shall be mounted on the local control panel in hazardous area and shall meet following requirements:
- Accept RTD inputs (platinum, 100ohm at 0 Deg C calibrated to DIN 43760 standards).
  - Continuous six channel monitoring with each channel input from one RTD. Read out scale shall read higher of the six temperatures.
  - Each channel shall have two independent alarm levels one for pre-trip alarm and one for trip alarm, settable continuously over measurement range.
  - Broken sensor failure detection without causing shut down.
  - Selector switches on monitor front, to read temperature, pre-trip alarm and trip set points for each channel shall be provided.
  - Analog output 4-20 mA dc isolated signals shall be provided for each channel for remote indication.
  - Monitor shall be latest.
- 1..3.2.5 Separate temperature monitors shall be provided for motor winding and bearings temperature monitoring.
- 1..3.3 Key Phasor
- 1..3.3.1 Key phasor system shall be provided by vendor for performing analysis of vibration signals to determine machine malfunctions. It shall consist of a proximity probe and transmitter, extension cable etc. and other accessories to make the system complete. Vendor shall provide necessary reference on the shaft to determine one-per-turn occurrence.
- 1..4 Speed Governor System
- Digital microprocessor based fault tolerant tripple modular redundant governing system of mounted in standalone cabinet and located in rack room.
- 1..4.1 HMI for operator interface shall be supplied loose with all mounting accessories for mounting this HMI in purchaser's hardwired console in general. This shall include all basic features of governor to enable operator to do all control and monitoring operations from console itself.
- 1..4.2 This shall include features like assignable speed range, adjustable speed set point, remote speed set point input, digital speed indication, adjustable speed ramp, override for testing the external over speed trip system etc.
- 1..4.3 It should be able to accept 4-20 mA signal from HIC at purchaser's DCS or LCP as a manual override to governor and pass on the same, after a bump less auto / manual selection & local / remote selector switches configured in woodward governor (shall be possible through HMI) to governor valve as manual control.



	GENERAL SPECIFICATION FOR MACHINE MONITORING SYSETM	GSTD-0210	0	
			Rev	
		SHEET 6 OF 8		

- 1..4.4 Bidder shall provide all hardware & software in the system (including the cable for serial data communication from system to purchaser's DCS ) for serial communication link for all data transfer from governor to purchaser's DCS. This serial link shall be RS 422 / RS 485 with MODBUS RTU protocol, bidder shall furnish all details like pin configuration and tag number wise MODBUS address mapping list etc. For smooth interfacing of this communication link with DCS.
- 1..4.5 The Governor Control System shall be Woodward or equivalent.
- 1..5 Accumulator of Lube Oil System
- 1..5.1 If accumulators are used with nitrogen for lube oil dampening at the desired pressure to meet the system requirement the following instrumentation with the accumulator to be provided by vendor:
- Accumulator shall have charge kit with isolation valves and connection hoses.
  - Standard Nitrogen cylinders available in India are at pressure of 140 kg/cm<sup>2</sup>g with standard connection sizes. Vendor shall provide the complete regulator system with protection for charging Nitrogen from Nitrogen cylinder to accumulator at the desired pressure. Regulator shall be suitable for the inlet pressure variation of 140 to 150 kg/cm<sup>2</sup>g while charging with suitable inlet connection to match the Nitrogen cylinder connection. Regulator system shall have pressure indicator, regulator, relief valve, needle valve etc. as a minimum. Material of construction shall be stainless steel.
- 1..6 The compressor loading-unloading scheme for reciprocating compressors shall be provided as per the minimum requirements specified in the job specifications. Manual as well as automatic schemes shall be provided.
- 1..7 Emergency switch shall be provided in the local panel/local. All such switches shall have a protective cover to avoid inadvertent shutdown.
- 1..8 Vendor shall provide the following common alarms for purchaser:
- Common machine pre-trip alarms.
  - Common machine trip alarm.
2. System Cabinets, Racks And Consoles
- 2..1 All system cabinets, marshalling racks and hardwired consoles shall be free standing and enclosed cubicles type. All these items shall have bottom cable entry.
- 2..2 Cabinets shall be fabricated from cold rolled steel sheet (CRCA) of minimum 2.0mm thickness suitably reinforced to prevent warping and buckling. Doors shall be fabricated out of 1.6 mm thick CRCA sheet. Cabinets having modular construction and with basic frame structure of heavy duty aluminium shall also be acceptable.
- 2..3 Cabinet/Console finish shall include sand blasting, grinding, chemical cleaning, surface finishing by suitable filler and two coats of high-grade lacquer with sanding between coats. Two coats of paint in the cabinet colour and a final coat after assembly at site, shall be given for non-glossy high satin finish.
- 2..4 In order to remove dissipated heat effectively vent louvers backed by wire fly screen shall be provided. Further, ventilation fans shall be provided wherever required. High temperature annunciation shall be provided on operator console.

	GENERAL SPECIFICATION FOR MACHINE MONITORING SYSETM	GSTD-0210	0	
			Rev	
		SHEET 7 OF 8		

- 2..5 Illumination shall be provided for all cabinets by fluorescent lamps, which shall be operated by door switch.
- 2..6 All cabinets/racks/consolos shall be adequately sized to avoid any congestion.
- 2..7 The height and colour of the cabinets shall be inline with other equipments being installed in the control room.
3. MCMS Software

The latest MCMS software modules for Orbit analysis and polar plots and other various diagnostics for machine health shall be supplied with the following minimum features.

The MCMS software shall be Version 6.x or latest at the time of supply having Enterprise Application package covering all the centrifugal, integral geared and reciprocating and its drive ( i.e. motor or steam turbine) with all required stages' probes. It shall have min. 3 Display client with one Web based client, Data Export thru' OPC A &E, Data acquisition license with Microsoft SQL (5 CAL min lic), Data importer suitable for accommodating all installed probes/sensors/stages TDI Transient Channels ' license, static channels' license and min. 500 point OPC data import license. It will also have System Extender with 2 Smart Notifiers, This will also have Rule Pack license software to cater to include the requirement of various stages, bearing/rotor, gearbox, Electric Motor, power turbine, centrifugal pump, of various steam turbines, gas turbines, hydraulic turbines, centrifugal and integral geared compressors, reciprocating compressors if any, installed in the entire project.


The central rack shall be supplied with required hardware and a lap top PC with a rack configuration software. The specification of lap top shall be latest at the time of supply with Microsoft Windows OS and MS Office license package.

The above MCMS software and its associated programming shall be performed via a common central Engineering station, which will be a server grade machine with the latest hardware and software at the time of supply (The specs of this server machine shall be identical to those of DCS engineering station). This shall be accommodated in central engineering room in the close vicinity of central cabinet room. The server shall be same as those of DCS/ESD system servers.

The Server shall interface with various racks via Ethernet interface via Industrial Ethernet switches/FO or UTP CAT-6 cable LAN/WAN. Similarly this set up will have one hardware firewall via which it will connect to LAN for viewing remote Display Client and web based client on other dedicated machines and/or any other machine from LAN.

The MCMS software shall be following facility

1. The Machine Condition Monitoring Software System should be capable of integrating all Online , Scanning, Wireless and Portable Vibration Monitoring System in a single software in line with API 670 latest edition
2. The condition Monitoring Software should have seamless integration with MPS supplied by different OEMs/ Pkg. Vendors. No interface hardware should be required to fetch the analysis data from Machine Protection System.
3. As per API 670 clause: 3.1.35, the buffered output has to allow connection of vibration analyzers, oscilloscope and other test instrumentations to the transducer's signals for advanced Analysis by third party (OEM / Diagnostic company).
4. In case of the decision support module capabilities mentioned what will be the input and the output of the decision support module for each category like Centrifugal compressor, Recip compressor, Gas Turbine generator, centrifugal pumps, motors, blowers, etc. This has to be formalized for each equipment.


	GENERAL SPECIFICATION FOR MACHINE MONITORING SYSETM	GSTD-0210	0	
			Rev	
		SHEET 8 OF 8		

5. The diagnostic plots required in the machine monitoring software should include plots like P-V Diagram, Rod position profile, which are important for Reciprocating Compressor.
6. Machine monitoring software should capture transient data. It is required that, the machine monitoring software should be capable of accepting unlimited number of data samples in transient state of equipment both in delta rpm (1rpm) and delta time (1second) basis simultaneously for all the measurement points in the equipment train.  
The software should also freeze pre transient data (200 samples) once equipment enters transient state.
  - a. MCMS vendors should have the capability to provide Machinery diagnostic services from a remote location, by connecting to the machinery management software's database.
  - b. Machinery management software shall have seamless integration with Meridium / SAP PM Module.
7. The machine condition software should have the capability to notify designated users via SMS / E- MAIL, the events like equipment trip on real time basis.
8. MCMS Software should be capable of informing ESD related problems.
9. MCMS SW should be able to capture static & dynamic vibration data before and after the occurrence of any event. This is important to observe & co-relate equipment behavior after the event to study either continued excursion or available damping.
10. MCMS SW should be able to collect data based on change in amplitudes or phase angle or any software or hardware alarm. It is essential to store additional samples simultaneously across the entire machine train when there is alarm triggered on may be only one probe. Such co-relation helps to identify the cross effect of vibration excursion for entire machine train
11. The software should also be enabled with Cyber Security for Industrial Internet requirement in future.

	PROJECTS & DEVELOPMENT INDIA LTD	GSTD-9998	0	
			Rev	
		SHEET 1 OF 13		

# INSPECTION AND TEST REQUIREMENTS FOR INSTRUMENTATION

0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD


	INSPECTION AND TEST REQUIREMENTS FOR INSTRUMENTATION	GSTD-9998	0	
			Rev	
		SHEET 2 OF 13		

## CONTENT

Sl. No.	DESCRIPTION
1.0	Inspection and Tests
1.1	General
1.2	Visual Inspection
1.3	Dimensional Inspection
1.4	Material Inspection
1.5	Non-Destructive Examination
1.6	Pressure Test
1.7	Pneumatic Test
1.8	Seat Leakage Test
1.9	Performance Test
1.10	Steam Test
1.11	Insulation Resistance Test
1.12	High-voltage Test

## ATTACHMENT

Sl. No.	DESCRIPTION
Table-A	Table-A- Table of Inspection and Test Items

	INSPECTION AND TEST REQUIREMENTS FOR INSTRUMENTATION	GSTD-9998	0
			Rev
		SHEET 3 OF 13	

## 1. INSPECTION AND TESTS


### 1.1 General

- 1.1.1 All instruments and system-oriented items shall undergo factory testing and inspection by authorized Third party representatives / Owner and PMC unless specified otherwise.
- 1.1.2 Wherever inspection at manufacturer's shop is waived because of any reason, the sub vendor's own testing reports shall be verified before despatch. In no case items shall be released without proper inspection verification.
- 1.1.3 The inspection and testing shall be carried out as per related specifications, international codes and practices/standards, approved documents and/or any other documents attached along with specifically suggesting testing to be carried out at manufacturer' works.
- 1.1.4 Items, for which 'Witness Inspection' is specifically exempted, manufacturer shall forward the test certificates as desired for review. The material shall be despatched only after obtaining written despatch clearance.
- 1.1.5 No system or system oriented item shall be despatched without integrated factory testing witnessed by representatives of / Third party inspector / Owner /PMC. The testing procedures shall be detailed out, based on testing requirements indicated in individual system specifications and shall be approved by Owner/ PMC. It must certify that the system is actually ready before calling the Owner/PMC for FAT. Also all the necessary documents and literature are to be submitted before calling for FAT.
- 1.1.6 Testing and inspection for all items shall be carried out as per approved factory testing procedures.
- 1.1.7 Performance specifications must be detailed out on each time which shall be verified by third party agency / by Owner / PMC during factory testing.
- 1.1.8 Acceptable criteria for Radiography and other NDT requirements for the instruments / instrument castings shall be inline with those specified in 'Piping Specifications' have been attached elsewhere in this package.
- 1.1.9 IBR certifications shall be provided by in the appropriate format duly signed by IBR authority or their authorised agency.
- 1.1.10 Verification of setpoint of rupture disc shall be part of witness inspection. Testing shall be carried out on the rupture disc, which are part of the actual rupture disc batch of manufacturer. This shall be in addition to the 3 numbers of spare rupture discs already indicated in the requirements. The testing, in general, shall be as per ASME section VIII.
- 1.1.11 Inspection and test items, witness inspection items for each kind of instrument at FAT (Factory acceptance test) shall be as shown in Table A.
- 1.1.12 Inspection and acceptance standards

Inspection and acceptance standards shall be as follows.

### 1.2 Visual Inspection

#### 1.2.1 Conformation items

	INSPECTION AND TEST REQUIREMENTS FOR INSTRUMENTATION	GSTD-9998	0
			Rev
		SHEET 4 OF 13	

1. Type and model
2. Tag no.
3. Rating
4. Range, Scale and symbol of unit
5. Set pressure and capacity of safety valves
6. Valve characteristics and CV value of control valves
7. Name of materials
8. Nameplate
9. Colour of painting
10. Die Marking (nominal size, material of flange and direction of flow)
11. Accessories
12. Quantity

#### 1.2.2 Harmful defects

- Defect such as cracks, deformation and flaws shall not be found in the casting, forging and machined surface of the pressure rating part.
- Defect such as inside surface weld protrusion; lack of fusion and incomplete penetration shall not be found in welded places of pressure retaining part.

1.2.3 The instrument shall be in rugged design and assembly of all components within the enclosure fixed firmly to avoid loosening or falling-off of any parts.

1.2.4 Painting of instrument's surface shall be such that there is no defect or lack of uniformity.

#### 1.3 Dimensional Inspection

☒ Main parts  
☐  
☐

Check and conform to the requirement of Purchaser's Spec, approved drawings or applicable code and standards.


#### 1.4 Material Inspection

##### 1.4.1 Mill test certificates

Manufacturer shall submit the mill test certificates for the following parts.


1. ANSI class 900 or above (ALL material used at the P.T. ratings)
2. The following parts made of steel for :
  - High temperature service (Alloy steel above C-Mo steel used at temperature of 400°C or over)
  - Low temperature service (Iron and steel material of design temperature bellow minus 11°C containing Al-killed steel)
  - Corrosion-resistant materials

- |      |   |   |
|------|---|---|
| I.   | Temperature detective parts                 | : <input checked="" type="checkbox"/> Flange and Thermowell |
| II.  | Orifice assembly                            | : <input checked="" type="checkbox"/> Flange                |
| III. | Venturi tube, Flow nozzle and Low-loss tube | : <input checked="" type="checkbox"/> Body                  |
| IV.  | Positive displacement flow meter and        | : <input checked="" type="checkbox"/> Body, Strainer and    |

	INSPECTION AND TEST REQUIREMENTS FOR INSTRUMENTATION	GSTD-9998	0	
			Rev	
		SHEET 5 OF 13		

- |       |                                      |   |
|-------|--------------------------------------|---|
|       | Turbine meter                        | Straightner   |
| V.    | Area type flow meter                 | : <input checked="" type="checkbox"/> Body and Flange                         |
| VI.   | Displacement type liquid level meter | : <input checked="" type="checkbox"/> Chamber and Flange                      |
| VII.  | Glass Gauge                          | : <input checked="" type="checkbox"/> Body and Flange                         |
| VIII. | Control valve                        | : <input checked="" type="checkbox"/> Valve body, Bonnet, Plug, Seat and Vane |
| IX.   | Safety valve                         | : <input checked="" type="checkbox"/> Valve body, Nozzle and Disc             |
| X.    | Condensate pot                       | : <input checked="" type="checkbox"/> Body                                    |
| XI.   | Gas eliminator                       | : <input checked="" type="checkbox"/> Body                                    |
- 1.4.2 Material grade 316SS or 316L SS of stainless steel, Purchaser may require Vendor to carry out the qualitative analysis for molybdenum.
- 1.5 Non-Destructive Examination
1. Control valve and safety valve  
Following Par. 1.5.2 and 1.5.3
2. Other instruments  
Shall be carried out in accordance with manufacture's standards approved by Purchaser
- 1.5.1 Ultrasonic Examination
1. Forging material on Orifice flange and Flow nozzle  
☒ ANSI class 900 or above  
[ ]
- 1.5.2 Radiography Examination
- [ ] The pressure retaining casting parts
1. Applicable material and quantity (refer table VI)
- Welded parts : [ ] JIS Z 3104, Z 3106  
☒ ASME VIII Division 1 uw-51 "Radiographic & Radioscopic Examination of Welded Joints"
2. Acceptant standards and grade
- Casting : [ ] JIS G 0581  
☒ ASTM E 446-9 or 186-93



 पी डी आई एल <b>PDIL</b>	INSPECTION AND TEST REQUIREMENTS FOR INSTRUMENTATION	GSTD-9998	0	
			Rev	
		SHEET 6 OF 13		

**Table VI Radiography Examination**

Materials			Quantity
Casting	class 1500 or over	C-steel	One out of total quantity of the same type, size and rating for pressure retaining critical parts(a)
	class 900 or over	C-Mo steel	
	class 600 or over	Cr-Mo steel Stainless steel	
	class 300 or over	Al-killed steel 2.5 Ni steel 3.5 Ni steel	
Pressure retaining welded parts	class 1500 or over	C-steel C-Mo steel	One spot on each welded parts per same material and same welder. All welded crossing parts
	class 300 or over	Cr-Mo steel Stainless steel	
	class 150 or over	Al-killed steel 2.5 Ni steel 3.5 Ni steel	

a. Following parts are Critical parts.

- Groove-welded parts of cast body
- Flangeneck and valve seat's vicinity of cast body
- Other welded parts included in pressure retaining parts

Note: 1. In case of practical difficulty to perform Radiography Test, Manufacture shall notify Purchaser in advance, and for such case, magnetic particle or liquid penetrant examination may be used in accordance with Par. 1.5.3 with Purchaser's approval.

2. For the welded parts having nominal size of 1-1/2 in. or below, magnetic particle or liquid penetrant examination in Par. 1.5.3 may be used.

### 1.5.3 Magnetic Particle or Liquid Penetrant Examination

**[X]** For the pressure retaining parts


	INSPECTION AND TEST REQUIREMENTS FOR INSTRUMENTATION	GSTD-9998	0
			Rev
		SHEET 7 OF 13	

Table VII Magnetic particle / Liquid penetrant examination

Materials			Quantity
Casting	class 900 or over	C-steel	20% of total quantity of the same type, size and rating for pressure retaining critical parts (a)
	class 600 or over	Cr-Mo steel Cr-Mo steel Stainless steel	
	class 150 or over	Al-killed steel 2.5 Ni steel 3.5 Ni steel	
Pressure retaining welded parts (b)	class 150 or over	All materials	20% of total welded parts

- Refer to Par. 1.5.2(1).
- Including butt groove-welded parts at site.

#### 1.6 Pressure Test

##### 1.6.1 Control Valve

###### 1. Body and Bonnets

☒ Hydrostatic test with Applicable codes and standards

###### 2. Body of special type

☒ Hydrostatic test

Test pressure and Hold time

☒ 1.5 times of max. Operating pressure / min. 2 kg/cm<sup>2</sup>g

☒ Minimum 5 minutes.

###### 3. Permanent distortion or Leakage

☒ shall not be found

##### 1.6.2 Safety Valve or Safety Relief Valve

###### 1. Pressure retaining parts


☒ Hydrostatic test before assembling

###### i. Test pressure and Hold time

☐ 1.5 times of Max. Operating pressure / min. 2 kg/cm<sup>2</sup>g.

☒ 2.2 times of Max. Operating pressure.

☒ Minimum 5 minutes.

	INSPECTION AND TEST REQUIREMENTS FOR INSTRUMENTATION	GSTD-9998	0
			Rev
		SHEET 8 OF 13	

- ii Distortion or leakage  
[X] shall not be found

- 2. The out side parts of enclosed type  
[X] Hydrostatic test after assembling

- i. Test pressure and Hold time  
[X] 1.5 times. Nominal pressure of flange  
[ ] 2.2 times. Nominal pressure of flange  
[X] Minimum 5 minutes.

- ii. Defects  
[X] Shall not be found

- 3. Special type valves

- [X] Hydrostatic test with the manufacturer's standards approved by purchaser, where Par. 1.6.2(1) and (2) are not applicable

#### 1.6.3 The pressure retaining parts of instrument

- [X] Hydrostatic test or Pneumatic test as per applicable codes and standard

- I Test pressure and Hold time  
[X] 1.5 time of Max. Operating pressure / Min. 2 kg/cm<sup>2</sup>  
[X] Min. 5 minutes
- ii Permanent distortion or Leakage  
[X] Shall not be found

If the above mentioned test is technically difficult, the test shall be carried out in accordance with the manufacturer's standards approved by purchaser.

#### 1.7 Pneumatic Test

##### 1.7.1 The pneumatic test for instrument


- I Test pressure & Hold time  
[X] Max. Operating Pressure. (Design press.)  
[X] Minimum 5 minutes
- ii Permanent distortion or Leakage  
[X] Shall not be found

#### 1.8 Seat Leakage Test

##### 1.8.1 Control Valve

Allowable leakage valve / (code):

- [X] ANSI B16.104 (FCI 70-2)

	INSPECTION AND TEST REQUIREMENTS FOR INSTRUMENTATION	GSTD-9998	0
			Rev
		SHEET 9 OF 13	

Unless other wise specified, butterfly valves shall not require the seat leakage test.

### 1.8.2 Safety valve

Seat leakage test (closing property) as follows.

#### 1. Safety valve for Steam

##### i. Test pressure

☒ 90% of set pressure

##### ii. Leakage

☒ Shall not be found

#### 2. Safety valve for Gas

##### i. Test pressure

☒ 90% of set pressure

##### ii. Allowable leakage value (Refer Table – VIII)

Table VIII - Allowable leakage value of Safety valve

Type	Orifice Area (mm)	Number of Bubbles (min)	Leakage Value (cm <sup>3</sup> /min)
General	16.0 and less	40	11.80
	20.5 and over	20	5.90
Balance bellows	16.0 and less	50	14.75
	20.5 and over	30	8.85

#### 3. Relief safety valves, Vacuum breakers and atmospheric valve

☒ Manufacture's standard (approved by Purchaser)

### 1.9 Performance Test

For each instruments, the performance test shall be carried out in accordance with procedure approved by Client / PMC.


Acceptance standard shall be in accordance with applicable codes & standard, All specification, and manufacture's standard shall be approved by Client / PMC.

#### 1.10 Steam Test

Steam test shall be performed as follows:

☐ Valves used for steam service Temperature of 450°C or more, and the body ratings of class 600 and above.

☐ After attaining the steady surface temperature same as temperature of the service with the pressure of service condition.

	INSPECTION AND TEST REQUIREMENTS FOR INSTRUMENTATION	GSTD-9998	0
			Rev
		SHEET 10 OF 13	

In the case, when steam test has been performed and the report is submitted for the valve of same type, same bore size and material from the same lot, the steam test for the other valves may be omitted.

#### 1. Leakage

- i. Body : ☐ Shall not be found
- ii. Seat : ☐ As per specified leakage value

#### 2. Operation

☐ To be smooth

After the steam test, the test of Par. 1.6 and Par. 1.8 shall be carried out.

#### 1.11 Insulation Resistance Test

- 1. Power supply circuit & alarm circuit : 10M  $\Omega$  or over (instrument panel: 3 M $\Omega$  or over/each panel)
- 2. Signal circuit : 5M  $\Omega$  or more (instrument panel: 3 M $\Omega$  or More per panel)

The test shall be carried out in accordance with the applicable codes & Standards. Due to any technical constraint to measure, this test can be omitted

#### 1.12 High-voltage Test


##### 1. A-C power supply and alarm circuits

- i. Voltage level less than 250 V : ☒ A-C 1500 V
- ii. Voltage level 250 V and above : ☒ A-C 2E + 1000V

'E' is the rated voltage.


##### 2. D-C power supply circuits : ☒ A-C 500V

Test can be omitted in case of any technical constraint.


	INSPECTION AND TEST REQUIREMENTS FOR INSTRUMENTATION	GSTD-9998	0
			Rev
		SHEET 11 OF 13	

**Table A : Table of Inspection and Test Items**

Kind of Instrument	Inspection and Test Items										
	Visual insp.	Dimensional insp.	Material insp.	Non-destructive exam	Pressure test	Pneumatic test	Seat Leakage test	Performance test	Insulation resistance test	High voltage test	Steam test
1 Thermocouple	○●T	○●T	—	—	—	—	—	□●T	□●T	□●T	—
2 Resistance thermometer bulb	●T ○	●T ○	—	—	—	—	—	●T □	□●T	□●T	—
3 Compensating lead wire	○●T	○●T	—	—	—	—	—	□●T	□●T	□●T	—
4 Bimetallic thermometer	○●T	○●T	—	—	—	—	—	□●T	—	—	—
5 Gas or liquid-filled thermometer	○●T	○●T	—	—	—	—	—	●T □	—	—	—
6 Thermowell	○●T	○●T	○ □●T	○ □●T	○ □●T	—	—	—	—	—	—
7 Orifice plate	○●T	○ □●T	○●T	—	—	—	—	—	—	—	—
8 Orifice flange	○●T	○●T	○ □●T	○ □●T	—	—	—	—	—	—	—
9 Restriction orifice	○●T	○ □●T	○●T	—	—	—	—	—	—	—	—
10 Flow nozzle low-loss tube	○●T	○●T	○ □●T	○ □●T	○ □●T	—	—	—	—	—	—
11 Venturi tube	○●T	○●T	○ □●T	○ □●T	○ □●T	—	—	—	—	—	—
12 Positive displacement flow meter	●T ○	●T ○	●T ○ □	●T ○ □	●T ○ □	—	—	●S ○ □	●T ○ □	●T ○ □	—
13 Area type flow meter	○●T	○●T	○ □●T	○ □●T	○ □●T	—	—	○ □●T	○ □●T	○ □●T	—
14 Thermal mass flow meter	●T ○	●T ○	●T ○	—	●T ○ □	—	—	●S ○ □	●T ○ □	●T ○ □	—
15 Turbine meter	●T ○	●T ○	●T ○ □	●T ○ □	●T ○ □	—	—	●S ○ □	●T ○ □	●T ○ □	—
16 Differential pressure flow meter	●T ○	●T ○	—	—	●T ○ □	—	—	●T ○ □	●T ○ □	●T ○ □	—
17 Differential pressure transmitter	●T ○	●T ○	—	—	●T ○ □	—	—	●T ○ □	●T ○ □	●T ○ □	—
18 Magnetic flow meter	●T ○	●T ○	●T ○	●T ○ □	●T ○ □	—	—	●S ○ □	●T ○ □	●T ○ □	—
19 Bourdon gauge	○●T	○●T	—	—	○ □●T	—	—	○ □●T	—	—	—
20 Draft gauge	○●T	○●T	—	—	—	—	—	○ □●T	—	—	—
21 Differential pressure gauge	○●T	○●T	—	—	○ □●T	—	—	○ □●T	—	—	—
22 Pressure transmitter	○●T	○●T	—	—	○ □●T	—	—	○ □●T	○ □●T	○ □●T	—
23 Displacement type level indicator, controller	●T ○	●S ○ □	●T ○	●T ○	●S ○ □	—	—	●S ○ □	●S ○ □	●T ○ □	—
24 Chamber for displacement type level meter	○●T	○ □●T	○ □●T	○ □●T	○ □●T	—	—	—	—	—	—
25 Glass gauge	○●T	○ □●T	○ □●T	○ □●T	○ □	—	—	—	—	—	—

 पी डी आई एल <b>PDIL</b>	INSPECTION AND TEST REQUIREMENTS FOR INSTRUMENTATION	GSTD-9998	0	
			Rev	
		SHEET 12 OF 13		

Kind of Instrument	Inspection and Test Items										
	Visual insp.	Dimensional insp.	Material insp.	Non-destructive exam	Pressure test	Pneumatic test	Seat Leakage test	Performance test	Insulation resistance test	High voltage test	Steam test
26 Float type level meter,	●T ○	●S ○	●T ○ □	●T ○ □	●S ○ □	—	—	●S ○ □	●S ○ □	●T ○ □	—
27 Differential pressure type level meter	○●T	●T ○	●T ○	—	●T ○ □	—	—	●T ○ □	●T ○ □	●T ○ □	—
28 Purge type level meter	○●T	○●T	—	—	—	—	—	○ □●T	—	—	—
29 Capacitance type level meter	○●T	●T ○ □	●T ○	—	—	—	—	●T ○ □	●T ○ □	●T ○ □	—
30 Conductivity type level meter	○●T	●T ○	●T ○	—	—	—	—	●T ○ □	●T ○ □	●T ○ □	—
31 Conductivity type level meter	●T ○	●S ○	—	—	—	—	—	●S ○ □	●S ○ □	●T ○ □	—
32 Weight sounding type level meter	●T ○	●S ○	—	—	—	—	—	●S ○ □	●S ○ □	●T ○ □	—
33 Radiation type level meter	●T ○	●S ○	—	—	—	—	—	●S ○ □	●S ○ □	●T ○ □	—
34 Pneumatic type control valve	●T ○	●S ○	●T ○ □	○ □●T	●S ○ □	—	●S ○ □	●S ○ □	●T ○ □	●T ○ □	
35 Hydraulic type control valve	●T ○	●S ○	●T ○ □	●T ○ □	●S ○ □	—	●S ○ □	●S ○ □	●T ○ □	●T ○ □	
36 Motor-operated control valve	●T ○	●S ○	●T ○ □	●T ○ □	●S ○ □	—	●S ○ □	●S ○ □	●S ○ □	●S ○ □	
37 Self-acting control valve	○●T	○●T	○ □●T	○ □●T	○ □●T	—	—	○ □●T	—	—	—
38 Indicator	○●T	○●T	—	—	—	—	—	○ □●T	○ □●T	○ □●T	—
39 Recorder unit	○●T	○●T	—	—	—	—	—	○ □●T	○ □●T	○ □●T	—
40 Controller unit	○●T	○●T	—	—	—	—	—	○ □●T	○ □●T	○ □●T	—
41 Integrator unit	○●T	○●T	—	—	—	—	—	○ □●T	○ □●T	○ □●T	—
42 Alarm setting unit	○●T	○●T	—	—	—	—	—	○ □●T	○ □●T	○ □●T	—
43 Computing unit	○●T	○●T	—	—	—	—	—	○ □●T	○ □●T	○ □●T	—
44 Converter unit	○●T	○●T	—	—	—	—	—	○ □●T	○ □●T	○ □●T	—
45 Limiter unit	○●T	○●T	—	—	—	—	—	○ □●T	○ □●T	○ □●T	—
46 Power source unit	○●T	○●T	—	—	—	—	—	○ □●T	○ □●T	○ □●T	—
47 Instrument panel	●T ○	●S ○	—	—	●T ○ □	●S ○ □	—	●S ○ □	●T ○ □	●T ○ □	—
48 Instrument desk	●T ○	●S ○	—	—	—	—	—	●S ○ □	●T ○ □	●T ○ □	—
49 Gauge board	●T ○	●S ○	—	—	●T ○ □	●S ○ □	—	●S ○ □	●T ○ □	●T ○ □	—
50 Safety valve	●T ○	●S ○ □	●T ○ □	●T ○ □	●T ○ □	—	●S ○ □	●S ○ □	—	—	—
51 Pilot operated safety relief	●T	●S	●T	●T	●T	—	●S	●S	—	—	—

	<b>INSPECTION AND TEST REQUIREMENTS FOR INSTRUMENTATION</b>	GSTD-9998	0
			Rev
		SHEET 13 OF 13	

Kind of Instrument	Inspection and Test Items										
	Visual insp.	Dimensional insp.	Material insp.	Non-destructive exam	Pressure test	Pneumatic test	Seat Leakage test	Performance test	Insulation resistance test	High voltage test	Steam test
valve	○	○ □	○ □	○ □	○ □		○ □	○ □			
52 Vacuum breaker	●T ○	●S ○ □	●T ○ □	●T ○ □	●T ○ □	—	●S ○ □	●S ○ □	—	—	—
53 Atmospheric valve	●T ○	●S ○ □	●T ○ □	●T ○ □	●T ○ □	—	●S ○ □	●S ○ □	—	—	—
54 Gas chromatograph	●T ○	●T ○	—	—	—	●T ○ □	—	●S ○ □	●S ○ □	●T ○ □	—
55 Mass spectrometer	●T ○	●T ○	—	—	—	●T ○ □	—	●S ○ □	●S ○ □	●T ○ □	—
56 Infrared type gas analyzer	●T ○	●T ○	—	—	—	●T ○ □	—	●S ○ □	●S ○ □	●T ○ □	—
57 Magnetic type gas analyzer	●T ○	●T ○	—	—	—	●T ○ □	—	●S ○ □	●S ○ □	●T ○ □	—
58 Thermal conductivity type analyzer	●T ○	●T ○	—	—	—	●T ○ □	—	●S ○ □	●S ○ □	●T ○ □	—
59 Combustion type gas analyzer	●T ○	●T ○ □	—	—	—	●T ○ □	—	●S ○ □	●S ○ □	●T ○ □	—
60 Density type gas analyzer	●T ○	●T ○	—	—	—	—	—	●S ○ □	●S ○ □	●T ○ □	—
61 Photo-electric type analyzer	●T ○	●T ○	—	—	—	—	—	●T ○ □	●T ○ □	●T ○ □	—
62 Moisture analyzer	○●T	●T ○	—	—	—	—	—	●T ○ □	●T ○ □	●T ○ □	—
63 pH meter	○●T	○●T	—	—	—	—	—	○ □●T	○ □●T	○ □●T	—
64 Turbidity analyzer Water quality analyzer	●T ○	●T ○	—	—	●T ○ □	—	—	●T ○ □	●T ○ □	●T ○ □	—
65 Density meter	○●T	○●T	—	—	○ □●T	—	—	○ □●T	○ □●T	○ □●T	—
66 Electric conductivity meter	○●T	○●T	—	—	○ □●T	—	—	○ □●T	○ □●T	○ □●T	—
67 Flame detector	●T ○	●T ○	—	—	—	—	—	●S ○ □	●S ○ □	●T ○ □	—
68. Mass Flow meter	●T ○	●T ○	●T ○ □	●T ○ □	●T ○ □	—	—	●S ○ □	●T ○ □	●T ○ □	—
69. Vortex Flow Meter	●T ○	●T ○	●T ○ □	●T ○ □	●T ○ □	—	—	●S ○ □	●T ○ □	●T ○ □	—
70 Gas detector	●T ○	●T ○	—	—	—	—	—	●S ○ □	●S ○ □	●T ○ □	—

- : Tested by Manufacturer.  
● : Tested by manufacturer & witnessed by 3<sup>rd</sup> party inspector(TPI).  
□ : Manufacturer will submit Inspection & test records.  
T : Total Inspection by TPI.  
S : Sample inspection by TPI.(10% of total quantity of the same type & rating.

Notes: PMC/OWNER may witness any or all testing in stages during manufacturer or at final stage before shipment.



 पी डी आई एल <b>PDIL</b>	<b>PROJECTS &amp; DEVELOPMENT INDIA LTD</b>	PNMP/PC288/E001/SEC-5.3.1	P	 बी एच ई एल <b>BHEL</b>
		DOCUMENT NO	REV	
		SHEET 1 of 83		

## SECTION – 5.3.1

### DESIGN PHILOSOPHY – PIPING

**PLANT : SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE.**

**PROJECT : SETTING UP OF HIGH ASH COAL-TO-AMMONIUM NITRATE PLANT IN MAHANADI COALFIELDS LIMITED (MCL).**

**CLIENT : BHARAT COAL GASIFICATION AND CHEMICALS LIMITED,**



## DESIGN PHILOSOPHY- PIPING

PNMP/PC288/E001/SEC-5.3.1

P

DOCUMENT NO

REV

SHEET 2 of 83



### CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	Scope
2.0	Design Philosophy
3.0	Codes, standards and supplementary specifications
4.0	General Design
5.0	Design Philosophy / Criteria General
5.1	Equipment Layout
5.2	Unit Piping
5.3	Offsite & Yard Piping
5.4	Flare Piping
5.5	Underground Piping
5.6	Air Systems
5.7	In-Line Instruments
5.8	Sample Connections
5.9	Vents and Drains
5.10	Line Strainers
5.11	Spectacle Blinds
5.12	Flexibility Analysis and Supporting
5.13	Personnel Protection
5.14	Mechanical Handling
6.0	Materials
7.0	Thermal Insulation of Piping
8.0	Painting
9.0	Welding

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 3 of 83		

LIST OF ATTACHMENTS

ANNEXURE / ATTACHMENT NUMBER	DESCRIPTION
1	Table Of Basic Span
2	Accessibility For Valves & Instruments
3	Vertical And Horizontal Guides Spacing
4	Clearances
5	Job Specific Requirements
6	Design Philosophy for Stress Analysis
7	Design Philosophy for 3D Modeling
8	Hydrotest drain & vent

## 1.0 SCOPE

The scope of this document is pertaining to the design philosophy, norms and specific requirements which shall be adhered by LSTK contractor or his associates and representatives during the course of the project in designing, procurement & construction of piping material.

### 1.1 Applicable Standard & Codes

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 4 of 83		

Standard No.	Title
ASME/ANSI B16.5	Pipe Flanges and Flanged Fittings
ASME/ANSI B16.9	Factory-Made Wrought Butt-Welding Fittings
ASME/ANSI B16.10	Face to Face and End to End Dimensions of Valves
ASME/ANSI B16.11	Forged Fittings, Socket- Welding and Threaded
ASME/ANSI B16.20	Metallic Gaskets for Pipe Flanges – Ring Joint, Spiral Wound and Jacketed
ASME/ANSI B16.21	Non-Metallic Flat Gaskets for Pipe Flanges
ASME/ANSI B16.25	Butt-Welding Ends
ASME/ANSI B16.34	Valves – Flanged, Threaded and Welding End
ASME/ANSI B16.47	Large Diameter Steel Flanges
ASME/ANSI B31.1	Power Piping
ASME/ANSI B31.3	Process Piping
ASME/ANSI B 31.3	Process piping-Dust Extraction piping
ASME/ANSI B31.5	Refrigeration Piping
ASME/ANSI B31.11	Slurry Transportation Piping Systems
ASME/ANSI B31.12	Hydrogen related service
ASME/ANSI B36.10M	Welded and Seamless Wrought Steel Pipe
ASME/ANSI B36.19M	Stainless Steel Pipe
API 5L	Specification for Line Pipe
API 6D	Specification for Pipe Line Valves (Gate, Plug, Ball and Check Valves)
API 6FA	Fire Test for Valves
API 501	Specifications for Metallic Gaskets for Refinery Piping
API 594	Check Valves:, Wafer-Lug and double flanged type
API 598	Valve Inspections and Testing
API 599	Steel Plug Valves Flanged and Butt-weld ends
API 600	Steel Gate Valves Flanged and Butt-welding ends, Bolted Bonnets
API 602	Gate, Globe, and Check Valves for Sizes DN 100 (NPS 4) And Smaller for the Petroleum and Natural Gas Industries
API 603	Class 150 – Corrosion Resistant Flanged End gate valves.
API 604	Ductile Iron Gate valves – Flanged ends
API 606	Compact C.S. Gate Valve extended body
API 607	Fire Test for soft seated Ball Valve.
API-608	Metal Ball Valves, Flanged, Threaded & BW Ends.
API 609	Butterfly Valves, Lug type & Wafer type

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 5 of 83		

API 610	Centrifugal pumps and centrifugal pumping systems
API 623	Steel Globe Valves—Flanged and Butt-welding Ends, Bolted Bonnets
API 941	Steels for Hydrogen Service at Elevated Temperatures and Pressures
IBR	Indian Boiler Regulations
AWWA C207-D	Large Dia. Steel Flanges (Ring Type).
EJMA	Expansion Joints Manufacture Association
MSS SP 6	Standard Finishes for Contact Faces of Pipe Flanges and Connecting End Flanges of Valves and Fittings
MSS SP 25	Standard Marking System for Valves, Fittings, Flanges & Unions
MSS SP 43	Wrought Stainless Steel Butt-weld Fitting
MSS SP 45	By-pass and Drain Connection
NACE MR0175-94	Sulphide Stress Cracking resistant Metallic Material
NFPA	National Fire Protection Association
EN 10204	Metallic Products - Types of Inspection documents

## 2.0 DESIGN PHILOSOPHY

2.1 Piping systems shall be in accordance with Clause 1.1, which permits the use of the following specifications:

ASME B31.1 Power Piping

ASME B31.3 Process Piping

ASME B31.4 Liquid Transportation Piping

ASME B31.5 Refrigeration Piping

ASME B31.8 Gas Transportation Piping

Materials, design, construction, testing and inspection shall be fully in accordance with the selected specification.

2.2 The dimensions, manufacturing tolerances and marking of ferrous and non ferrous piping components shall conform to the applicable standards .The design shall comply with all applicable codes, laws and statutory regulations. The Contractor shall optimize the layout with the approval of the owner and include any changes resulting from HAZOP studies and taking into consideration the following:

- General site layout taking into account the topographical geo-technical aspect of the site
- Access for maintenance and fire appliances
- The interdependency of units and buildings with each other within the complex
- Safety escape routes for personnel based on emergency or disaster management plans in the event of environmental upset or fire
- Suitable drainage system of Project site

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 6 of 83		

2.3 Material of construction shall be suitable for specified process duty (both normal and abnormal operations) and have a projected life and corrosion/ erosion allowance in excess of minimum life of the project. Piping materials specified in piping materials specification shall be used for selection of material of construction of major services.

All materials under steam service shall be supplied with proper certificates in prescribed forms.

#### 2.4 **Design Pressure**

The design pressure of each component in a piping system shall be the most severe condition of the followings:

- i) Design pressure of equipment to which it is connected
- ii) Set pressure of a pressure relieving device which protects the system
- iii) Shutoff discharge pressure of a centrifugal pump, not protected by a pressure relieving device.

If the shutoff discharge pressure is unknown, it may be determined by the largest of the followings:

- a) 1.2 times the differential pressure at normal flow plus the maximum pump suction pressure
- b) 1.1 times pump discharge pressure at normal flow

c) Full vacuum for a system operating below atmospheric pressure

#### 2.5 **Design Temperature**

The design temperature of a piping system shall be the design temperature of connected equipment, unless the equipment is obviously overrated. For un-insulated piping, the design temperature may be determined in accordance with the ASME B31.3.

The reducing coefficient for piping components not specified in the ASME B31.3 shall be 95% for the fluid temperatures over 37°C.

The design temperature for a steam traced or steam-jacketed piping shall be the higher of the followings:

- Fluid temperature
- Normal operating temperature of steam

### 3.0 **CODES, STANDARDS AND SUPPLEMENTARY SPECIFICATIONS**

3.1. The latest edition of codes listed in clause 1.1 shall be applicable for piping system design, materials, fabrication, manufacture, erection, construction and inspection etc. For any item not covered in the list of codes and standards / International Standards / proven design may be finalized based on discussion with OWNER/Consultant.

3.2 Where conflict occurs, the order of precedence shall be:

- a) Statutory Regulations
- b) National, International and Industry Standards and Codes of Practice.
- c) Technical Specifications

3.3 Standards, codes and supplementary specifications for piping design shall be applied as follows:

- i) Process and utility piping to ASME B31.3 Process Piping
- ii) Power Plant piping to ASME B 31.1

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 7 of 83		

- iii) Requirements of Anhydrous Ammonia Code
- iv) Sour service piping to NACE (National Association of Corrosion Engineers) specification MR0175.
- v) Plant layout and fire protection piping to Dangerous Goods Regulations and “Storage and Handling of Flammable and Combustible Liquids”, supplemented where required by NFPA (National Fire Protection Association) Code 30.
- vi) Fire protection system shall be designed and installed in accordance with applicable NFPA (National Fire Protection Association) Codes.
- vii) Piping fabrication tolerances to ASME B31.3 and PFI (Pipe Fabrication Institute) practice ES-3.
- viii) Colour coding for identification of piping material to PFI Practice ES-22/ as per owner's approval.
- ix) Pipe wall thicknesses shall be in accordance with ANSI B36.10 or B36.19.
- x) Ammonia – Code of Safety IS-4544.

#### 4.0 GENERAL DESIGN

- 4.1 Valve shall be provided at battery limit for respective piping system.
- 4.2 Flanges for process and utility piping shall be in accordance with ANSI B16.5 and ANSI B16.47.
- 4.3 Wherever possible all purchased equipment shall be supplied with flanges that comply with ANSI B16.5.
- 4.4 The minimum size of piping to be used in pipe-racks shall be 2” NB.
- 4.5 With the exception of equipment connections the minimum size of piping shall be ½” NPS.
- 4.6 Pipe sizes 1 ¼”, 2 ½”, 3 ½” and 5” NPS shall not be used except as connections to purchased equipment.
- 4.7 Threaded pipe nipples between headers and vent, drain and instrument isolation valves shall be Schedule 160 for CS and Schedule 80S for SS in the size range ½” to 2” NPS.
- 4.8 Piping 2” NPS and above shall be butt-welded. All weld joints in piping 1½” NPS and below shall be socket welded using socket weld fittings.
- 4.9 In Class 900 and higher pressure rating double block valves shall be used for systems open to atmosphere, such as vents and drains. Piping in hazardous service shall have vents, drains and bleeds routed to a safe location. Category ‘M’ substances shall be vented to the flare system.
- 4.10 When a line of one material specification is connected to a line of higher material specification, the connecting line shall be constructed of the higher material specification or pressure rating up to & including the first block valve.
- 4.11 As a minimum, piping systems shall have isolation facilities as follows:  
ASME B31.3 Category ‘M’ service and Normal service (Class 900 and above) shall have double block isolation valves with a downstream drop-out spool.  
ASME B31.3 Normal service (Class 150 to 600) shall have a valve and downstream spectacle blind.  
ASME B31.3 Category ‘D’ service shall have a valve and downstream spectacle blind.  
Generally, equipment shall have provision for isolation of piping to each equipment connection by means of valving and /or blinds as determined by service conditions.
- 4.12 Criteria for Isolation Valves

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 8 of 83		

Installation (Class Rating)	Process Isolation	Drain/ Vent	Pressure Taping	Level Taping	Flow Element	Safety Valve	Control Valve
150 / 300#	Single	Single	Single	Single	Single	Single	Single
600 #	Single	Single	Double	Single	Double	Single	Single
Above 600#	Double	Double	Double	Double	Double	Double	Single

Note: For S/D & at battery limit, it will be as per process requirements

Piping flexibility shall be achieved by the use of piping offsets and expansion loops whenever possible. Expansion joints shall not be used without written permission of the Owner.

## 5. DESIGN PHILOSOPHY / GENERAL CRITERIA

### 5.1 Equipment Layout

#### 5.1.1 Basis of Equipment Layout

Equipment Layout shall be finalised based on the following data:

- Site Location Plan
- P&I Ds
- Equipment Data Sheets
- Wind Direction
- Overall Plot Plan
- Safety Distance and Specific Distance mentioned in Piping Design Basis and as per statutory requirements.

#### 5.1.2 Development of Equipment Layout

The following aspects shall be considered during development of equipment layout;

- Process Requirement -Proper interconnection between equipment as per P&IDs to achieve the intended process parameters.
- Economy of piping material- Minimize the quantity of costly piping.
- Erection & Construction requirements:

Erection scheme and schedule of all equipment must be considered during equipment layout to have smooth erection mainly in case of tall columns, heavy equipments like thick walled reactors, space for laying tall columns, approach roads for cranes / derricks for lifting the column or reactors and requirement of special foundation / pile etc.

#### d) Operation and Maintenance Requirement

- Overhead and side clearances for exchangers and pumps
- Provision of exchangers tube bundle pulling area
- Horizontal & overhead clearances for easy movement of working personnel
- Crane approaches for air coolers/fired heaters
- Provision of catalyst loading/unloading facilities.
- Provision of monorail for pumps and exchangers
- Provision of EOT crane for compressors.
- Provision of operator's cabin.
- All coke chambers shall be having the lift provision.



<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 9 of 83		

- e) Similar equipment grouping - All columns, exchangers, pumps etc. should be grouped together for convenience of maintenance and safety wherever feasible.
- f) The technological structures should be interconnected for easy movement of operational personnel.
- g) U/G piping corridors for main headers should be marked in equipment layout for all underground piping.

## 5.2 Plant Layout & Design guidelines

### 5.2.1 General

- 5.2.1.1 The plant layout shall be based on ensuring adequate access, to allow construction, inspection, maintenance and operation to be performed in a safe and efficient manner. The alignment of equipment and pipe shall offer an organised appearance. The layout shall be in accordance with, but not limited to, the design practices described in this criteria.
- 5.2.1.2 Where dynamic loading, limited pressure drop or other severe service condition applies, particular care shall be taken in routing pipe lines.
- 5.2.1.3 Flushing connections shall be provided on all lines containing flammable or toxic material, slurries, and materials which solidify or lead to scaling or choking, when the line is idle or even in operation. Sufficient Nitrogen purging points shall also be provided. Supply piping of fuel gas shall be arranged for equal flow distribution.
- 5.2.1.4 Trolley beams, pipe davits, shall be provided with appropriate removable hoists mechanism for charging and discharging catalysts, chemicals, packing rings etc.
- 5.2.1.5 Piping and all other services shall be arranged so as to permit ready access of Cranes for removal of Equipment for inspection and servicing.
- 5.2.1.6 All utility and process piping shall be located above ground, and major lines shall be located in overhead pipe ways.  
The following lines may be buried providing they are adequately protected.
  - Cooling Water Lines 18" dia. and larger
  - Fire water mains
  - Drain and Sewer (oily and chemical) lines from catch basin to mains and manholes
- 5.2.1.7 Lines that must be run below grade, and must be periodically inspected or replaced, shall be identified on the P & ID's; these lines must be placed in covered concrete trenches. Sleeper-ways shall not be used in process areas where they may block access for personnel and equipment.
- 5.2.1.8 Fire protection system shall be designed as per NFPA, / TAC and as per statutory requirements. Refer Fire Fighting Design Basis.
- 5.2.1.9 Drip legs and dead ends shall be avoided, especially for piping where solids or fluids may congeal from corrosive condensate.
- 5.2.1.10 Where sleeper ways are used the elevations shall be staggered to permit ease of crossing or change of direction at intersections. Flat turns may be used when entire sleeper ways change direction. Flat turns must not be used within pipe racks.
- 5.2.1.11 All cooling towers shall have sunshades at top distribution decks to avoid algae growth. Cooling towers should be located away from process unit area, preferably downstream direction of wind. Orient the short side of the tower along the prevailing summer wind for maximum efficiency. Locate cooling towers a minimum of 30m away from process units, utility units, fired equipment, and process equipment.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 10 of 83		

- 5.2.1.12 Locate flare stacks upwind of process units, with a minimum distance of 90 m from process equipment, tanks and cooling towers.
- 5.2.1.13 Spacing and routing of piping shall be such that expanding/contracting lines (including insulation) will not clash with adjacent lines, structures, instruments and electrical equipment during warm up and cool down.
- 5.2.1.14 Piping to be sloped shall be indicated on the P&ID's.

## 5.2.2 Pipe-Rack/T-Post/Small Portals

- 5.2.2.1 In general, equipment layout shall be prepared considering straight pipe rack, however other shapes like L / T / U / H / Z etc can also be considered based on area available.
- 5.2.2.2 The width of the rack shall be 4M, 6M, 8M, 10M or 12M for single bay having four (4) tiers maximum. In general, the spacing between pipe rack portals (span) shall be taken as 8 M for main rack. However it can be decreased to 6 M depending on the size/number of the pumps to be housed below pipe rack. Intermediate Beams between two portals shall be provided to support smaller pipes  $\leq 2"$ . 20% extra space shall be provided on the pipe rack and portals on each tier for future expansion/modifications. Water lines more than 16" shall not be routed over rack.
- Clearance beneath pipe rack shall be 3.8 M minimum.
  - Road clearance shall be 9 M minimum wherever heavy duty crane movement is required during construction and future maintenance.
  - Road clearance shall be 7.5 M minimum for main roads.
  - Road clearance shall be 5 M minimum for secondary roads.
  - T-Portal's width shall not be more than 2.5 M and height shall not be less than 3.0M.

## 5.2.3 Towers and Vertical Vessels

- 5.2.3.1 Towers and vertical vessels shall be arranged in a row with common centre line, decided by the largest vessels, placing O.D. of the equipment minimum 4 M away from the pipe rack. A minimum clearance of 3 M shall be allowed between tower shells, but in any case adjacent towers shall be checked so that platforms do not overlap considering the deflection of towers (deflection of towers shall be considered minimum  $L/200$  MM, WHERE, (L=height of tower). A minimum 100 mm horizontal gap shall also be provided between platforms of adjacent towers after deflection and that a minimum 900 mm is left between tower plinths. Also the gap between vertical vessels shall allow full opening of manhole covers without restriction.
- 5.2.3.2 Efforts shall be made to provide interconnecting platforms at suitable levels for adjacent towers and/or adjacent technological structure etc., Interconnections where ever feasible shall be done, after taking thermal expansions of towers into consideration.
- 5.2.3.3 The maximum vertical distance between platforms shall be 6 m. All level switches, LGs etc including their isolation valves shall be accessible from ladders or platforms. To handle heavy items (like relief valves, blinds etc.), davit of suitable capacity to lift higher weight of safety valves/ Blind/ Internals etc. is needed. The davit shall be on the side of the vessel away from the rack. The area at grade shall be kept clear for a dropout. Davit capacity shall be minimum 1 MT.
- 5.2.3.4 Chemical vessels to be located close to the dosing point to the extent possible, specially ammonia & corrosion inhibitors.

## 5.2.4 Re-boiler

- 5.2.4.1 Re-boiler shall be located next to the tower they serve except fired heater type. The elevation of re-boiler shall be as given in the P & ID's. Horizontal thermo siphon types are usually supported by the tower and are located on the back side to be accessible for maintenance. Large vertical

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 11 of 83		

types may require a supporting structure which cannot be supported from the tower/column. Re-boiler piping shall be checked for pressure drop before finalization.

#### 5.2.5 **Horizontal Vessels**

- 5.2.5.1 The horizontal vessels shall be laid perpendicular to pipe rack and shall be placed minimum 4M away from the pipe rack. The clearance between horizontal vessel shells shall be minimum 2M or 900 mm clear aisle whichever is higher.

#### 5.2.6 **Pumps**

- 5.2.6.1 Wherever practical, pumps shall be arranged in rows with the centre line of the discharge on a common line. In general, pumps shall be kept inside the pipe rack. However in case of smaller racks, pumps shall be kept on one side or outside the pipe rack to provide clear access under the rack as per clause 5.2.11.2.
- 5.2.6.2 Pump foundation height shall be 300 mm above H.P.P. Pumps which are handling hydrocarbon at temperature above 315°C and pumps for which specific notes are given in P&ID shall be necessarily housed outside the rack.
- 5.2.6.3 Gap between each pump foundation / and foundation of technical structure should be sufficient for easy removal of equipment after piping. Clearance between two adjacent pumps shall be such that clear 900 mm aisle is available.
- 5.2.6.4 No monorail should normally be provided for pumps outside rack and sufficient space below rack shall be available for pump maintenance.

#### 5.2.7 **Exchangers**

- 5.2.7.1 In most of the cases floating head of exchangers are placed on a line minimum 4M away from pipe rack. Shell and tube type exchangers may have a removable shell cover with flanged head. Tube pulling or rod cleaning area must be allowed at the channel end. This shall be minimum the tube bundle length + 1.5M from the channel head. In case of vertical exchanger suitable platform shall be provided below the top flange of channel or bonnet.
- 5.2.7.2 Minimum clearance in between two horizontal exchangers shall be 2M or 900mm clear aisle whichever is higher.
- 5.2.7.3 Likewise Heat Exchanger train should be suitably spaced such that shell/ tube inlet/outlet piping do not foul floating Head Covers creating maintenance problem.
- 5.2.7.4 Hydro extractor is considered for exchanger bundle/ shell removal. Monorails to be provided for tube bundle removal only for exchangers not accessible to Hydro extractor. No special bundle removal arrangement will be provided for exchangers which are open to sky. Davit shall be provided for floating head cover for all exchangers.

#### 5.2.8 **Fin Fan Exchangers**

- 5.2.8.1 Fin fan exchangers shall be located over the main pipe rack or on technological structure. 15.0 M horizontal distance shall be maintained from furnace/heater. Concrete floor shall be provided below the fin-fan coolers located above the pipe rack. The width of the structure from where Air Fin exchanger assembly is supported shall be minimum 2.0 M more than the Air Fin exchanger tube bundle length so that proper supporting of inlet/outlet piping manifolds can be done from the main members of pipe rack/technological structure to transfer piping load to main structural members. Monorail shall be provided at one end of air cooler platform area for lowering the gear boxes. Adequate headroom /clearance shall be provided between concrete floor and fan location.

#### 5.2.9 **Furnaces**

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 12 of 83		

- 5.2.9.1 Furnaces are located upwind or side wind of process units to blow any combustible leaks away from the open flame. They are located minimum / 90 M away from storage tanks and 30 M away from control room. Vessels / reactors directly connected to furnace are exception.
- 5.2.9.2 Furnaces shall be arranged with centreline on a common line in case of circular furnace and wherever a common stack is furnished to cater more than one furnace the stacks shall be located at the end or side which is away from the unit. In case of individual box furnaces, the edge of the furnaces on the rack side shall be matched. F.D. fans shall be located at one corner of furnace area away from equipments handling hydrocarbons. It shall be ensured that there are no working platforms within an elevation of 6.0 M below the tip of stack height inside a 25.0 M radius of the stack. However the stack height shall be governed by statutory authority.
- 5.2.9.3 For maintenance, vertical tube furnaces must have access to permit a crane to remove and replace tubing. Horizontal tube furnaces must have horizontal free space equal to tube length for tube pulling / maintenance / cleaning.
- 5.2.9.4 In case of bottom floor fired heaters, there shall be adequate headroom clearance underneath the furnace for removal of burners. In case of wall fired furnaces minimum 2.0 M wide platform with escape route at" each end is necessary.
- 5.2.9.5 Pits and trenches are not permitted under furnace or any fired equipment. Underground drain points and manhole covers shall be sealed within furnace vicinity.
- 5.2.9.6 APHs should be located in such a way that the modules can be removed by crane. However, layout of furnaces, ID / FD fans, stacks and APH etc shall be arranged as per final approved vendor data.
- 5.2.10 **Compressors and their Prime Movers**
- 5.2.10.1 Two major types of compressors used in process plants:
1. Centrifugal compressors
  2. Reciprocating compressors.
- 5.2.10.2 Compressors shall be located to keep suction lines as short as possible. Drivers for compressor may be electric motor, gas engine, gas-fired turbine or steam turbines as per P& ID. The gas compressors shall be located downwind side of furnace so that leaks are not blown towards furnace. In general compressors are kept under shed. When compressors are kept under shed, sides are fully open for the low shed or partially closed from top for high shed to avoid accumulation of heavier gases in the shed.
- 5.2.10.3 In case of a turbine driven compressor, if exhaust steam is condensed, turbine and compressor to be located at an elevated level and condenser to be located below turbine.
- 5.2.10.4 A major consideration in centrifugal compressor location is the lube and seal oil console. It must be accessible from road and must be lower than the compressor to allow gravity drain of oil to the consoles oil tank.
- 5.2.10.5 Intercoolers are placed near compressor and are kept within/outside shed, keeping the safe distance. Knockout pots and after coolers may be kept outside the shed but near compressor house.
- 5.2.10.6 For compressors one electrically operated Crane to handle heaviest removable piece shall be provided for each compressor house. Maintenance bay for compressors shall be provided. Maintenance bay shall be accessible from road to facilitate unloading of load on to truck etc. For removal of bundles of exchangers located within building monorail arrangement shall be provided.
- 5.2.10.7 Compressor manufacturer may be consulted for better layout and additional requirement for maintenance. However licensor's requirement, if any, shall also be taken into consideration.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> भारतीय वोल्टीज एल BHEL</div>
		DOCUMENT NO	REV	
		SHEET 13 of 83		

5.2.10.8 In case the compressors are located at grade level; the finished floor level for compressor house shall be 300 mm above HPP. However if the compressors are located at elevated structure the finished floor can be same as HPP.

5.2.10.9 Layout of compressor house for plant shall be such as to have minimum distance of:

- a) When installed in a line
  - i) 5 meters on either side of compressor train
  - ii) 5 meters between compressors
- b) When installed in parallel
  - i) 5 meters at both ends of compressor/turbine train.
  - ii) 5 meters between compressors

5.2.10.10 All distances are to be measured from the edge of base plate.

5.2.10.11 The bidder shall submit plan layout of the compressor house and the design of plant layout shall be in agreement with owner. The compressor house shall be covered. The drop down area shall be provided with removal grating and structure. All other area shall be covered.

## 5.2.11 Clearance and Accessibility

### 5.2.11.1 Crane Access & Tube bundle pulling

Equipment, structures shall be arranged to permit crane access to service air coolers, compressors and exchangers. All exchanger tube bundles shall be "jacked out" against shell. A clear space for tube bundle removal shall be provided. Dropout bay may be considered for exchangers at elevated structures. For high pressure exchangers, shell pulling on rails should be considered.

### 5.2.11.2 Access to Pumps

Clear access of 3.8M vertically and 4.5M horizontally shall be provided centrally under main pipe rack for small mobile equipment to service pumps, wherever these are put under pipe ways with prior specific approval. Pumps outside rack shall be approachable by small cranes etc. from under the pipe rack.

### 5.2.11.3 Access to lower items to grade (Lowering Area)

Clear access shall be provided at grade on the access side for lowering external and internal fittings from tall elevated equipment by providing pipe davits.

### 5.2.11.4 Layout & Access Requirements for Platforms ladders and Stairs

For providing platform ladder & staircase following guidelines shall be followed;

- Two means of access (i.e. two ladders or one ladder and one stair case) shall be provided at any elevated platform which serves three or more vessels & for B/L valves operating platform.
  - Platforms, ladders and stairways shall be the minimum, consistent with access and safety requirements
  - Stairway for tanks to be provided on upstream of predominant wind direction
- i) Platform at elevated structure
    - a) Dual access (i.e. one staircase and one ladder) shall be provided at large elevated structure if any part of platform has more than 22.65M (75 ft) of travel.
    - b) Air coolers shall have platforms with interconnected walk-ways provided to service valving, fan motors and instruments. Access requirements shall conform to paragraph (a) above.



<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 14 of 83		

- c) When fired heaters are located adjacent to one another, they shall have inter-connecting platforms on the upper and lower section. Inter-connecting platforms between towers may be provided taking into consideration expansion of towers.
- ii) Platforms with stair access shall be provided for:
  - a) Location at which normal monitoring (once a day or more) is required or where samples are taken.
  - b) Locations where vessels or equipment items need operator attention "such as compressors, heaters, boilers etc.
- iii) Platforms with ladder access shall be provided for:
  - a) Points which require occasional operating access including valves, spectacle blind and motor operated valves, and heater stack sampling points.
  - b) Man ways above grade on equipment.
- iv) Ladder location
  - a) Wherever practicable, ladder shall be so arranged that users face equipment or platform rather than facing open space.
  - b) Landings shall be staggered. No ladder shall be more than 6 M in one flight.

#### 5.2.12 Valves

- 5.2.12.1 Piping shall be so arranged that valves can be operated easily. Frequently operated valves shall be located in such a way that the valves are easily accessible from grade, platforms, stairs or ladders, and that the bottom of a hand wheel is located less than 1.8 m above the operating floor level.
- 5.2.12.2 Other valves should also be accessible where they are located at more than 1.8 m above the operating floor level. Chain-operated valves shall not be used.
- 5.2.12.3 For valves in trenches, if hand wheels are located more than 300 mm below the cover plate, the valves shall be provided with extension stems extending to within 100 mm below the cover plate.
- 5.2.12.4 Manually operated valves, which are used in conjunction with locally mounted flow indicators, shall be placed at the same operating level and located where the instrument can be readily observed.
- 5.2.12.5 Double block valves with a bleeder connection shall be provided with interconnecting piping where intolerable contamination could result from valve leakage.
- 5.2.12.6 Where block valves are installed in branch lines from headers, the valves shall be located in horizontal runs at high points so that lines will drain both ways.
- 5.2.12.7 All valves shall be so installed that the stems are not below horizontal positions unless otherwise specified.
- 5.2.12.8 All valves shown on the piping and instrument flow diagrams as located at nozzles of equipment, such as towers and reservoirs, shall be connected directly to the nozzles.
- 5.2.12.9 Battery limit valves, if required, shall be grouped together and consideration shall be given to provide a common operation platform.
- 5.2.12.10 Vessel nozzles located below the normal or emergency liquid level shall be provided with the block valves, if practical. Other vessel nozzles shall be provided with block valves only if required for operation.

#### 5.2.13 Control Valves

- 5.2.13.1 All control valves shall be easily accessible from grade or permanent platforms and conveniently located for operations and maintenance.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> भारतीय वोल्टीज एल BHEL</div>
		DOCUMENT NO	REV	
		SHEET 15 of 83		

5.2.13.2 Control valves shall be provided with block valves, a bypass valve and a drain valve. Fitting (flange or pipe fitting) shall be provided between the control valve and the block valves for easy maintenance. The drain valve shall be provided with the fittings (flange or pipe fittings) upstream of the control valve.

5.2.13.3 Block valves, bypass valve and drain valve may be omitted at the following conditions:

- 1) Block valves
  - a) Where operating conditions are mild, and omission of the block valves will not jeopardize safety or operability of the unit.
  - b) Where continuous operation using a bypass valve is impossible.
  - c) For the downstream block valve of control valve, where discharged to atmosphere.
- 2) Bypass valve
  - a) Where the block valve is omitted.
  - b) Where continuous operation using a bypass valve is impossible.
  - c) Where a globe valve is used instead of upstream block valve of a control valve, when discharged to atmosphere.
- 3) Drain valve
  - a) Where operating conditions of piping for water, brine, non-flammable or nontoxic fluid are mild.

5.2.13.4 Unless otherwise specified on piping and instrument flow diagrams, sizes of block valves and bypass valves shall generally be as follows:

(Unit: Inch)

Flange Size of Control Valve	Line Size	Block Valve Size	Bypass Valve Size
3/4	3/4	3/4	3/4
	1	1	1
	1-1/2	1-1/2	1-1/2
	2,3,4	2	1
1	1	1	1
	1-1/2	1-1/2	1-1/2
	2,3,4	2	1-1/2
1-1/2	1-1/2	1-1/2	1-1/2
	2,3,4	2	2
2	2	2	2
	3,4,6	3	3
2-1/2	3,4,6	3	3
3	3	3	3
	4,6,8	4	4
4	4	4	4
	6,8,10	6	6

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 16 of 83		

6	6	6	6
	8,10,12	8	8
8	8	8	8
	10,12	10	10
10	10	10	10
	12,14	12	12

Control valves, where practicable, shall be installed with the stems vertical.

#### 5.2.14 Orifice

5.2.14.1 The length of straight run piping upstream and downstream of the orifice shall be in accordance with API RP550, Manual on Installation of Refinery Instruments and Control Systems, unless otherwise specified.

5.2.14.2 The straight run shall be designed for a beta ratio of 0.7. The smaller ratio may be used where practical considerations preclude the longer straight run installation.

5.2.14.3 Orifice runs shall be located in the horizontal. Orifice flanges with a centre line elevation 4.5m above grade, including installed in pipe racks, shall be accessible from a platform with permanent ladder.

5.2.14.4 Orifice taps, in general, shall be located as follows: (Please also refer specs. for Instrumentation)

i) Air, Gas and steam

Top vertical centreline (preferred)

45 degrees above horizontal centreline (alternate)

ii) Liquid

Horizontal centreline (preferred)

45 degrees below horizontal centreline (alternate)

Tap orientation shall be shown on piping isometrics. Finally all orifice impulse tapping / spare tapping will have to be seal run.

#### 5.2.15 Clearances

Minimum clearances shall be as indicated in Annexure-4.

#### 5.3 Unit Piping

##### 5.3.1 Basis of Unit Piping

- Piping & Instrument Diagram
- Equipment layout
- Equipment Data sheet & Setting plan
- Line list
- Instrument Data sheet
- Structural & building drawings
- Topography of the plant
- Piping material specification
- Overall plot plan

The following objective shall be ascertained during piping layout;



<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 17 of 83		

- Proper access to all operating points including valves, and for all orifice tapping points and instruments in particular (refer Annexure-2).
- Proper access to interrelated operating points for specific purpose and for maintenance.

### 5.3.2 Pipe Ways/Rack piping

- 5.3.2.1 Racks shall be designed to give the piping shortest possible run and to provide clear head rooms over main walkways, secondary walkways and platforms.
- 5.3.2.2 Predominantly process lines are to be kept at lower tier and utility & hot process lines on upper tier.
- 5.3.2.3 Generally the top tier is to be kept for Electrical (if not provided in underground trench as per electrical design basis) and Instrument cable trays. Cable tray laying to take care of necessary clearances for the fire proofing of structure.
- 5.3.2.4 Generally the hot lines and cold lines shall be kept apart in different groups on a tier and bigger size lines shall be kept nearer to the column.
- 5.3.2.5 Minimum spacing between adjacent lines shall be decided based on O.D of bigger size flange (minimum rating 300# to be considered), O.D of the smaller pipe, individual insulation thickness and additional 25 mm clearance, preferably. Wherever, even if flange is not appearing, the minimum spacing shall be based on above basis only.
- 5.3.2.6 Actual line spacing, especially at 'L' bend and loop locations, shall take care of thermal expansion / thermal contraction / non expansion of adjacent line. Non expansion / thermal contraction may stop the free expansion of the adjacent line at "L' bend location.
- 5.3.2.7 Anchors on the racks are to be provided on the anchor bay, if the concept of anchor bay is adopted. Otherwise anchors shall be distributed over two to three consecutive bays.
- 5.3.2.8 Anchors shall be provided within unit on all hot lines leaving the unit.
- 5.3.2.9 Process lines crossing units (within units or from unit to main pipe way) are normally provided with a block valve, spectacle blind and drain valve. Block valves are to be grouped and locations of block valves in vertical run of pipe are preferred. If the block valves have to be located in an overhead pipe way, staircase access to platform above the lines shall have to be provided.
- 5.3.2.10 Provision of block valves, blinds etc. shall be as per Process Design Basis and P & IDs.
- 5.3.2.11 All small bore piping shall be designed in a way so as to ensure adequate space for maintenance and operation. For small bore piping intermediate support shall be provided in between portals.
- 5.3.2.12 Stubs on saline water (if applicable) service shall be from top of main header.
- 5.3.2.13 Minimum branch size for tapping including for instruments e.g. PG/ PTI TE etc. shall be of 3" NPD and 150 mm height on internal cement lined pipes.
- 5.3.2.14 Aboveground lines shall be grouped to run on pipe racks or sleepers in so far as practicable.
- 5.3.2.15 Hot lines on pipe racks or sleepers shall be grouped and expansion loops shall be nested together. The number of expansion loops shall be kept to a minimum.
- 5.3.2.16 Piping handling corrosive fluids shall be run under piping handling non corrosive fluids, and shall not, where possible, be run overhead across walkways or normal passages for personnel.
- 5.3.2.17 All process and utility piping will be located aboveground within the plant battery limit, except water mains.
- 5.3.2.18 All piping shall be arranged in horizontal banks, where possible, to facilitate supporting. Banks running north-south shall be at different elevations from banks running east-west. Exceptions are permitted to avoid unnecessary change in elevation at change of direction or where essential to avoid pockets.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> BHEL</div>
		DOCUMENT NO	REV	
		SHEET 18 of 83		

- 5.3.2.19 All piping shall be routed for the shortest possible run and have the minimum number of fittings consistent with provision for expansion and flexibility. All piping shall be arranged in a neat manner, providing free access around all operating equipment.
- 5.3.2.20 Vertical lines at vessels shall run close to the vessel shell to facilitate supporting. The line shall be arranged and grouped to allow the use of single support.
- 5.3.2.21 Lines carrying molten solids, slurries or highly viscous liquids shall have a sufficient slope for each gravity flow.
- 5.3.2.22 The shortest and most direct layout possible shall be provided for gravity flow lines, especially when the fluid is subject to solidification and when the differential pressure is small.
- 5.3.2.23 Piping shall be arranged to facilitate handling of equipment for inspection or maintenance.
- 5.3.2.24 Vapour collecting system shall be routed so that the vapor rises continuously from the vessel being vented to a higher point without pocketing.
- 5.3.2.25 Pockets shall be avoided in lines, particularly those carrying corrosive chemicals, slurries, vents, blow down lines, etc.
- 5.3.3 Column / Vessel Piping Control Valves**
- 5.3.3.1 Piping from column shall drop or rise immediately upon leaving the nozzle and run parallel and as close as practicable to vessel. Re-boiler outlet piping shall be as short as possible with minimum bends.
- 5.3.3.2 Piping shall be grouped as far as possible for the ease of supports and shall run on the rack side of the column.
- 5.3.3.3 Manholes shall be kept on the road side of the column and approachable from the platform. Platform width shall be such that minimum 1.0 M space is available beyond manhole for movement.
- 5.3.3.4 Piping shall be supported from cleats welded on the vessel as far as possible.
- 5.3.3.5 Proper guides at intervals shall be provided for long vertical lines.
- 5.3.3.6 Access platforms/ladders shall be provided along the column for valves and instruments. Minimum width of platform shall be 750 mm clear.
- 5.3.3.7 For ease of operation and maintenance, column and vessels which are grouped together, shall have their platforms at the same elevation interconnected by walkways wherever feasible. However each column \ vessel shall have an independent access also. Column vessel platforms should be designed in such a way so that all the nozzles should be approachable from platforms.
- 5.3.3.8 Unless specifically indicated in P&ID's control valves shall preferably be kept at grade instead of platform.
- 5.3.3.9 Piping intended for vacuum services shall be routed as short as possible, with minimum bends and flanged joints.
- 5.3.3.10 Piping support cleats shall be designed for safety valves considering impact loading during popping off.
- 5.3.4 Exchanger Piping**
- 5.3.4.1 Exchanger piping shall not run in the way of built in or mobile handling facilities.
- 5.3.4.2 Wrench clearance shall have to be provided at exchanger flanges.
- 5.3.4.3 Piping shall be arranged so that they do not hinder removal of shell end and channel cover and withdrawal of tube bundle.
- 5.3.5 Heater/ Furnace Piping**

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 19 of 83		

- 5.3.5.1 Arrange piping to permit burner removal by providing break up flanges in the piping.
- 5.3.5.2 Burner valves shall be located close to peep holes for operation. Piping to burners shall be arranged in such a way to give equal and sufficient quantity of oil/gas to all burners.
- 5.3.5.3 Only flexible metallic SS hoses shall be used for burner piping if required.
- 5.3.5.4 Block valves for emergency snuffing steam valves shall be located minimum 15M away from the heater, preferably on the upwind side of the heater.
- 5.3.5.5 Piping from various passes of heater outlet nozzles should preferably be symmetrical. Transfer line from heater to column shall be as short as possible, without pockets, free draining and with minimum bends.
- 5.3.5.6 No piping shall be routed in the tube withdrawal area. If unavoidable, break up flanges shall be provided in the piping for removal.
- 5.3.5.7 All furnaces, if they are located in the same area they should be interconnected with platforms at different locations.
- 5.3.6 **Pump Piping**
- 5.3.6.1 Pump drives shall have clear access.
- 5.3.6.2 Pump suction piping shall be as short as possible and shall be arranged with particular care to avoid vapour pockets.
- 5.3.6.3 Reducers immediately connected to the pump suction shall be eccentric type flat side up to avoid the accumulation of gas pocket. For end suction pumps, elbows shall not be directly connected to the suction flange. A straight piece minimum 3 times the line size shall have to be provided at the suction nozzle.
- 5.3.6.4 Pump discharge check valve if installed in vertical lines shall be fitted with a drain connection as close as possible downstream of the valve.
- 5.3.6.5 When a suction vessel operates under vacuum, the vent connection of the pump has to be permanently connected to vapour space of the suction vessel to allow possible filling of the pump with liquid before it is started.
- 5.3.6.6 Unless otherwise specified T-type strainers shall be used on pump suction piping for sizes 2" and above.
- 5.3.6.7 Y-type strainers to be used for all sizes in steam services and for pump suction lines 1½ and below.
- 5.3.6.8 All small bore piping connected to pump (drain to OWS & CBD, seat and gland leak drain) shall have provision for break up flanges for removal of pumps.
- 5.3.6.9 Piping shall be so arranged that forces and moments imposed on the pump nozzle do not exceed the allowable values as per API 610 (centrifugal pumps and centrifugal pumping systems).
- 5.3.6.10 Pump discharge should preferably be routed away from the pump rather than towards the motor side.
- 5.3.6.11 Pump cooling water connection shall be taken from the top of circulating cooling water header.
- 5.3.7 **Compressor Piping**
- 5.3.7.1 Suction lines shall be as short as possible.
- 5.3.7.2 Suction piping shall have adequate flanged joints for ease of erection and maintenance.
- 5.3.7.3 Lube oil cooler space shall be provided such as to facilitate tube bundle removal.

<div><div><div>पी डी आई एल PDIL</div></div></div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div><div><div>भेल BHEL</div></div></div>
		DOCUMENT NO	REV	
		SHEET 20 of 83		

- 5.3.7.4 All operating valves on main suction and discharge piping shall be lined on one side as far as possible.
- 5.3.7.5 A minimum straight length of suction pipe is to be provided as per manufacturer's recommendation.
- 5.3.7.6 Piping shall be designed so that forces and moments imposed on the compressor do not exceed the manufacturer's recommendation.
- 5.3.7.7 Compressor suction lines between the knockout drum and the compressor shall be as short as practicable.
- 5.3.7.8 Where the line between knockout drum and the compressor cannot be routed without pocket, low point in compressor line shall be provided with drains to remove any possible accumulation of liquid. In no case accumulation at low point should be allowed to go towards the compressor.
- 5.3.7.9 Low points in the discharge line from an air compressor shall be avoided because it is possible for lube oil to be trapped and subsequently ignited. If low points are unavoidable, they shall be provided with drains- In case of reciprocating compressor, piping shall be suitably supported to avoid vibrations due to pulsating flow. Unless specific requirements of no pockets are there from the licensor, all the piping shall run at 500 mm above grade level so that proper. Supports can be provided and also to minimize vibrations.
- 5.3.7.10 Analog study shall be carried out for complete compressor piping including suction I discharge piping as per P&ID' s and the analog study recommendations if any, shall be implemented.
- 5.3.7.11 Reciprocating compressor piping should not be supported from compressor shed I platform structure.
- 5.3.7.12 Pulsation dampers or surge bottles at the suction and discharge of reciprocating and displacement type compressors shall be provided according to manufacturer's recommendations.
- 5.3.7.13 A suction filter shall be provided in each compressor suction line to completely remove debris from the system.
- 5.3.7.14 Whenever possible, suction and discharge piping in the immediate vicinity of a compressor shall be located at or close to grade level to minimize vibration.
- 5.3.7.15 Spring loaded hangers or equivalent means shall be provided in compressor piping to minimize stress to nozzles. The allowable end reactions shall be based on manufacturer's recommendations.
- 5.3.8 Piping around Tanks Area**
- 5.3.8.1 Nozzles for level controlling instruments shall be oriented within an angle not exceeding 60 degrees against the fluid inlet nozzles.
- 5.3.8.2 Nozzles shall be easily accessible from platforms or ladders, if provided with block valves, sampling valves, instruments, and all other devices to be manually operated.
- 5.3.8.3 Fluid inlet nozzles shall be located as far apart as possible from fluid outlet nozzles.
- 5.3.8.4 Vessel working platforms where man ways and hand holes are located shall preferably be provided with utility stations.
- 5.3.8.5 The first pipe support from tanks shall be located sufficiently away from the tank to prevent damage caused by settling.
- 5.3.8.6 The number of pipelines in the tank dyke shall be kept at minimum and shall be routed in the shortest practicable way to main pipe track outside the tank dyke, with adequate allowance for expansion. With nozzle tank Dyke the piping connected to that tank shall only be routed. Pad shall be provided at pipette sleeve interface at dyke wall entry point.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 21 of 83		

- 5.3.8.7 Manifolds shall be located outside the tank dyke & by the side of the roads, easily accessible by the walkway.
- 5.3.8.8 Plug valves whenever specified shall be of pressure balance type.
- 5.3.8.9 Analysis shall be carried out to prevent damage to lines and tank connection caused by tank settlement. If exceptionally high settlement is expected, Dressers coupling or flexible ball joint may be provided, after necessary analysis.
- 5.3.8.10 Special consideration shall be given as regards to spacing of nozzles while installing special item like hammer blind, MOV etc.
- 5.3.9 **Relief System/blow down System Piping (CBD, OWS, FLARE)**
- 5.3.9.1 Relief of liquids and easily condensable hydrocarbons are usually discharged to a closed system.
- 5.3.9.2 Wherever the inlet line size is higher than the safety valve inlet size, reducer shall be installed adjacent to inlet of safety valve.
- 5.3.9.3 Relief valve discharging steam, air or other non-flammable vapour or gas directly to atmosphere shall be equipped with drain and shall be suitably piped to prevent accumulation of liquid at valve outlet. Liquid phase blow down system piping connected to a closed system shall be self draining to the blow down drum. Closed blow down header shall be sloped towards the CBD drum to assure free drainage.
- 5.3.9.4 Liquid-vapour phase relief valves shall discharge into the flare header at an angle 45 degrees in the direction of header flow, to minimize the effect of kinetic energy and to avoid accumulation of liquid.
- 5.3.9.5 Pockets in the flare header and blow down system shall be prohibited.
- 5.3.9.6 Relief valve discharge piping shall be taken to safe location as per following;
- 5.3.9.7 3M above top platform of column or structure, within 6M radius for steam and 8M for Hydro carbon / toxic discharge.
- 5.3.9.8 25M horizontally away from furnace.
- 5.3.9.9 Inlet and outlet piping of pressure relief valve shall be adequately supported to take care of the thrust induced by the relief valve during popping.
- 5.3.9.10 Reaction forces due to safety valve popping shall be ascertained in the connected piping. The effect of these forces on the piping supports and the anchors of the piping system shall be calculated to ascertain that the allowable limits at these locations are not exceeded. The supporting structure also shall be adequately designed so that when subjected to these reaction forces the supporting elements connected to piping as well as the basic supporting structure i.e. platform members etc. are capable of withstanding them. System stresses in the inlet and outlet piping portions at safety valves also shall be kept within the allowable limits, inclusive of the distribution branching points in the inlet portion. These reactive forces shall not lead to any leakage at the flanged joints present in the system. To ascertain these necessary calculations for checking leakage at the flanged joints shall be performed.
- 5.3.9.11 Safety and relief valves shall be accessible from platform or grade. For the valves weighing more than 45 kg, davits or other lifting devices shall be provided. Alternatively crane access shall be provided for these valves.
- 5.3.9.12 Safety and relief valves shall be installed in a vertical position and shall have a minimum of pipe length between the protected line or equipment and the valve inlet.
- 5.3.9.13 Safety valves discharging to atmosphere shall have the outlet piping extending at least 2.2 m above operating platforms or levels within a radius of 7.5 m. A 9 mm minimum weep hole shall be provided at the lowest point of the outlet piping.



<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 22 of 83		

- 5.3.9.14 Safety and relief valves connected to flare lines shall be located higher than the flare header, where the fluid discharged from valve is liquid or condensable.
- 5.3.9.15 Outlet piping or safety and relief valves, including flare lines, shall be designed to prevent excessive stresses in the line due to rapid temperature change or uneven temperature distribution.
- 5.3.9.16 All flare headers shall be sloped 1 m per 400 m to 1 m per 1000 m downward to the blow down drum.

5.3.9.17 Flare System shall be designed such that:

- There will be 1 Running + 1 standby Safety Valve. (For all process & utilities lines)
- Each Valve shall have full relieving capacity.
- Isolation Valve shall be provided on Up Stream side & Spectacle Blind with Valve on downstream side so that individual safety valve can be isolated for maintenance purpose.

### 5.3.10 **Steam Piping - Indian Boiler Regulations (IBR)**

5.3.10.1 Generally steam lines with conditions listed below fall in the scope of IBR;

- Lines having design pressure (maximum working pressure) Above 3.5 Kg/cm<sup>2</sup> (g)
- Line sizes above 10" inside diameter having design pressure 1.0 Kg/cm<sup>2</sup> (g) & above.
- Lines with pressure less than 1.0 Kg/cm<sup>2</sup> (g) are excluded.
- Users of steam like steam tracing lines, jacket of the steam jacketed lines, and steam heating coil within the equipment are excluded from IBR scope.
- Boiler feed water lines to steam generator, condensate lines to steam generator and flash drum as marked in P&I D shall be under purview of IBR.

5.3.10.2 IBR requirements (in brief)

- All materials used on lines falling under IBR must be accompanied with IBR Inspection certificate in form IIIA/IIIC, as applicable, in original. Alternatively, photocopy of the original certificate duly countersigned and attested by local IBR inspector is acceptable.  
Chief inspector of boilers shall be the inspection authority for Indigenous (Indian) supply. However, for non - indigenous supply, IBR inspection shall be carried out by the inspection agencies approved by IBR (Central Boilers Board).
- Drawings like General Arrangement Drawings (GAD) and system isometrics / line wise isometrics of lines falling under IBR must also be approved by IBR authority of State in which the system is being installed.
- All welders used on fabrication of IBR system must possess IBR welding qualification certificate.
- IBR system must be designed to comply IBR regulations as well as ASME B31.3. All design calculations towards the same must be approved by IBR authority.
- IBR approval is obtained with requisite fees payable to Indian Boiler Board of the State concerned.
- Steam generators (boilers/heat exchangers) shall require exclusive IBR approval along with its integral piping up to the final isolation valve.
- The discretion of IBR authority of state is final and binding for the above cases.

### 5.3.11 **Steam Header & Supply Lines / Steam and Condensate Systems**

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> BHEL</div>
		DOCUMENT NO	REV	
		SHEET 23 of 83		

- 5.3.11.1 Steam piping shall be designed to have complete condensate removal. Drip legs shall be provided with steam traps at low points in the system.
- 5.3.11.2 All steam branch connections shall be taken from the top of the header.
- 5.3.11.3 Return exhaust steam / condensate lines shall connect to the top of the exhaust steam Condensate header.
- 5.3.11.4 Where block valves have been installed in the main steam header such that condensate can collect either side of the valve when closed, a safe means of draining the condensate prior to opening the valve shall be provided.
- 5.3.11.5 Steam header shall be located generally on the upper tier and at one end of the rack adjacent to columns.
- 5.3.11.6 Branch lines from horizontal steam header, except condensate collection points, shall be connected to the top of the pipe header.
- 5.3.11.7 Isolation valves (if provided) on the branch line shall preferably be provided on the horizontal run and outside the pipe rack.
- 5.3.11.8 All branch lines shall be drainable.
- 5.3.11.9 Drip legs & steam traps shall be provided at all low points and dead ends of steam header. Drip legs at low points shall be closer to downstream riser and shall be provided to suit bidirectional flows, if applicable.
- 5.3.11.10 All turbines on automatic control for startup shall be provided with a steam trap in the steam inlet line.
- 5.3.11.11 All traps shall be provided with strainers if integral strainers are not provided.
- 5.3.11.12 Steam traps discharging to atmosphere shall be connected to storm water drain/storm sewer, in case of open system. In case of condensate recovery, traps shall discharge into condensate header.
- 5.3.11.13 Expansion loops are to be provided to take care of the expansions within units.
- 5.3.11.14 Wherever condensate is to be drained, proper condensate draining facility shall be provided.

#### 5.3.12 **Steam Tracing**

- 5.3.12.1 Tracers for the individual lines shall be supplied from manifolds when there are two or more connections. Steam supply headers shall be located on continuous platform along the rack. No steam supply station shall be located at grade.
- 5.3.12.2 Standard module for steam distribution and condensate collection manifolds with integral glandless piston valve and thermostatic steam trap shall be used. Number of tracers shall be 4/8/12 and tracer size 0.5" to .75" depending upon the detail engineering requirement. 20% or minimum 2 no. tracer connections shall be kept spare for future use for both steam supply and condensate collection manifolds.
- 5.3.12.3 All manifolds shall be installed in vertical position and manifold size shall be 3".
- 5.3.12.4 For steam tracing balanced pressure thermostatic steam trap with 40 mesh strainer to be used.
- 5.3.12.5 Manifolds shall be accessible from grade or from a platform.
- 5.3.12.6 Pockets in steam tracers shall be avoided as far as possible.
- 5.3.12.7 Tracers shall be limited to the following run length upstream of traps:

Size of Tracer	Length of tracer pipe (Meters)
	Steam operating pressure

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 24 of 83		

	20 psig	50 psig	100 psig	150 psig	200 psig & above
0.5" (Inch)	30	45	60	75	90

5.3.12.8 Tracers shall generally be of 0.5". Tracers shall be of CS steel seamless pipe and valves on the steam tracing circuit including steam station block valve shall be glandless piston type construction. Heat transfer cement shall be applied in between main pipe and tracer pipe to improve heat transfer.

5.3.12.9 Size of the lead line to manifold shall be as follows:

Number of connections	Size of Lead Line
2	3/4"
3	1"
4-6	1 1/2"
7 -12	2"

5.3.12.10 The lead line to manifold, manifold up to the block valves of individual tracer shall be carbon steel of IBR quality.

5.3.12.11 Tracer lines shall be provided with break up flanges for main line flange joints and valves.

5.3.12.12 All tracers shall have individual steam traps before condensate manifolds.

5.3.12.13 Condensate manifold including the last valve on individual tracer shall be of carbon steel.

5.3.12.14 All steam traps discharging to a closed system shall have a block valve upstream and downstream of the trap. A bypass globe valve shall be installed around the trap. Check valve shall be installed on the downstream of the steam trap near the condensate header in case discharging to a closed system.

Number of tracers required on a line shall be as follows:	
Size of Line	Number of Tracers
up to 4"	1
6" to 16"	2
18" to 24"	3
26" & above	To Calculate

### 5.3.13 Steam Jacketing System

5.3.13.1 A steam jacketed pipe consists of a product line which passes through the centre of a larger diameter steam line.

5.3.13.2 The nominal size of the inner pipe (CORE) and outer pipe (JACKET) in inches shall be as per table below unless otherwise mentioned in project piping material specification (PMS) or P&ID.

Core pipe	Jacket pipe	Steam feeder to jacket
3/4"	1-1/2"	0.5"
1"	2"	0.5"
1-1/2"	3"	0.5"
2"	3"	0.5"
4"	6"	0.75"



<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 25 of 83		

6"	8"	0.75"
8"	10"	0.75"
10"	12"	0.75"

- 5.3.13.3 For jacketed lines using high pressure steam, actual calculations for core, jacket and feeder pipe shall be performed before finalization of sizing.
- 5.3.13.4 Distance between steam inlet and condensate outlet shall be similar to steam tracing system. Baffle plates, flanged joints or end caps shall be used to discontinue one feed length from the next.
- 5.3.13.5 Flanged jump over shall be used in case of a flanged joint. In case of discontinuous jacketing simple jump-overs shall be employed. The length of jacket shall be 4 to 5 meters or as mentioned in job specification.
- 5.3.13.6 Intermediate partial baffles shall be provided if a separate branch portion is to be heated from the main line stream.
- 5.3.13.7 Steam inlet to jacket shall generally be provided from top of the pipe in case of horizontal lines. The jump over and condensate outlets shall be from the bottom.
- 5.3.13.8 In case of vertical lines steam inlet shall be done at the topmost points and condensate outlet shall be done from the lowest possible points. Two consecutive Slipovers shall be 180 deg. Apart.
- 5.3.13.9 Each feed length shall be provided with individual trap before connecting to condensate recovery headers.
- 5.3.13.10 Balanced pressure I bi-metallic type thermostatic steam traps with 40 mesh strainer shall be used in jacketing.
- 5.3.13.11 To keep proper concentricity between core and jacket pipe internal guides (rods or flat bars) shall be provided at intervals depending on the size of the pipe.
- 5.3.13.12 Wherever anchors are provided on jacket lines proper interconnection of jacket pipe and core pipe shall have to be provided with proper jump over for steam.
- 5.3.14 Water Piping**
- 5.3.14.1 Water piping shall be designed to minimize the possibility of water hammer.
- 5.3.14.2 Water main headers may run underground to prevent freezing.
- 5.3.14.3 Unless local code or regulation prohibits, firewater lines shall be underground to prevent freezing. Firewater piping system shall conform to regulations of the competent governmental authorities.
- 5.3.15 Instrument Air Piping**
- 5.3.15.1 Instrument air lines shall not be connected to process lines, service lines, and other equipment.
- 5.3.15.2 Instrument air shall not be used as plant air or service air.
- 5.3.15.3 Branch lines from the instrument air header shall be taken from the top of the header and shall be provided with a block valve close to the header. Also in the upstream of Instrument manifold, Gate valve has to be provided
- 5.3.16 Supports and Anchors**
- 5.3.16.1 Supports and/or anchors shall be provided close to changes in direction of lines, branch lines and, particularly, close to valves to prevent excessive sagging, vibration and strain.
- 5.3.16.2 Allowable spans between pipe supports shall be determined to keep the maximum deflection within 16 mm.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 26 of 83		

- 5.3.16.3 In cases where periodic maintenance requires removal of equipment, such as pumps and relief valves, and where lines must be dismantled for cleaning, piping shall be supported to minimize the necessity of temporary supports.
- 5.3.16.4 Spring-loaded hangers may be used on piping subject to thermal expansion or contraction. In cases where the movement is very large, or the limitation of reaction and stress are very severe, constant support spring hangers shall be used.
- 5.3.16.5 Suction and discharge lines of rotating equipment shall be supported as close as possible to equipment nozzles, and shall be relieved of excessive strains by using proper pipe supports.
- 5.3.16.6 Supports shall not be directly welded to pipes. Where welding is unavoidable, supports having the same chemical composition as pipe shall be carefully welded.
- 5.3.16.7 All piping shall be properly supported to minimize vibration.
- 5.3.16.8 Outlet piping of safety and relief valves shall be supported so that the inlet piping is capable of withstanding the reaction caused by operation of safety and relief valves. Furthermore, the supports shall be designed to minimize the stresses due to thermal expansion and the stresses in the valve body due to the weight of piping.
- 5.3.16.9 Expansion joints shall be guided and anchored to the extent necessary for their proper operation and alignment.
- 5.3.16.10 Anchors shall provide sufficient fixation to substantially transmit all load effects into the foundations.
- 5.3.16.11 Underground piping shall be given special anchoring consideration for differential settlement.
- 5.3.16.12 All small bore high pressure tapings shall have gusset plate supported.
- 5.3.17 Utility Stations**
- 5.3.17.1 Requisite number of utility stations shall be provided throughout the unit to cater for the utility requirement. Utility stations shall have four connections one for LP steam (SL), one for Plant Air (AP) and one for Service Water (WS) and one for nitrogen each of 1.0" with isolation valves unless otherwise specified in P&ID.
- Utility connection with nitrogen shall be provided with NRV along with isolation valve kept at a separate location other than this cluster @ 15 M.
- 5.3.17.2 Air and water lines shall have quick type hose connection and steam line shall have flanged type hose connection. All connections shall be directed downward. All connections shall have globe valve for isolation purpose. An inter connection with valve shall be provided between steam and service water lines shall be provided. Inert gas hose, when required, shall have built in non return valve in quick connection coupling of piping end.
- 5.3.17.3 Number of utility stations shall be such that all equipments shall be approachable from at least one utility station. The approach of utility station shall be considered 15 M all around the station location.
- 5.3.17.4 The Utility stations shall generally be located adjacent to pipe-rack column.
- 5.3.17.5 The utility stations shall also be provided on elevated structures like – technological structure, operating platforms of vertical equipments etc.
- 5.3.17.6 Operating platforms having manholes must have a utility station. Utility station locations shall be limited to a height of 35 M from H.P.P.
- 5.4 Offsite & Yard Piping**
- 5.4.1 In general, offsite piping (except tank ages area), electrical cable and instrumentation cable shall also be laid either on pipe rack or pipe sleepers on cable trays.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 27 of 83		

5.4.2 Wherever piping is laid on pipe sleepers, it shall have hard surfacing below it keeping a gap of 300 mm from the bottom of the pipes. Hard surfacing should be completed before start of pipe laying. Width of hard surfacing shall be about 1.0 meter more than the piping corridor. This extra hard surfacing shall be for movement of operating personnel along the piping corridor.

5.4.3 Pipes at road crossing shall be under culverts in general. Overhead pipe bridges may be used for areas where pipe racks are provided. Where culverts are not provided, pipe sleeves shall be used for underground road crossing. Culverts / overhead pipe bridges shall be adequately designed to take care of future requirements. Minimum 20% extra width shall be provided in all such structures.

5.4.4 Clearances between lines shall be minimum "C" as given below:

$$C = (D_o + D_f) / 2 + 25 \text{ mm} + \text{Insulation thickness(es) where,}$$

$D_o$  – outside diameter of smaller pipe (mm)

$D_f$  – outside diameter of flange of bigger pipe (mm)

However this 'C' spacing between the offsite piping on the rack/sleeper can be suitably increased so that the lines should not touch each other after insulation / lateral thermal expansion.

5.4.5 Adequate clearance shall be provided for every long & high temperature lines to avoid clashing at the bends. See 5.2.2 also for line spacing at 'L' bends and loops.

5.4.6 Expansion loops for all lines shall generally be kept at the same location.

5.4.7 Vents shall be provided on all high points & drains shall be provided at all low points. Drain valves at sleeper piping shall be kept outside the sleeper way if the same is not accessible and valves shall be put in horizontal only.

5.4.8 Places where piping is extended to make drain valves accessible – 2 nos. of stiffeners, irrespective of pipe rating, shall be provided.

## 5.5 Flare Piping

5.5.1 Flare header shall be sloped towards flare knock-out drum. Only horizontal loop shall be provided as per requirement to accommodate thermal expansion. The desired slope shall be ensured throughout including flat loop. Flare header shall be supported on shoe of height ranging from 100mm to 300mm.

5.5.2 Proper thermal analysis temperature shall be established including the possibility of temperature gradient along the line before providing expansion loops. Efforts shall be made to minimize the number of loops. Flare line between knock out drum and water seal drum shall be designed for pressure fluctuations and adequately supported to avoid vibrations.

## 5.6 Underground Piping

5.6.1 Underground steel piping shall be protected from electric corrosion.

5.6.2 Underground piping passing under loaded areas, such as main roads in the plant, shall be protected from heavy traffic by casing pipes or covers extending at least 1 m on either side of the area or having the wall thickness sufficient to bear earth pressure.

5.6.3 Underground piping shall be sloped to all drain points with a downward slope of not less than 1 m in 150 m.

5.6.4 Expansion elbows or joints of underground piping for hot fluids, such as steam or heated heavy oil, shall be enclosed in a conduit from which they are separated to allow free longitudinal expansion.

5.6.5 The following points to be considered in designing of Underground piping;

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 28 of 83		

- i) All Sewage lines (oily and chemical) from catch basin to mains and manholes shall be laid underground.
- ii) Valve chamber wherever required shall be made of brick or concrete. Valve chamber should be spacious to attend valves during operation/Maintenance.
- iii) All U.G. headers shall clear equipment foundations as far as possible. Under special cases, the C.W. header may be laid over the footing of foundations.
- iv) Provide break flange at + 500 MM from floor level connection with cathodic protection to isolate underground pipe from above ground piping with insulating gasket KIT.
- v) Pipes shall be laid below electrical cables if any.
- vi) Top of underground piping shall be below grade level at least 1 meter deep in case of open areas and 1.5 meter deep for roads.

5.6.6 All underground pipe work shall be provided with following protection:

- i) At location where Underground Piping becomes above ground, Insulating Gasket with material Glass Filled Teflon shall be provided.
- ii) Cathodic Protection shall be provided to all underground piping. Specification shall be submitted by the Contractor & shall be approved by the Owner.
- iii) Underground piping shall be wrapped & coated and shall be "Holiday Tested" before Hydro Test. (For wrapping/coating specification- refer Design Philosophy-Construction/Erection, Pre-Commissioning, Commissioning and Start-Up).
- iv) All underground pipes shall have Sand Bed, at least 150 MM all around the pipe.
- v) Underground pipe crossing roads, access ways, and rails shall have Hume Pipe Sleeves/casing pipe (R.C.C or C.S).

5.6.7 Piping in Trenches

Where it is impossible to run pipe aboveground or underground, trenches may be used. Trenches for piping close to process equipment should be avoided, whenever possible.

The following points to be considered in designing of trench pipes:

Piping located below grade, requiring inspection, servicing or provided with protective heating.

Fire water lines/Process lines. (Ref Fire Fighting Design Philosophy)

Drain lines requiring gravity flow trenches.

Sump for valves and trenches shall be provided.

Suitable draining scheme for trenches shall be provided.

5.7 **Air Systems**

Branch connections shall be taken from the top of the header. Low points shall be fitted with drains.

5.8 **In-Line Instruments**

5.8.1 Liquid level controllers and level glasses shall be located so as to be accessible from grade, platform or permanent ladder. The level glass shall be readable from grade wherever possible.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> BHEL</div>
		DOCUMENT NO	REV	
		SHEET 29 of 83		

- 5.8.2 Relief valves shall be accessible. Relief valves with a centre line elevation over 4.5 M above grade (except in pipe racks) shall be accessible from a platform or permanent ladder.
- 5.8.3 Relief valves that discharge to a closed system shall be installed higher than the collection header, with no pockets in the discharge line.
- 5.8.4 Relief valves that discharge to atmosphere shall have tail-pipes extended to a minimum of 3.0 M above the nearest operating platform that is within a radius of 8 M.
- 5.8.5 Provide steam traps at pocketed low points and at dead ends of steam headers. Provide steam traps on excessively long runs of steam piping to ensure dry quality steam at destination. Steam traps located more than 4.5 M above grade, except in pipe racks, shall be accessible from a platform.
- 5.8.6 Control valves shall be accessible from grade or platforms. In general, the instruments or indicators showing the process variables shall be visible from the control valve.
- 5.8.7 Orifice runs shall be located in the horizontal. Orifice flanges with a centre line elevation over 4.5m above grade, except in pipe racks, shall be accessible from a platform or permanent ladder.
- 5.8.8 Orifice taps shall be located as follows:
- i) Air, Gas and steam
    - Top vertical centreline (preferred)
    - 45 degrees above horizontal centreline (alternate)
  - ii) Liquid
    - Horizontal centreline (preferred)
    - 45 degrees below horizontal centreline (alternate)
  - iii) Tap orientation shall be shown on piping isometrics.
- 5.9 **Sample Connections**
- Sample connections shall be accessible from grade or platforms. In general, where liquid samples are taken in a bottle, locate the sample outlet above a drain funnel to permit free running of the liquid before sampling.
- 5.10 **Vents and Drains**
- 5.10.1 For hydrotest drain & vent philosophy refer annexure-9.
- 5.10.2 Process vents and drains shall be indicated on the P&ID's
- 5.10.3 Vent, drain and sampling valves on process lines, not connected to a piping system, shall be provided with appropriate end closures.
- 5.10.4 Vents shall be located at high points of pipelines when necessary.
- 5.10.5 Drains shall be located at low points to empty pipelines or equipment after testing or during maintenance (i.e. for every loop).
- 5.10.6 All drains and vents shall be provided with valve, except that vents for test purpose for flare lines (header), may be plugged. Exposed threads shall generally be seal welded.
- 5.10.7 Low-point hydrostatic drains and high-point hydrostatic vents shall be added as required; locations to be determined during the design review.
- 5.10.8 Vent valves shall be the globe or gate type and drain valves the gate type.
- 5.10.9 Valved bleeds shall be provided at control valve stations, level switches, level controllers, and gauge glasses.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 30 of 83		

#### 5.11 **Line Strainers**

- 5.11.1 Provide temporary conical type strainers in 2" NB and above butt weld pump suction lines for use during start-up. Arrange piping to facilitate removal.
- 5.11.2 Provide permanent Y-type strainers for pump suction piping below 2" NB Thd Or SW.
- 5.11.3 Provide temporary basket type strainers located at the suction pulsation device inlet for start-up of reciprocating compressors. Arrange piping to facilitate removal of the filter.
- 5.11.4 Provide temporary basket type strainers and locate them as close as possible to the compressor inlet flange for start-up of centrifugal compressors. Arrange piping to facilitate removal of the filter.
- 5.11.5 Allowable pressure drop when specified shall be certified by vendor along with the offer. If asked specifically, vendor shall furnish pressure drop calculations
- 5.11.6 All 2" & higher sized Y type strainers shall be provided with 3/4" threaded ,tap and solid threaded plug as drain connection. For less than 2", this shall be ½ " size.
- 5.11.7 Bottom flange of Y-type strainer shall not have tapped hole. Full length standard size studs shall be used for joining blind flange.
- 5.11.8 For fabricated strainers, all BW joints shall be fully radiographed and fillet welds shall be 100% DP/MP checked.
- 5.11.9 All the strainers shall be hydrostatically tested at twice the design pressure

#### 5.12 **Spectacle Blinds**

- 5.12.1 Spectacle blinds shall be provided to isolate equipment. In hazardous service flanged drop-out spools shall be provided for safety purposes. Both shall be shown on the P&ID's.
- 5.12.2 Spectacle blinds shall be accessible from grade or platforms. Blinds located in a pipe-rack are considered to be accessible. Blinds that weigh over 40kg shall be accessible by mobile equipment. Where this is not possible davits or hitching points shall be provided.

#### 5.13 **Flexibility Analysis and Supporting**

##### 5.13.1 **Pipe Supporting Criteria & General Guidelines**

- 5.13.1.1 Piping system shall be properly supported taking into account the following points:
  1. Load of bare pipe + fluid + insulation (if any).
  2. Load of bare pipe + water fill.
  3. Load of valves and online equipment and instrument.
  4. Thermal loads during operation.
  5. Steam-out condition, if applicable.
  6. Wind loads for piping at higher elevation, e.g. transfer lines, column over head lines, flare headers, etc.
  7. Forced vibration due to pulsating flow.
  8. Vibration due to two phase flow.
  9. Loads due to internal pressure.
  10. Any external loads/concentrated loads and cold load of springs.
- 5.13.1.2 Pipe supporting shall preferably follow the minimum basic span as given in Annexure-1 except for flare line in off site on trestles in which case the maximum basic span shall be restricted to 18.0 meters, irrespective of line size.



<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> BHEL</div>
		DOCUMENT NO	REV	
		SHEET 31 of 83		

- 5.13.1.3 For sizes not covered in Annexure-1, basic span shall be established based on project requirement. For piping on rack or sleeper, as a minimum, providing resting support on every grid of pipe rack / sleeper is mandatory. Depending on the pipe size, as a rule, guides shall be provided on straight run of pipes at intervals as specified in Annexure-3 unless specifically becomes non-viable due to flexibility problems.
- 5.13.1.4 Additional supports, guides, anchors, special supports like spring supports and sway braces shall be provided after detailed analysis of piping system to restrict the forces experienced on nozzles of critical items like pumps, compressors, turbines, exchangers, air fin coolers etc.
- 5.13.1.5 For lines which do not need any support otherwise but become unsupported by opening of flange, etc, during maintenance and thereby may transfer the total load on a small branch off, a permanent support shall be suitably provided which may be a spring support also. Bare pipes of size 14" and above on elevated structures shall be supported with pad or shoe. While bare pipes of size 6" and above, on sleepers, corrosion pads shall be provided.
- 5.13.1.6 Pads shall be provided for insulated pipes before welding the shoes for sizes 8" & above.
- 5.13.1.7 Adequate stiffening shall be provided for the following:
- Lines in above 600#,
  - Lines having two phases flow,
  - Lines having Pulsating flow such as discharge of reciprocating compressors & reciprocating pumps.
- 5.13.1.8 For pulsating flow lines detailed thermal and vibration analysis by analog study shall be done to decide location of anchor supports and guides etc. Pulsating flow lines shall be as identified by licensor/owner.
- 5.13.1.9 Wherever two phase flow in piping is expected, piping design shall be checked by dynamic analysis to prevent vibrations.
- 5.13.1.10 Pipe support design shall be such that deflection in piping systems due to sustained loads shall not exceed 15mm, in any case, between two adjacent supports.
- 5.13.1.11 As far as possible long trunnion types of supports (more than 0.5 metre) are to be avoided. In case long trunnion support is unavoidable in straight length of pipe, trunnion height to be restricted to 0.5 M and balance height to be made up by providing extended structure.
- 5.13.1.12 In the heaters where steam air decoking provision is there, the main lines and decoking lines should be supported in a way so that either of the lines should not be in the hanging position while connected to other one. Same philosophy shall be adopted for similar type of switch over arrangement.
- 5.13.1.13 Piping passing through the technology structure or passing near the concrete column etc. should have adequate annular space to avoid restriction of line movement during thermal expansion. The gap should take care the thermal expansion along with insulation thickness.
- 5.13.1.14 High density PUF blocks shall be considered for cold piping supports. Use of wood blocks shall be avoided.
- 5.13.1.15 All pipes supports shall be so designed that there is no undue tension on equipment flanges. Flange joints should not move away from each other in case of unbolting of the joint.

#### 5.13.2 Flexibility Analysis Criteria & General Guidelines

Formal computer analysis shall be performed on piping systems as per design philosophy for stress analysis (Refer annexure)

The directions of forces and moments shall be in accordance with Welding Research Council Bulletin 107 (WRC 107), with the exception that the radial force (P) shall be away from the

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> BHEL</div>
		DOCUMENT NO	REV	
		SHEET 32 of 83		

vessel. All forces and moments shall be assumed to act simultaneously and apply at the nozzle/vessel interface.

Air coolers to API 661 shall be specified with Fx forces and Mz moments increased to 1.2 times the value shown in Figure 8 of API 661 for nozzle sizes 6"NPS and larger to simplify piping flexibility analysis and facilitate piping layout.

Piping stress analysis and equipment nozzle loading analysis shall be in accordance with ASME B31.3 and the relevant API, ANSI/ISO and NEMA Codes.

#### 5.13.2.1 **API 610 Pumps**

The allowable nozzle loads on centrifugal pumps shall meet the load criteria of API 610. Heavy duty base plate shall be specified where the pump design temperature is in excess of 150°C.

#### 5.13.2.2 **ASME or Manufacturer's Standard Pumps**

The allowable nozzle loads on horizontal centrifugal pumps design to ASME B73.1 shall be specified by the manufacturer. For preliminary layout and analysis NEMA SM 23 criteria shall be used for individual nozzles.

#### 5.13.2.3 **Other Horizontal Centrifugal Pumps**

The allowable nozzle loads shall meet the load criteria specified by the manufacturer.

#### 5.13.2.4 **Vertical Turbine, Can-Types Pumps**

The combined bending and tensional thermal stress in the piping attached to the nozzle shall be limited to 25 percent of the allowable stress range shown in ASME B31.3. The combined stress due to dead load and other sustained loads shall be limited to 25 percent of the allowable hot stress.

#### 5.13.2.5 **Fired Heater**

The allowable heater terminal connection load criteria for each fired heater shall be given in the appropriate purchase specification. In the absence of any allowable nozzle load criteria, the preliminary piping layout may be based on limiting the combined dead load and thermal bending and torsional stress in the piping attached to the heater terminal connections to 25 percent of the allowable stress range shown in ASME B31.1/B31.3. The combined stress due to dead load and other sustained loads shall be limited to 25 percent of the hot stress. A ½" lateral clearance at the nozzle penetration opening (s) shall be assumed for layout and design purposes. Final lateral clearance shall be confirmed by the supplier.

For piping design purposes, differential settlement between items of major equipment on separate foundations shall be taken as 10 mm.

Cold springing in piping shall not be permitted without written permission from the Owner. Cold springing of piping directly connected to rotating equipment is not permitted under any circumstances.

Piping shall be analyzed for expansion, contraction, differential settlement, relief, valve reaction and effects mentioned at Cl. 5.13.1.

The design of piping systems shall take into account the different conditions expected during operation, start-up, shut-down, cold branch in case of standby pump, tracing, etc. Hydrocarbon lines shall be designed for steam-out conditions, if specified in line schedule. The use of expansion joints shall be considered only when space or pressure drop limitation does not permit pipe bends. Expansion joint of axial type shall be avoided.

Forces and moments due to weight, thermal loads and other imposed loads on the equipment nozzle must not exceed the allowed loads for the equipment.

Minimum analysis temperature shall be the design temperature of the line as per line list.



<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 33 of 83		

### 5.13.3 Method of Analysis

- 5.13.3.1 Formal computer analysis shall be performed on piping systems as per design philosophy for stress analysis.
- 5.13.3.2 The package used shall be latest version of CEASER / AUTO PIPE / SIMPLEX / CAEPIPE. Only one of these packages shall be used for the project & not a combination of the above packages.
- 5.13.3.3 All lines shall be analyzed at design I analysis temperature. In the absence of analysis temperature lines shall be analyzed at design temperature.
- 5.13.3.4 However in case of wide difference in design and operating temperature, temperature for analysis shall be established in process documents. (E.g. flare line)
- 5.13.3.5 All non-critical lines may be analyzed using other methods.
- 5.13.3.6 Special analysis methods shall be followed for lines involving pulsating flow such as those connected to reciprocating pumps & compressors which require acoustical plus analog study by approved agencies and shall require entire system analysis along with piping & equipments.
- 5.13.3.7 Seismic analysis shall be done for line sizes 12" and above.

### 5.14 Personnel Protection

- 5.14.1 Eyewash and emergency safety showers shall be provided in areas where operating personnel are subject to hazardous sprays, emissions or spills.
- 5.14.2 Personnel protection shall be provided on un-insulated lines and equipment operating above 70 deg C when they constitute a hazard to the operators during normal operation of the facility.
- 5.14.3 Leakage indicating tape and spray impingement shrouds shall be provided at flanged joints in hazardous service.

### 5.15 Mechanical Handling

Handling facilities such as davits and monorails shall be provided on vessels over 10m in height where the weight of removable internal and/or external equipment is greater than 35 Kg.

## 6. MATERIALS

### 6.1 General

- 6.1.1 Basic material selection of particular line depending on its service, temperature and corrosivity shall be spelt out in process package. Material specification shall follow the requirements as specified in PMS as per Licensor's requirement. PMS / VMS shall be supplied by bidder and will be approved by owner / PMC. PMS shall generally follow the requirements given in this section.
- 6.1.2 All materials for piping components shall be new and conform to the relevant code and/or specification.
- 6.1.3 All plate, sections, pipe, fittings, flanges, valves and special items shall have Material Test Certificates.
- 6.1.4 All alloy materials shall have Material Certificates verifying the alloy content.
- 6.1.5 All bolting and gasket material shall have Letters of Compliance as a minimum.
- 6.1.6 Electric Resistance Welded (ERW) pipe and fittings shall only be used for category 'D' service as defined by ASME B31.3.
- 6.1.7 Category 'M' and Normal Service piping as defined by ASME B31.3 shall use seamless or 100% radio graphed Electric Fusion Welded (EFW) pipe and fittings.
- 6.1.8 Only piping materials listed in ASME B31.3 shall be used.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 34 of 83		

- 6.1.9 For services defined within ASME B31.3 as Category 'M', no socket welded or threaded construction or connections shall be used for process equipment piping systems. Construction shall be by butt-welding with 100% radiography. Flanged connections shall be minimized.
- 6.1.10 All insulation and gaskets shall be asbestos free. Aluminium or copper alloys shall not be used for any component in the piping systems.
- 6.1.11 The use of 1.25Cr-0.5Mo alloy shall be a minimum requirement for piping systems having a design temperature above 425°C.
- 6.1.12 Nelson Curves in accordance with API 941 (Steels for Hydrogen Service at Elevated Temperatures and Pressures) shall be applicable to piping system materials in hydrogen service.
- 6.1.13 The minimum corrosion allowance for any material, other than stainless steel, shall not be less than 1.5 mm.
- 6.1.14 All instrument air pipe line shall be of SS304.
- 6.1.15 All Austenitic Stainless Steel items/parts shall be supplied in solution annealed condition.
- 6.1.16 For all Austenitic Stainless steels, Inter granular Corrosion' (IGC) Test shall be conducted as per following:  
 ASTM A262 Practice 'B' with acceptance criteria of 60 mils/year (max) for casting.  
 ASTM A262 Practice 'E' with acceptance criteria of 'No cracks as observed from 20 X magnification & microscopic structure to be observed from 250 X magnification for other than casting.  
 For IGC test, two sets shall be drawn from each solution annealing lot; one set corresponding to highest carbon content and other set corresponding to the highest rating/thickness. When testing is conducted as per practice "E" photograph of microscopic structure shall be submitted for record.
- 6.1.17 All items of stabilized SS grades, resolution annealing shall be done. It shall be carried out subsequent to normal resolution annealing. Soaking temperature and holding time for stabilizing heat treatment shall be 900 deg. Celsius and 4 hours.
- 6.1.18 For Category 'D' utility piping, where scaling and impurities are to be avoided (such as potable water and deluge water) hot dipped galvanized and threaded fittings may be used in sizes up to and including 4" NB. Galvanized piping shall not be used in environments containing acids or other corrosive commodities. In corrosive environments stainless steel piping material shall be used for such utility systems.
- 6.1.19 Unless otherwise specified by licensor, 25Cr-22Ni-2Mo type stainless alloy (UNS S31050) shall be used for urea service piping system, if any. However, licensor specification shall prevail in case of conflict.
- 6.2 **PIPE**
- 6.2.1 General
- 6.2.1.1 Calculation of pipe thickness and branch reinforcement shall be based on requirements of ASME B31.3. Proper corrosion allowance and mill tolerance shall be considered to achieve the selected thickness.
- 6.2.1.2 For carbon steel and low alloy steel pipes (except for steam tracing piping) minimum pipe thickness shall be:  
 S80 up to 0.75",  
 XS for 1" to 2",  
 STD for above 2"

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> BHEL</div>
		DOCUMENT NO	REV	
		SHEET 35 of 83		

For stainless pipes minimum pipe thickness shall be

40S up to 2",

10S for above 2"

The philosophy of minimum thickness/schedule is applicable for both seamless and welded pipes.

The above mentioned minimum thickness/schedule criteria is not applicable to category-D classes.

6.2.1.3 All welded pipes shall have uniform negative wall thickness tolerance of 12.5% for wall thickness calculations purpose.

6.2.1.4 For thicknesses exceeding minimum thickness/schedule criteria, Schedule XS shall be selected for CS & AS classes (for 2" & above). Intermediate schedules between STD & XS shall be ignored. Similarly for SS classes (2" & above) S10, S20, S30 & 40S may be selected beyond minimum thickness/schedule criteria.

6.2.1.5 If, the thicknesses exceed XS in CS & AS classes and 40s in SS classes, only then, the thickness shall be calculated based on actual service conditions (line condition) subject to a minimum of 80% class rating. Maximum 10% of corrosion allowance may be reduced in special cases, to optimize the pipe schedules.

6.2.1.6 In general, the pressure-temperature combination to calculate wall thickness shall be as follows:

Material	Class	Size	Design Condition
C.S. (A 106 GR.,B, API-5L GR.B, A672 GR.B60/C60 :CL 12) LTCS (A333 GR.6), Low Alloys (1.25% Cr- 0.5% Mo. 2.25% Cr-1.0% Mo. 5%Cr-0.5% Mo. 9%Cr- 1.0% Mo	150	Up to 24"	Class condition
		Above 24"	Line condition
	300	Up to 14"	Class condition
		Above 14"	Line condition
	600	Up to 8"	Class condition
		Above 8"	Line condition
	900	Up to 8"	Class condition
		Above 8"	Line condition
	1500 & 2500	Up to 4"	Class condition
		Above 4"	Line condition
SS (A312 TP304, 304L,316L,321,347) OR (A358 TP304,304L,316, 316L, 321,347)	150	Up to 24"	Class condition
		Above 24"	Line condition
	300	Up to 14"	Class condition
		Above 14"	Line condition
	600	Up to 6"	Class condition
		Above 6"	Line condition
	900,1500	Up to 4"	Class condition
		Above 4"	Line condition
	2500	Up to 2"	Class condition
		Above 2"	Line condition

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 36 of 83		

Higher Alloys	150	Up to 6"	Class condition
		Above 6"	Line condition
	300-2500	All sizes	Line condition

6.2.1.7 Up to sizes 48", D/t ratio shall be restricted to 100(max.) Where D is nominal dia. And t is nominal thickness. However for category-D classes D/t ratio may be taken as max.150 where t is minimum calculated thickness excluding Corrosion and Manufacturing allowance. The minimum corrosion allowance for all material shall be as specified by the Process Licensor.

6.2.1.8 Pipe sizes shall normally be 0.5", 0.75", 1.0", 1.5", 2.0", 3", 4", 6", 8", 10", 12", 14", 16", 18", 20", 24", 26", 28", 30", 32", 36", 40", 44" and 48".

## 6.2.2 Pipe Type

### 6.2.2.1 Up to Class 900#

Material	Size	Type
CS, LTCS, AS (except for Cat 'D' fluids & LP hydrocarbon in offsite)	Up to 14"	Seamless
	16" and above	E.F.S.W(Electro Fusion Seam Welded)
SS Process lines	Up to 6"	Seamless
	8" and above	E.F.S.W
SS Non process lines	Up to 1.50"	Seamless
	2" & Above	Welded
CS (Cat 'D' fluids)	ALL size	Welded
CS (LP hydrocarbons (offsite))	Up to 6"	Seamless
	Above 6"	E.F.S.W /Welded

### 6.2.2.2 Class 1500# & above

Material	Size	Type
CS, LTCS, AS & SS	Up to 24"	Seamless
	26" and above	E.F.S.W

Note: Instrument impulse piping for steam services shall be Sch160 – ½" Seamless

## 6.2.3 Materials and manufacture

6.2.3.1 Furnace butt-welded, furnace lap-welded, and spiral/Helical welded pipes are not permitted.

6.2.3.2 Unless exempted, welded pipes shall be acceptable only with longitudinal weld made employing automatic welding with 100% radiography for all welds.

6.2.3.3 Double Longitudinal seam 180° apart is allowed for sizes 36" and larger only.

6.2.3.4 ERW Pipes shall not have any circumferential seam joint in a random length. However , in case of EFW pipe (48"&above) ,in one random length one welded circumferential seam joint of same quality as longitudinal weld is permitted which shall be at least 2 meters from either end. The longitudinal seams of two portions of same random length shall be staggered by at least 90 degree apart and all welds shall be 100% radiographed. However, circumferential seam joint is permitted only with one longitudinal seam.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 37 of 83		

6.2.3.5 When galvanizing specified, it shall be coated with zinc inside and outside by hot-dip process to ASTM A53.

#### 6.2.4 Ends

Unless otherwise specified, the ends of piping items shall be to the following standards:

SW/SCRD : ASME B 16.11

FLANGED : ASME B16.5 and ASME B16.47

THREADING : ASME/ANSI B1.20.1 (NPT, Taper threads)

BW : ASME B16.25

Wall thicknesses 22 mm and smaller shall be as shown on Figure 2a and the 22 mm greater on Figure 3a in ANSI B16.25.

#### 6.2.5 Inspection and Tests

6.2.5.1 Hydrostatic tests shall be applied to each length of pipe and be in accordance with the requirements of ASTM A530/A999, as applicable, unless otherwise specified.

6.2.5.2 Water for hydrostatic test of austenitic stainless steel pipes shall not contain chlorides more than 50 ppm in weight.

6.2.5.3 In case of seamless & welded pipes, parent material including weld and heat effected zone for low temperature service shall be impact tested (on charpy v notch) at the lowest design temperature in accordance with requirements of code/ specification.

6.2.5.4 All welded pipes indicated as 'CRYO' & 'LT' shall be impact tested, as per requirement and acceptance criteria of ASME B31.3. The impact test temp shall be -196°C, -80 °C & -45°C, for stainless steel, 3-1/2 Ni steel and Carbon steel respectively unless specifically mentioned.

6.2.5.5 Specified heat treatment for carbon steel and alloy steel solution annealing for stainless steel pipes shall be carried out after weld repairs; number of weld repairs at same spot shall be restricted to maximum two (2) by approved repair procedure.

6.2.5.6 Transverse tension test shall be carried out on pipes of nominal size 8" and above and thickness of Sch.120 and above as per supplementary requirements of respective standards.

6.2.5.7 Check analysis shall be carried out as per ASTM A530 for pipes as per ASTM A312 and pipe size > 8" and thickness > Sch120, Check analysis shall also be carried out as per supplementary requirement S1 of ASTM-A-312.

6.2.5.8 For seamless pipes, each length of pipe with following specifications shall be ultrasonically tested as per ASTM E 213 or ASTM A388.

(a) Size upto 4 inches and Sch > 120

(b) Size > 5 inches and thk > 12 mm.

Any defects producing signal greater than the appropriate reference groove shall be unacceptable. The allowable defect shall be longitudinal flat bottom groove on the outside or inside surface of the pipes and length not greater than 25 mm, width not greater than 1.6 mm and depth not greater than the smaller of 1 mm or 5% of the wall thickness.

#### 6.2.6 Marking

Each pipe shall be legibly marked using stenciling or etching on the outer surface of pipes in accordance with the ASTM or API Standard.

### 6.3 Fittings

#### 6.3.1 General

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> BHEL</div>
		DOCUMENT NO	REV	
		SHEET 38 of 83		

- 6.3.1.1 Thickness of fittings at ends to match pipe thickness for BW fittings. For reducing BW fittings having different wall thicknesses at each end, the greater one shall be employed and the ends shall be matched to suit respective thickness.
- 6.3.1.2 SW fittings shall be 3000#, 6000# and 9000# depending on the pipe thicknesses S80, S160 and above S160 respectively.
- 6.3.1.3 All branch connections shall be as follows:  
Up to 1 1/2" NB: O-lets/ Tee  
2" and above: Tees/O-lets / Pipe to Pipe with or without reinforcement pad up to 600# rating.  
Only Tees/O-lets above 600# rating.
- 6.3.1.4 If the branch connections are made by welding the branch pipe directly to the run pipe, the required reinforcement shall be designed in accordance with the ASME B31.3. For underground piping, all branches shall be with reinforcement pad of 2 D diameter & thickness similar to header shall be used.
- 6.3.1.5 Fittings of NPS 2 and larger shall be butt weld type and fittings of NPS 1-1/2 and smaller socket weld or threaded type. For the rating 900 # & above only butt welded fittings, valves etc. have to be used. SW fitting are allowed up to 600 # only.
- 6.3.1.6 Long radius butt welding elbows shall be used wherever possible. Unless otherwise specified, flanged elbows shall not be used.
- 6.3.1.7 All welded fittings shall have maximum negative tolerance equivalent to pipe selected.
- 6.3.1.8 All welded fittings shall be double welded for size 16" and above. Inside weld projection shall not exceed 1.6mm, and the welds shall be ground smooth at least 25mm from the ends.
- 6.3.1.9 For fittings made out of welded pipe, the pipe itself shall be of double welded type, manufactured with the addition of filler material and made employing automatic welding only.
- 6.3.1.10 All welded fittings shall be normalized for CS and normalized & tempered for AS.
- 6.3.1.11 All welded fittings shall be 100% radiographed by X-ray for all welds made by fitting manufacturer as well as for welds on the parent material.
- 6.3.1.12 Bevel ends of all BW fittings shall undergo 100% MP/DP test.
- 6.3.1.13 All pipes employed for manufacturing of fittings shall be required to have undergone Hydro test to ASTM A530/A999, as applicable.
- 6.3.1.14 When fluids have the possibility of causing corrosion in crevice, socket welded piping fitting will not be used.
- 6.3.1.15 Miters may be used in Category 'D' service above 6". For other than Category 'D' fluid in 150# and 300# Class miters can be permitted for sizes above 48". Miters to be designed as per ASME B31.3. However, use of miters shall be minimum. All miters shall be with 100% Radiography.
- 6.3.1.16 Miter bends may be used within the limitations in the ASME B31.3 only where they have been stress analyzed and subject to approval of OWNER.
- 6.3.1.17 Bushings shall not be used.
- 6.3.2 Materials and Manufacture
- 6.3.2.1 Elbows and tees shall not be machined direct from bar stock.
- 6.3.2.2 Caps shall be of one piece material without welded seams unless prior written approval by the Purchaser has been obtained.
- 6.3.2.3 Nozzle welded type tees (fabricated type tees) are not permitted except for NPS 60 and larger.



<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> BHEL</div>
		DOCUMENT NO	REV	
		SHEET 39 of 83		

- 6.3.2.4 Swage nipples shall be manufactured from seamless pipe in accordance with ASTM A234 or ASTM A403 as applicable.
- 6.3.2.5 Galvanized fittings shall be coated with zinc inside and outside by hot-dip process to ASTM A153 after all forming and heat treatment has been completed.
- 6.3.2.6 All bevelling on galvanized fittings shall be made after galvanizing.
- 6.3.2.7 Large diameter fittings that the material standards (ASME/ANSI) do not cover in size or shape shall be designed in accordance with ANSI B31.3 and be manufactured to have the same quality as the requirements of the applicable material standards.
- 6.3.2.8 The gasket contact surfaces of stub ends shall be flat with face finish between 125 AARH to 200 AARH according to ANSI B46.1.
- 6.3.2.9 Seamless stub ends shall not have any welds on the body.
- 6.3.2.10 Threaded ends shall have NPT taper threads in accordance with ANSI B1.20.1 up to 1.5" NB & IS: 554 from 2" to 6" NB.
- 6.3.2.11 Unless and otherwise specified in the requisition all socket weld and screwed fittings shall be in accordance with ANSI B16.11 to the extent covered in the specification except for unions which shall be in accordance with MSS-SP-83.
- 6.3.2.12 Special fittings like Weldolet, Sockolet, Sweepolet etc which are not covered in ANSI, MSS-SP, shall be as per Manufacturer's Std. Contours of these fittings shall meet the requirements of ANSI 31.3. Manufacturer shall submit drawings/catalogues for approval before manufacturing.
- 6.3.2.13 All welded fittings shall be double welded. Inside weld projection shall not exceed 1.6 mm. However 25 mm from the ends shall be flush smooth.
- 6.3.2.14 Specified heat treatment for carbon steel & alloy steel fittings and solution annealing for stainless steel fittings shall be carried out after weld repairs. Number of weld repair at same spot shall be restricted to maximum two by approved repair procedure.
- 6.3.2.15 All welded stainless steel fittings indicated as "CRYO" shall be impact tested as per requirement and acceptance criteria of ASME B31.3. The impact test temperature shall be -196 °C, -101°C & - 45°C. For Stainless Steel, 3-1/2 Ni steel and carbon steel respectively unless specifically mentioned otherwise in MR.
- 6.3.2.16 Thickness/Schedule lower or higher than specified shall not be accepted.
- 6.3.2.17 Finished dimensions shall be in accordance with ANSI B16.9, B16.11 and B16.28. Dimensions not specified in the standards may be to the Vendor's standards with the Purchaser's approval.
- 6.3.2.18 Outside diameters and wall thicknesses shall be in conformance with ASME B36.10 or ASME B36.19.
- 6.3.2.19 Unless otherwise specified on the purchase order documents, end connections shall be as follows:

Threaded Ends	Taper threads as per ASME B1.20.1
Socket-Welding Ends	ASME B16.11
Bevelled Ends	ASME B16.25, Figure 2a for wall thickness $\leq$ 22mm ASME B16.25, Figure 3a for wall thickness $\geq$ 22mm

- 6.3.2.20 Swage nipple dimensions shall be in accordance with MSS SP-95 unless otherwise specified on purchase order documents.
- 6.3.2.21 Dimensional tolerances on fittings shall be within the limit specified in the applicable ANSI or MSS standards, except that circumferential tolerance at the bevelled end in sizes NFS 26 and larger shall be within the range of -0.2 to +0.3 percent of the nominal circumferential length.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 40 of 83		

### 6.3.3 Marking

- 6.3.3.1 Each wrought steel fittings shall be legibly marked using stencilling or etching on the exterior surface of fittings in accordance with the applicable ASTM Standards and MSS SP-25.
- 6.3.3.2 Each forged steel fittings shall be marked using raised letter forging, low stress round nose stamps or etching on the collar portion of the forging, or the raised boss portion in accordance with the applicable ASTM Standard and MSS SP-25.
- 6.3.3.3 For fittings of NPS 1-1/2 and under, at least material identification shall be marked but other markings may be on a label or tag.

## 6.4 Flanges

### 6.4.1 General

- 6.4.1.1 The number of flanges in piping systems shall be kept to minimum and should be installed only to facilitate maintenance and inspection and where construction or process conditions dictate. They are for instance:

- Where pipelines are connected to at connections with flanged equipment and valves.
- Where frequent dismantling of piping is required.
- Where clearance for dismantling equipment is required.
- Where steel piping is connected to nonmetallic or nonferrous piping.

### 6.4.1.2 Hardness of the Flanges

- i) For Ring Joint Flanges Blinds and Spacers, the hardness shall be as follows:

Flange Material	Min. Hardness of Groove (BHN)
Carbon Steel	120
1% Cr to 5% Cr, 1/2 Mo	150
Type 304, 316, 347, 321	160
Type 304L, 316L	140

- ii) For RTJ flanges, blinds & spacers, the hardness of the groove shall be specified on the test report
- iii) Bore of weld neck flange shall correspond to the inside diameter of pipe for specified schedule/ thickness. Ends shall be bevelled to suit the specified schedule/thickness.
- iv) For RTJ flanges, only octagonal section ring joint flanges shall be used.

### 6.4.1.3 Face Finish

The face finish of flanges/flanged items shall be Serrated type (125-250  $\mu$  AARH) as per ASME B16.5/ ASME B16.47.

### 6.4.1.4 Type of Flanges shall be as follows:

Rating	Size	Type	Remarks
150	Up to 1.50"	SW RF	
	2" & above	WN RF	
		WN RF/LJ FF	For SS (Utility services)
		WN RF/ Slip-On	If used in CAT 'D' service
300,600	Up to 1.50"	SW RF	



<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> BHEL</div>
		DOCUMENT NO	REV	
		SHEET 41 of 83		

	2" & above	WN RF	except H2 SERVICE
		WN RTJ	For H2 SERVICE
For 900,& Above	All	WN RTJ.	

i) Ring joint type flanges shall be used for flanges of 900 Lb rating or higher, or for design temperatures exceeding 450°C. This is applicable for all type of service. The flanges can also be used for lower ratings for service conditions which require higher degree of tightness.

ii) Ring joint type flanges shall be used for services requiring higher degree of tightness, for sub zero temp, for ammonia service etc.

iii) All flange joints on piping system including flanges on the equipment, manholes, etc shall be tightened using Torque wrench I hydraulic bolt tensioner depending upon service criticality.

#### 6.4.2 Materials and Manufacture

6.4.2.1 All flanges shall be of forged one piece material (seamless), and plate may not be substituted without written approval from the Purchaser.

6.4.2.2 Ring type joint groove facing Roughness shall not exceed (side wall surface of gasket groove) 63 AARH.

6.4.2.3 When galvanizing is specified, forged flanges shall be coated with zinc inside and outside by hot-dip process to ASTM A153 after all forming and heat treatment has been completed.

6.4.2.4 All threads on galvanized forged flanges shall be cut after galvanizing.

#### 6.4.3 Dimensions

Flanges shall be designed as follows:

NPS 24 and smaller : ANSI B16.5

Above NPS 24 : ANSI B16.47

Unless otherwise specified, end connections shall be as follows:

- Threaded : Internal taper pipe threads to ANSI B1.20.1

- Socket welding, Slip-on and Lapped joint: ANSI B16.5

- Bevelled : Figure 7 for wall thickness 22mm and smaller

Figure 8 for wall thickness greater than 22mm in ANSI B16.5.

Dimensional tolerances shall be within the limit specified in the applicable standards (ANSI/API).

#### 6.4.4 Inspection and Tests

6.4.4.1 Any flanges do not require hydrostatic testing.

6.4.4.2 One tension test shall be carried out for each heat in each heat treatment charge.

6.4.4.3 Impact test for low temp service shall be carried out at the lowest design temperature and shall meet the requirements of the applicable material specifications.

#### 6.4.5 Marking & Preservation

Each flange shall be marked using low stress round nose stamps on the external rim of flanges in accordance with the applicable ASTM Standards and MSS SP-25.

### 6.5 Gaskets

6.5.1 Gaskets shall be as follows:

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> BHEL</div>
		DOCUMENT NO	REV	
		SHEET 42 of 83		

Rating	Material/service	Type	Material of construction
150	CS & SS (utilities)	Plain	Asbestos free
150,300,600	CS, AS & LTCS (except H2 service)	Spiral wound	SS304
150,300,600	SS (except H2 service)	Spiral wound	SS316 (where trim material is SS304/316) SS316L (where trim material is SS304L/316L)
300(*),600(*),900, 1500, 2500	CS	OCTAGONAL RTJ	Soft Iron
300(*),600(*),900 1500, 2500	AS	OCTAGONAL RTJ	5Cr-Alloy steel
300(*),600(*),900 1500, 2500	SS	OCTAGONAL RTJ	SS

\* Only if RTJ is specially mentioned in PMS.

- 6.5.2 Gasket material shall be asbestos free.
- 6.5.3 Full face gaskets shall have bolt holes punched out.
- 6.5.4 Non-metallic ring gaskets as per ASME/ANSI B16.21 shall match flanges to ASME/ANSI B16.5 up to 24", and ASME/ANSI B16.47 unless otherwise specified.
- 6.5.5 Spiral wound gaskets as per ASME B16.20 shall match flanges to ASME/ANSI B16.5 up to 24", and ASME B16.47 for sizes > 24" unless otherwise specified.
- 6.5.6 Inner ring shall be provided for the following:
- As per ASME B16.20 requirement.
  - For sizes 26" & above in all classes.
  - For vacuum and hydrogen service.
  - For SS321, SS347 and H grade SS classes.
  - For classes where temperature is higher than 427°C.
  - For 900# rating and above classes.
- 6.5.7 In case of RTJ gaskets, only octagonal section ring gaskets shall be used & shall have proper marking stamped. Material certificate shall be available for the gasket.
- 6.5.8 Hardness of RTJ gasket shall be 20 BHN (min) less than the corresponding flange groove hardness.
- 6.6 Stud, Bolts, Nuts and Jack Screws**
- 6.6.1 All bolting shall be as per ASME/ANSI 18.2.1 for Studs, M/C Bolts and Jack screws, and ASME/ANSI B18.2.2 for nuts. Machine Bolts shall not be used in piping flange joint, except for Butterfly Valves, which shall be lug type, having UNC Threads in lugs facilitating opening of flanges from both sides.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> BHEL</div>
		DOCUMENT NO	REV	
		SHEET 43 of 83		

- 6.6.2 Threads shall be unified (UNC for; 1" dia and 8UN for > 1" dia) as per ANSI B1.1 with class 2A fit for Studs, M/C Bolts and jack screws, and class 2B fit for nuts.
- 6.6.3 Stud bolts shall be threaded full length with two heavy hex nuts. Length tolerance shall be in accordance with the requirement of table F2 of Annexure 6 of ASME B16.5
- 6.6.4 The nuts shall be double chamfered, semi-finished, heavy hexagonal type and shall be made by the hot forged process.
- 6.6.5 The length of the studs/ bolts should be such that minimum two threads should be out of the nut on either side.
- 6.6.6 All the stud bolt should have metallurgical certificates in case of Alloy/ SS metallurgy with identified color marking at the stud ends/ bolt side face.
- 6.6.7 For Stainless steel flanges fasteners shall also be of Stainless Steel.
- 6.6.8 Heads of jack screws and M/C bolts shall be heavy hexagonal type. Jack screw end shall be rounded.
- 6.6.9 Tops and Bearing Surface of Nuts in size 5/8 inch nominal size and smaller shall be double chamfered. Larger size nuts shall be double chamfered or have washer faced bearing surface and chamfered top.
- 6.6.10 Wherever bolt tensioning is specified stud bolt length shall be longer by minimum one diameter do suit bolt tensioner. Excess threads shall be protected by a threaded cap.

## 6.7 Valves

### 6.7.1 General

#### 6.7.1.1 Type

- i) SW Valves up to 1 1/2 inch – up to 600# except ball & plug valves which shall be flanged for all sizes.
- ii) Flanged cast valve above 1 1/2" for 150#, 300#, 600#
- iii) Welded Valves- 900# and above

#### 6.7.1.2 Criteria for Body Bonnet Joint & Ends of the Valves

Pipe Class Rating	Body / Bonnet	Body / Bonnet	Ends	Ends
	Size ≤ 1.5 "	Size > 1.5 "	Size ≤ 1.5 "	Size > 1.5 "
150 / 300#	Bolted	Bolted	SW	Flanged
600 #	RTJ	RTJ or Pressure seal	SW	Flanged
900# & Above	Threaded seal welded/ Welded bonnet	Pressure Seal	BW	BW

- 6.7.1.3 All flanged valves (except forged) shall have flanges integral with the valve body.
- 6.7.1.4 Yoke material shall be at least equal to body material.
- 6.7.1.5 Valves shall have pure graphite as gland packing material. Asbestos and other gland packing material shall not be used.
- 6.7.1.6 Forgings are acceptable in place of Castings but not vice-versa.
- 6.7.1.7 No Cast Iron/Ductile Iron valves to be used in any service.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> BHEL</div>
		DOCUMENT NO	REV	
		SHEET 44 of 83		

6.7.1.8 Valves in saline water (if applicable) service shall be with non ferrous trims and all wetted parts other than trims shall be epoxy coated.

6.7.1.9 All “IBR” valves shall be painted red in body–bonnet / body–cover joint.

## 6.7.2 Design

### 6.7.2.1 General

6.7.2.1.1 The minimum body wall thickness for the steel valves in size and/or rating not specified in the applicable standards shall conform to ANSI B16.34 (Standard Class).

6.7.2.1.2 Extension bonnet, when required, shall be integral with the Bonnet but a tube extension may be welded to the bonnet with full penetration welding.

6.7.2.1.3 Body/Disc seat construction is defined as follows:

#### a) Renewable Seat

- A separate seat ring threaded in, rolled in the body or on the disc

#### b) Integral Seat

- Integral with the body or disc

- A hard faced deposit on the body or disc

- Direct deposition of 13% chromium seat material on the body is not acceptable.

- A separate seat ring continuously welded in the steel body or on the disc.

6.7.2.1.4 If the seat surface with a hard faced deposit is specified, the integral seat is acceptable instead of the renewable seat.

6.7.2.1.5 The seat surfaces with no hard faced deposit shall be the renewable seat except austenitic stainless steel valves.

6.7.2.1.6 If a combination trim, e.g. a hard faced deposit and 13Cr is specified, the former shall be used for the body seat surface and the latter for the disc seat.

6.7.2.1.7 Where a hard faced trim is specified, the back seat of the bonnet may be of a direct weld deposit.

6.7.2.1.8 Unless otherwise specified in the purchase order documents, the use of soft seals in wedge or disc is not acceptable.

6.7.2.1.9 Hand wheels shall not be made of gray iron or non-metallic materials.

### 6.7.2.2 Steel Gate Valves

6.7.2.2.1 Gate valves shall conform to the following standards:

- General use valves : API 600

- 150Lb stainless steel valves : API 603

6.7.2.2.2 The valves shall be of outside screw-and-yoke type with a rising stem and non- rising hand wheel.

6.7.2.2.3 The valves shall be of a solid wedge type; either a plain solid wedge or a flexible solid wedge.

6.7.2.2.4 The wedges shall have the integral seats. The renewable seats are not acceptable.

6.7.2.2.5 The valves for liquefied petroleum gases shall be provided with a relief hole on the wedge to relieve excess body cavity pressure upstream unless purchase order document requires cavity pressure relief downstream.

### 6.7.2.3 Steel Globe Valves

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 45 of 83		

6.7.2.3.1 Globe valves shall conform to the standards listed below in so far as applicable:

6.7.2.3.2 General use valves: API 623 / ASME B16.34.

6.7.2.3.3 The disc shall be of the integral type with a spherical seating surface.

6.7.2.3.4 Other type disc will be acceptable except a soft ring seated.

6.7.2.3.5 The disc shall be loosely attached to the stem to allow for proper seating and fitted to receive the locking device which retains the disc on the stem.

6.7.2.3.6 A disk thrust plate shall be provided between the end of the stem and the disc, except for small size valves.

6.7.2.3.7 The disc thrust plate shall have a differential hardness of 50HB minimum for the stem.

6.7.2.3.8 When in the fully open position, the net area between the disc and the seat shall be at least equal to the area of the end port.

#### 6.7.2.4 **Steel Swing Check Valves**

6.7.2.4.1 Swing check valves shall conform to the standards listed below in so far as applicable:

6.7.2.4.2 General use valves: API 602 / API 6D / API594/ BS 1868.

6.7.2.4.3 The disc shall be of the integral type with a flat seating face.

6.7.2.4.4 The disc shall be secured to the hinge by a locking device to allow for the self- seating of the disc on the body seat.

6.7.2.4.5 A hinge and hinge pin shall be provided and mounted in the body to permit full movement of the disc.

6.7.2.4.6 If the service requires an outside lever with adjustable weights, damping device, etc., to control the movement of the disc, dual plate type check valves with a spring loaded may be used except that they shall not be used for corrosive services.

#### 6.7.2.5 **Single/Dual Plate Check Valves**

6.7.2.5.1 Single/Dual Plate Check Valves shall conform to API 594. These types of valves may be used for swing check valves in case of space limitation.

6.7.2.5.2 Dual plate Check Valves shall not be used for corrosive services.

#### 6.7.2.6 **Ball Valves**

6.7.2.6.1 Ball valves shall conform to API 6D/API608.

6.7.2.6.2 The ball of Ball valves shall not protrude outside the end flanges.

6.7.2.6.3 Ball valves shall be floating ball type /Trunnion mounted type as per following:

Class	Floating Ball	Trunnion Mounted
150	8" & below	10" & above.
300	4" & below	6" & above
600 & above	1½" & below	2" & above

6.7.2.6.4 The manufacturer shall propose higher ratings at the seat materials specified for Owner's approval.

6.7.2.6.5 The valves shall be of full bore type. For NPS 4 & over they may be of reduced bore type unless otherwise specified. Ball port shall be cylindrical.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 46 of 83		

- 6.7.2.6.6 Sealed cavity balls shall be designed to withstand the full hydrostatic body test pressure.
- 6.7.2.6.7 A relief hole, unless otherwise specified, shall be provided on the upstream-side ball for relieving pressure within the body cavity at the ball close and open positions unless the purchase order document requires it down stream.
- 6.7.2.6.8 Stem retention shall not depend on the packing gland.
- 6.7.2.6.9 The stem shall be of anti-blowout type and should be retained by the body back seat for fire safe design.
- 6.7.2.6.10 Glands shall be of the bolted type. An internal screwed stuffing box is not acceptable.
- 6.7.2.6.11 Body seat shall be of a renewable seat ring. The wrench shall be designed to make wrench operation ease even when the valves are insulated without any stem or bonnet extensions.
- 6.7.2.6.12 The valves shall be fitted with an anti-static device to ensure electrical continuity from the ball to the stem and from the stem to the body.
- 6.7.2.6.13 The valves used in process services shall be of fire safe design especially for the ball seats, stems and body flanges.
- 6.7.2.6.14 Ball valves may be used in place of gate or plug valves with the following limitations:
- 6.7.2.6.15 Operating conditions are within the permissible pressure – temperature range of seat materials.
- 6.7.2.6.16 Fire safe type is used for hydrocarbon services.
- 6.7.2.7 Butterfly Valves**
- 6.7.2.7.1 Butterfly valves shall conform to API 609.
- 6.7.2.7.2 The valves shall be of wafer lug type, body threaded, with a tight seal in the closed position. Lug shall have Internal UNC Threads. Lug shall be threaded such that either flange can be dismantled for maintenance.
- 6.7.2.7.3 Unless otherwise specified, the valves may be seated with concentric location of disc and seat. They shall be provided with a soft seat material built in the body and suitable for the specified conditions.
- 6.7.2.7.4 The manufacturer shall propose the maximum differential pressure across the disc and the temperature limitation dictated by the soft seal material for Owner's approval.
- 6.7.2.7.5 Minimum rating for the Butterfly Valve shall be PN 16.
- 6.7.2.8 Plug Valves**
- 6.7.2.8.1 Plug valves may be fully in accordance with manufacturer's standard except for:
- Minimum body wall thickness to ANSI B16.34
- Face to face dimension to ANSI B16.10
- 6.7.2.8.2 The valves shall be of reduced bore type.
- 6.7.2.8.3 The valves shall have PTFE body seats to prevent galling at plug seating. Lubricated plug valves are not acceptable.
- 6.7.2.8.4 The manufacturer shall propose the temperature limitation dictated by the soft material.
- 6.7.2.8.5 The plugs shall be fitted with an anti-static device for all services.
- 6.7.2.8.6 The valves used in process services shall be of fire safe design to API 6D, but limited to gland parts only.
- 6.7.2.8.7 For Acid service, having temperature higher than 75 DegC Plug Valves to be used & IGC testing to be considered.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 47 of 83		

### 6.7.3 Valve Dimensions

6.7.3.1 End flanges, when specified, shall be as follows:

- NPS 24 and smaller	:	ANSI B16.5
- NPS 26 to NPS 60	:	ANSI B16.47
- Threaded end (NPT)	:	ANSI B1.20.1
- Socket welding end	:	ANSI B16.11
- Butt welding end	:	ANSI B16.25

(Wall thickness 22mm and smaller - Fig 2a,

For over 22mm thickness- Fig 3a)

6.7.3.2 Face-to-Face/End-to-End dimension shall be as per ANSI B16.10. In case the same is not covered under B16.10, the dimension shall be as per BS 2080/manufacturer standard.

6.7.3.3 Valve under cryogenic service (temp. below -45°C) shall be as per BS-6364 and shall be procured from pre-qualified vendor.

6.7.3.4 Generally the valves are hand wheel or lever operated. However, suitable gear operator in enclosed gear box shall be provided for valves as follows:

Gate Valves:	
CL150	14"NPS and larger
CL300	10"NPS and larger
CL600 & 900	8"NPS and larger
CL1500 & CL2500	3"NPS and larger

Globe and Angle Valves:	
CL150	12"NPS and larger
CL300	8"NPS and larger
CL600	6" NPS and larger
CL900	4" NPS and larger
CL1500 & 2500	3" NPS and larger

Ball Valves:	
CL150 to 300	8" NPS and larger
CL600	8"NPS and larger
CL900 to 1500	3" NPS and larger

Butterfly Valves:	
CL150 to 600	8"NPS and larger
Plug Valves:	



<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> BHEL</div>
		DOCUMENT NO	REV	
		SHEET 48 of 83		

CL150 to 600	6" NPS and larger
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6.7.3.5 Spectacle blinds and paddle blinds/spacers shall be provided per the pressure class and size range divisions shown below:

Spectacle Blind	Paddle Blind/Spacer
CL150 14"NPS and below	CL150 16"NPS and above
CL300 10" NPS and below	CL300 12"NPS and above
CL600 8" NPS and below	CL600 10"NPS and above

6.7.3.6 Hand wheel diameter shall not exceed 750mm and lever length shall not exceed 500 mm on each side. Effort to operate shall not exceed 35 kgf at hand wheel periphery. However, failing to meet the above requirement, vendor shall offer gear operation.

6.7.3.7 Quarter-turn valves shall have "open" position indicators with limit stops.

6.7.3.8 By-Pass

A globe type valve (size as per ASME/ANSI B61.34) shall be provided as by-pass for the following sizes of the gate valves:

Class	Size
150	26" & above
300	16" & above
600	6" & above
900	4" & above
1500	4" & above
2500	3" & above

By-pass Piping, Fitting and Valves shall be of compatible material and design. Complete fillet welds for by-pass installation shall be DP/MP tested.

NDT of by-pass valve shall be in line with main valve.

#### 6.7.4 Inspection and Tests

6.7.4.1 Shop inspection and tests shall be carried out to API 598 and related MSS standards.

6.7.4.2 Radiography of Cast Valves

6.7.4.2.1 Radiography procedure, areas of casting to be radiographed, and the acceptance criteria shall be as per ASME B16.34.

6.7.4.2.2 The minimum requirement of radiography shall be as under (except as mentioned in Cl.6.7.4.2.3 & Cl.6.7.4.2.4):

Class	Size	Qty.
150	Up to 24"	10%
150	26" & above	100%
300	Up to 16"	10%
300	18" & above	100%



<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 49 of 83		

600 & above	All	100%
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6.7.4.2.3 Radiography requirement for special/critical piping classes (hydrogen, hydrogen bearing, stress relieved caustic services) shall be as follows:

Class	Size	Qty.
150	up to 24"	50%
150	Above 24"	100%
300	up to 16"	50%
300	Above 16"	100%

6.7.4.2.4 Radiography requirement for special/critical piping classes (Oxygen, NACE and any other lethal service) shall be as follows:

Class	Size	Qty.
150	All Sizes	100%
300	All Sizes	100%

6.7.4.2.5 The welds of body-to-bonnet and body-to-end flange shall be subjected to 100% NDT; both radiographic and magnetic or liquid penetrant examinations.

6.7.4.2.6 Bevelled ends on each butt welding end valves shall be subjected to 100% radiographic examination and, magnetic particle or liquid penetrant examination.

#### 6.7.4.3 Pressure Tests

6.7.4.3.1 Each Valve shall be pressure tested in accordance with API 598.

6.7.4.3.2 High pressure closure test shall be required for gate and globe valves.

6.7.4.3.3 Water for pressure tests on austenitic stainless steel valves and those having internals of austenitic stainless steel shall not contain chlorides more than 50 ppm in weight.

### 6.8 Special Valves (Orbit, Y-body Globe, Jacketed valves of all types)

6.8.1 Special Valves shall strictly follow the requirements of Valve data sheet, Process data sheet/Specialty data sheet.

6.8.2 Special Valves shall be made out of 100% radiographic casting/ 100% ultrasound forging.

6.8.3 Jacketed Valves shall be tested to 100% DP/ MP check on Jacket welding, 100% radiography test of valve body, 100% hydro test of Jacket.

6.8.4 Large diameter swing check valves shall be equipped with an anti-hunting device, where closing of the check valve could cause a surge.

### 6.9 Traps

6.9.1 Vendor shall also furnish the performance curve indicating the capacity hi mass/hour at various differential pressures across the trap.

6.9.2 Parts subject to wear and tear shall be suitably hardened. Traps shall function in horizontal as well as in vertical installation.

6.9.3 Traps shall have integral strainers.

6.9.4 All traps shall be hydrostatically tested to twice the design pressure.

### 6.10 Hoses

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 50 of 83		

- 6.10.1 Manufacturer shall guarantee suitability of hoses for the service and working conditions specified in the requisition, if the material is not specified in the Material Requisition for any particular service.
- 6.10.2 All hoses shall be marked with service and working pressure at minimum two ends clearly.
- 6.10.3 Hoses shall be resistant to ageing, abrasion and suitable for outdoor installations.
- 6.10.4 Complete Hose assembly shall be tested at two times the design pressure
- 6.10.5 Steam hoses shall be subject to steam resistance test.
- 6.11 Expansion Joints**
- 6.11.1 The applicable codes are ASME B31.3 and EJMA (Expansion Joint Manufacturer's Association).
- 6.11.2 Bellows shall be formed from solution annealed sheet conforming to the latest ASTM Spec. Any longitudinal weld shall be 100% radiographed. The finished longitudinal weld must be of the same thickness and same surface finish as the parent material.
- 6.11.3 Circumferential welds are not permitted. Bellows are to be hydraulically or expansion (punched) formed. Rolled formed bellows are not acceptable. Noticeable punch or die marks resulting from expansion operation are not acceptable.
- 6.11.4 No repairs of any kind are allowed on the bellows after forming. Deep scratches and dents are not acceptable.
- 6.11.5 The out of roundness shall be limited to  $\pm 3\text{mm}$ . This is the max deviation between the max & min diameter.
- 6.11.6 The actual circumference of the welding end shall be maintained to  $\pm 3\text{mm}$  of the theoretical circumference.
- 6.11.7 Apart from the usual requirements, the vendor shall also furnish
- Design calculations to justify stiffness and fatigue life.
  - Axial, lateral stiffness, angular stiffness, effective pressure thrust area.
  - Installation/maintenance manual.
- 6.12 Supports & Spring Assemblies**
- 6.12.1 The Material, Design, Manufacture and Fabrication shall be generally as per MSS-SP-58/ MSS-SP-89 and/or BS 3974.
- 6.12.2 Testing of springs shall be as per BS1726.
- 6.13 NDT Requirements for piping**
- 6.13.1 Classes in 150# for normal service shall be subjected to 10% radiography and 10%DP/ MP test (for CS&AS) or 10% DP test (for SS).
- 6.13.2 Classes in 300# for normal service shall be subjected to 20% radiography and 20% DP/MP test (for CS&AS) or 20%DP test (for SS).
- 6.13.3 Classes in 600# and above, 100% radiography on weld joints shall be employed. In 100% radiography classes any fillet welds employed shall have 100% DP/MP test in CS/AS classes and 100% DP test in SS classes.
- 6.13.4 For hydrogen and hydrogen bearing hydrocarbon services radiography and DP/MP shall be 50% in 150# and 300# class ratings.
- 6.13.5 All oxygen, NACE and any other lethal service shall have 100% radiography on weld joints in all class ratings. Castings used in these services shall have 100% radiography.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 51 of 83		

- 6.13.6 For fire water service, IBR, etc., any statutory NDT requirements, not covered above, shall also be complied.
- 6.13.7 Classes in Cat-D service shall be subjected to 5% radiography and 10% DP/ MP test (for CS&AS) or 10% DP test (for SS).
- 6.14 **Special Service Requirements**
- 6.14.1 **IBR Service**
- 6.14.1.1 IBR stands for Indian Boiler Regulation. For steam services, it is statutory obligation to meet IBR requirements.
- 6.14.1.2 For items under IBR, composition restrictions, test reports, painting, etc. shall be as per IBR's stipulations.
- 6.14.1.3 For carbon steel piping items under IBR, the chemical composition shall conform to the following:
- |                   |                                  |
|-------------------|----------------------------------|
| Carbon (Max)      | 0.25 %                           |
| Others (S, P, Mn) | As prescribed in IBR regulation. |
- 6.14.1.4 The chemical composition condition as indicated in this clause is not applicable for items other than IBR services.

<div><div><div>पी डी आई एल PDIL</div></div></div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div><div></div></div>
		DOCUMENT NO	REV	
		SHEET 52 of 83		

## 6.14.2 Hydrogen services

6.14.2.1 Testing requirements for piping items intended for use in hydrogen service are specified here. These requirements are applicable in addition to requirements specified in Technical scope/specification elsewhere in this document and the most stringent condition shall prevail.

“Special Requirements for Hydrogen Service (Spec No. API-941)” and ASME B31.12 shall be followed for all Hydrogen and Hydrogen bearing hydrocarbon services.

### 6.14.2.2 PIPE, FITTINGS AND FLANGES

- a) All carbon steel pipes, fittings and flanges having wall thickness 9.53 mm (0.375") and above shall be normalized. Cold drawn pipes shall be normalized after the final cold draw pass for all thicknesses.
- b) All Alloy Steel (Cr-Mo) pipes, fittings and flanges shall be normalized and tempered. The normalizing and tempering shall be a separate heating operation and not a part of the hot forming operation.
- c) Hardness testing to be as per ASTM E110. For carbon steel Pipes & Fittings, hardness of weld and HAZ shall be 200 BHN (max). For alloy steel Pipes & Fittings, hardness of weld and HAZ shall be 225 BHN (max).
- d) For all Carbon steel and Alloy steel Pipes, Fittings and Flanges with wall thickness over 20mm, Charpy-V Notch impact testing shall be carried out in accordance with paragraph UG-84 of ASME Section VIII, Div-1 for weld metal and base metal from the thickest item per heat of material and per heat treating batch. Impact test specimen shall be in complete heat treated condition and accordance with ASTM A370. Impact energies at 0°Celsius shall average greater than 27J (20ft-lb) per set of three specimens, with a minimum of 20J (15 ft-lb).
- e) All girth welded joints (longitudinal and circumferential) shall be 100% radiographed in accordance with UW-51 of section VIII, Div-1 and ASME Section V. Radiography shall be performed after post weld heat treatment.

### 6.14.2.3 VALVES

- a) General
- b) All cast valve flanges & bodies with flange rating of Class 900 or greater shall be examined in accordance with paragraphs 7.2 through 7.5 of Appendix-VII of ASME SEC-VIII, DIV.1, regardless of casting quality factor.
- c) Body / bonnet / cover joints & stuffing box of all valves shall have low emission. One valve per metallurgy, per rating, per size shall be helium leak tested as per ASME Sec.V, Subsection A, Article 10 (Detector Probe Technique), Appendix IV at a minimum of 25% of the allowable (rated) cold working pressure. Selection of valves for helium leak test shall be at random. Test duration shall be as follows:

Test duration in Minutes					
Nominal size	Pressure Class				
	Upto 300	600	800 & 900	1500	2500
Up to 2"	3	6	9	12	12
3" to 6"	6	9	12	15	18
8" to 16"	9	9	12	15	18
18" to 24"	9	12	15	18	21

The valve shall show no leakage. No leakage is defined as a total leakage rate of less than 0.0001 ml/s of helium.

- d) Only normalized and tempered material shall be used in the following specifications:

Castings: A217 Gr.WC1, A217 Gr.WC4, A217 Gr.WC5, A217 Gr.WC6, A217Gr.WC9, A217Gr.C5, A217 Gr.C12

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> भारतीय वोल्टीज एल BHEL</div>
		DOCUMENT NO	REV	
		SHEET 53 of 83		

Forging: A182 Gr.F11 C1.2

#### 6.14.2.4 CS & AS VALVES

- a) Bend test and Magnetic Particle inspection of the entire surface of body and bonnet casting shall be in accordance with ASTM A217. Supplementary requirement S3 & S4 evaluation of magnetic particle, inspection shall be in accordance with MSS-SP-53 except that no linear discontinuities shall be allowed.
- b) Hardness testing to be as per ASTM E110. The Brinell hardness of heat treated casting shall not exceed 200 BHN for carbon steel & 225 BHN for alloy steel.
- c) Repair to defective casting shall be outlined in writing to the purchaser before repair starts. Repair method to be approved prior to welding.
- d) Casting shall be preheated to a minimum of 400°F prior to welding and all Chromium-Molybdenum alloys shall be post weld heat treated after welding is complete. Stress relieving is essential for welds.
- e) Carbon steel shall be normalized and alloy steels shall be normalized & tempered.
- f) Dye Penetrant test of welds shall be in accordance with ASTM B165 Procedure B-2 and interpretation as per Appendix-8 of ASME-VIII Div.1.
- g) The tensile stress for AS shall be less than 100,000 psi.
- h) Charpy V-notch impact testing is to be done for valve material (average 20 ft-lb for set of 3 [minimum value 15 ft-lb] at 30°F).

#### 6.14.2.5 SS VALVES

- a) Valve casting shall be in solution heat treated and pickled condition.
- b) Critical body and bonnet casing section typically defined by ASME B 16.34 shall be radiographed and shall meet ASTM E446 (up to 2" thick) Category A, B & CA Level 2, Category CB, OC & CD Level 3, Category D, B & F Level 0. For wall thickness 2" to 4.5" comparable plates of ASTM E186 shall be used. ASTM E94 and ASTM E142 shall be used for recommended practice & controlling quality of radiography as guide. The entire surface of all castings shall be dye-penetrant inspected after pickling.
- c) Welds shall be 100% radiographed and evaluated in accordance with paragraph 344.5 of ASME B31.3 with a minimum casting quality factor of 0.95. Dye Penetration test shall be as per ASTM E165 Procedure B-2, Interpretation as per Appendix-8 of ASME-VIII Div.I.

#### 6.14.3 NACE & Sour Service

For items under this category, unless otherwise specified in PMS, NACE:- MR-01-75 shall be followed. Hardness shall be below BHN 200 for C.S. material. Carbon equivalent (CE) shall be limited to 0.43.

#### 6.14.4 CRYO & Fire-Safe

For items to be used under cryogenic conditions, temp below - 45°C and those required to be fire-safe, special designs and tests would be applicable. Pre-qualification criteria need to be specified before execution of job.

#### 6.14.5 Low Temperature service

- 6.14.5.1 Low Temperature Carbon Steel shall be normalized & impact tested.

#### 6.14.6 General requirements

- 6.14.6.1 All alloy steel piping items shall be Normalized & Tempered.
- 6.14.6.2 All alloy steel and higher alloyed piping material shall be subjected to PMI test.

#### 6.15 Inspection of supply items

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> BHEL</div>
		DOCUMENT NO	REV	
		SHEET 54 of 83		

- 6.15.1 Inspection authority means the Third Party Inspection Agencies (TPIA) approved by the Owner to carryout inspection of materials.
- 6.15.2 The inspecting authority shall have the right to select random samples for check test and reject materials, if samples furnished as above and tested as per the specifications fail to meet the requirement specified.
- 6.15.3 All the items shall be inspected and tested in the presence of one or more representatives of the purchaser during various stages of manufacturing. Material shall be considered acceptable for dispatch only after final certificate of acceptance is issued by the Inspector.
- 6.15.4 Testing performed in the presence of the purchaser's representatives shall not relieve the supplier of their own responsibilities and guarantees and any other contractual obligations.
- 6.15.5 Quality Assurance plan (QAP) / Inspection Test Plan (ITP) shall be submitted by bidder for approval by Third Party Inspection Agency (TPIA)/ Owner.
- 6.15.6 Scope of Inspection by TPIA:

Review (R) of Chemical composition report, Heat treatment chart, Intergranular corrosion (IGC) test and Non Destructive Examination (RT/UT Report).

Witness (W) of Mechanical Testing: Tensile test, bend test, hardness test, transverse tension test, Impact test, flattening test etc (as applicable).

Random witness (10% RW): Hydrostatic test, Positive Material Identification (PMI) for Alloy/Stainless steels, Dye Penetration (DP) / Magnetic Particle (MP) Test, Galvanizing, Dimensional check, Marking, Visual check.

## 7. THERMAL INSULATION OF PIPING

- 7.1 This consist of insulation for heat conservation, process stabilization, temperature maintenance, insulation for steam traced lines, jacketed lines, insulation for electrical traced lines insulation for fire protection for operating temperatures above ambient temperature for all sizes of lines. Wherever insulation for personnel protection is mentioned, the same shall be provided judiciously as per insulation specifications.
- 7.2 Preformed pipe sections shall be used for all sizes of piping and inspection windows shall be provided in insulation at critical locations to be decided at the time of execution.
- 7.3 All materials shall be of high quality and good appearance. Insulation materials shall be of low chloride content, chemically inert, non sulphurous, rot proof, vermin proof, impervious to hot water and steam, non-injurious to health and non-corrosive to steel and aluminum (even if soaked in water at ambient temperatures for extended periods). The use of insulation or finishing materials containing Asbestos in any form is not permitted.
- 7.4 The insulation of piping, equipments and vessels shall be carried out with the recommended insulating materials and the thicknesses as per process design basis. Hot insulation over austenitic stainless steel surfaces shall be inhibited with sodium silicate as per ASTM C-795. The inhibited insulation material shall be tested as per ASTM C-692. Restriction of leachable chloride to 10ppm (max) shall be demonstrated as per the test method ASTM C-871.
- 7.5 For detailed specification of insulation refer Design Philosophy-Construction/Erection, Pre-Commissioning, Commissioning and Start-Up.

### 7.6 Extent of Insulation

- 7.6.1 Extent of insulation shall be as per final approved P&ID/ Line list /General Arrangement drawing/Isometrics and vessel and equipment data sheets.
- 7.6.2 Insulated piping system shall have straight pipe, bends, tees and pipe fittings completely insulated.



<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 55 of 83		

- 7.6.3 For all cold lines, all steam and condensate lines, all hot oil lines and trace heated & jacketed lines, the extent of insulation shall include valves and flange joints also.
- 7.6.4 For bucket and float type traps the inlet piping and trap shall be insulated.
- 7.6.5 For thermostatic and thermodynamic traps insulation shall terminate at approx 500mm before trap.
- 7.6.6 Instrumentation such as level gauges, level controllers, level switches, dp cells, etc., shall have their fluid containing sections and associated piping completely insulated.

## 8. Painting

### 8.1 Scope of Painting

#### 8.1.1 The following surfaces and materials shall require painting.

- All un-insulated C.S & A.S piping, fittings, valves, columns, vessels, drums, & storage tanks, heat exchangers etc. including painting of identification marks on insulated lines.
- Identification colour bands on all piping as required including insulated aluminium clad, galvanized, SS and non ferrous piping.
- Pipes, fittings & valve surfaces under insulation of carbon steel and alloy steel insulated piping system.
- Pipes, fittings, valves surfaces under insulation of stainless steel insulated piping system.
- All structural steel works, supports, walkways, handrails and platforms etc.

#### 8.1.2 The following surfaces and materials shall not require painting:

- Un-insulated austenitic stainless steel and higher alloy piping.
- Plastic and plastic coated materials.
- Non ferrous material like aluminum, galvanized, brass, bronze piping etc.

### 8.2 Colour Coding

Painting work shall require satisfying the requirements of the area where the plant is being setup. All painting and color coding shall be as per local painting manual.

### 8.3 Surface Preparation & Painting Application

Surface preparation and painting application shall be as per Std Specification

No surface shall be coated in rain, wind or in environment where injurious airborne element exists, where surface temperature is below 5 deg F above dew point, where relative humidity is greater than 90% and temperature is below 40 deg F.

Paint application shall follow the strict instruction of paint manufacturer whose paint is being employed.

All procedures from surface preparation to finish painting; including testing shall be well documented through a quality procedure approved by PMC/OWNER.

### 8.4 Painting Materials

As per STD Specification (Refer Civil/Construction Section of Document)

## 9.0 WELDING

### 9.1 Applicable Codes & Standards

All welding work, equipment for welding, heat treatment, other auxiliary functions and the welding personnel shall meet the requirements of the latest editions of the following accepted standards and procedures.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> BHEL</div>
		DOCUMENT NO	REV	
		SHEET 56 of 83		

- a) Process Piping : ASME B31.3  
b) The Indian Boiler Regulations : IBR

In addition, the following codes and specifications referred in the code of fabrication shall be followed for the welding specifications, consumable qualifications and non destructive test procedures.

- i) Welding and Brazing Qualifications ASME BPV- Sec IX.  
ii) Non destructive examination ASME BPV Sec V.  
iii) Material specifications: Welding rods, electrodes and filler metals ASME BPV Sec II Part C.

The additional requirements mentioned in this specification, over and above those obligatory as per codes, shall be followed wherever specified.

## 9.2 Welding Processes

9.2.1 Welding of various materials shall be carried out using one or more of the following processes with the approval of the Engineer-in-charge.

- Shielded Metal Arc Welding process (SMAW)
- Gas Tungsten Arc Welding process (GTAW).

9.2.2 Automatic and semi-automatic welding processes shall be employed only with the express approval of the OWNER / PMC. The welding procedure adopted and consumables used shall be specifically approved.

9.2.3 A combination of different welding processes could be employed for a particular joint only after duly qualifying the welding procedure to be adopted and obtaining the approval of OWNER/ PMC.



<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 57 of 83		

## ANNEXURE – 1

**TABLE OF BASIC SPAN**

Pipe Size In.	SCH/Thk (in)	PIPE- VAPOR INSULATION			PIPE- LIQUID INSULATION			BARE PIPE EMPTY		BARE PIPE WATER FILLED		Pipe size in.
		BASIC SPAN (L)M			BASIC SPAN (L)M							
		UPTO 175° C	176° C TO 315°C	316°C TO 400°C	UPTO 175° C	176° C TO 315°C	316°C TO 400°C	SPAN(L) M	WEIGHT KG/M	SPAN(L) M	WEIGHT KG/M	
3/4"	SCH 40	3.5	3.5	2.5	3.5	3.0	2.0	4.5	1.68	4.0	2.04	3/4"
1"	SCH 40	4.5	4.0	3.0	4.5	3.5	3.0	5.0	2.52	4.5	'3.07	1"
1-1/2"	SCH 40	5.0	5.0	4.5	5.0	4.5	3.5	6.0	4.08	5.0	.5.4	1-1/2"
2"	SCH 40	5.5	5.0	4.5	5.0	4.5	3.5	8.5	5.47	5.5	7.65	2"
2-112"	SCH 40	6.5	6.0	5.0	6.0	5.5	4.5	7.5	8.7	6.5	11.79	2-112"
3"	SCH 40	7.5	6.5	5.5	6.5	6.0	5.0	8.0	11.35	6.5	16.15	3"
4"	SCH 40	8.0	7.5	6.5	7.5	7.0	6.0	9.0	16.2	7.5	24.45	4"
6"	SCH 40	10.0	9.5	8.5	9.0	8.0	7.5	10.5	28.3	9.0	46.7	6"
8"	SCH 40	12.0	11.0	10.0	10.0	10.0	9.0	12.0	42.84	10.0	75.22	8"
10"	SCH 40	13.5	13.0	12.0	11.5	10.5	10.5	14.0	60.74	11.5	111.9	10"
12"	3/8"w	14.5	13.5	13.0	12.0	11.5	11.0	15.0	74.40	12.0	147.5	12"
14"	3/8"w	15.0-	14.5	13.5	12.0	12.0	11.5	16.0	82.5	12.5	172.05	14"
16"	3/8"w	16.0	15.5	14.5	13.0	12.5	12.0	17.0	94.5	13.0	213.15	16"
18"	3/8"w	17.0	16.5	15.0	13.5	13.0	12.0	18.0	106.5	13.5	258.3	18"
20"	3/8"w	18.0	17.5	16.0	14.0	13.5	12.5	19.0	118.5	14.0	307.5	20"
24"	3/8"w	20.0	19.0	17.5	14.5	14.5	13.0	21.0	1425	15.0	418.2	24"
3/4"	SCH 80	3.5	3.5	2.5	3.5	3.0	2.0	4.5	2.20	4.0	2.49	3/4"
1"	SCH 80	4.5	4.0	3.0	4.5	3.5	3.0	5.0	3.25	4.5	3.72	1"
1-112"	SCH 80	5.0	5.0	4.5	5.0	4.5	4.0	6.0	5.45	5.0	6.60	1-112"
2"	SCH 80	6.0	5.0	4.5	5.5	5.0	4.0	6.5	7.53	6.0	9.45	2"
2-112"	SCH 80	6.5	6.0	5.5	6.0	6.0	5.0	7.5	11.49	6.5	14.25	2-1/2"
3"	SCH 80	7.5	6.5	6.0	6.5	6.5	6.0	8.0	15.37	7.0	19.66	3"
4"	SCH 80	8.0	8.0	7.0	7.5	7.5	6.5	9.0	22.47	8.0	29.94	4"
6"	SCH 80	10.5	10.0	9.0	9.5	9.0	8.5	10.5	42.90	9.5	59.85	6"
8"	½" w	12.0	11.5	10.5	10.5	10.0	10.0	12.0	65.10	11.0	94.8	8"



## DESIGN PHILOSOPHY- PIPING

PNMP/PC288/E001/SEC-5.3.1

P

DOCUMENT NO

REV

SHEET 58 of 83




10"	½" w	13.5	13.0	12.0	11.5	11.5	10.5	14.0	82.20	12.0	130.69	10"
12"	½" w	14.5	13.5	13.0	12.5	12.0	11.5	15.0	98.13	13.0	168.64	12"
14"	½" w	15.0	14.5	13.5	13.0	12.5	12.0	16.0	108.15	13.5	194.4	14"
16"	½" w	16.0	15.5	15.0	13.5	13.0	13.0	17.0	124.2	14.0	240.0	16"
18"	½" w	17.5	17.0	16.0	14.5	14.0	13.5	18.0	140.25	14.5	286.64	18"
20"	½" w	18.0	17.5	17.0	15.0	14.5	14.0	19.0	157.5	15.0	341.8	20"
24"	½" w	20.0	19.0	18.5	16.0	15.0	15.0	21.0	188.25	16.0	458.44	24"
1"	10S	4.0	3.5	3.0	4.0	3.0	2.5	4.5	2.08	4.0	2.7	1"
1-112"	10S	5.0	4.5	3.5	4.5	4.0	3.0	5.5	3.12	5.0	4.57	1-112"
2"	10S	5.0	4.5	3.5	4.5	4.0	3.0	6.0	3.94	5.5	6.33	2"
2-112"	10S	6.5	5.5	4.5	5.5	5.0	4.5	7.0	5.26	6.0	8.85	2-1/2"
3"	10S	7.0	6.0	5.0	6.0	5.5	5.0	7.5	6.45	6.0	11.91	3"
4"	10S	7.5	7.0	6.0	6.0	6.0	6.0	8.0	8.34	7.0	17.87	4"
6"	10S	9.5	9.0	8.0	8.0	7.5	7.5	10.0	13.82	8.5	34.54	6"
8"	10S	11.0	10.5	10.0	9.5	9.5	8.5	11.5	19.94	10.0	55.5	8"
10"	10S	12.5	12.0	11.0	10.5	10.0	9.5	13.0	27.53	11.0	83.4	10"
12"	10S	14.0	13.0	12.0	11.0	11.0	10.0	14.5	36.00	11.5	114.6	12"
14"	10S	14.5	14.0	13.0	11.5	11.0	11.0	15.5	41.18	11.5	132.6	14"
16"	10S	16.5	14.5	14.0	12.0	11.5	11.5	16.5	47.33	12.5	172.2	16"
18"	10S	16.5	15.5	14.5	12.5	12.5	11.5	17.5	53.18	13.0	212.1	18"
20"	10S	17.5	16.5	15.5	13.0	13.0	12.0	18.5	68.50	13.0	264.5	20"
24"	10S	19.0	18.0	17.0	14.0	13.5	12.5	20.5	94.37	14.0	376.8	24"

<div><div>पी डी आई एल PDIL</div></div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div><div>बी एच ई लिमिटेड BHEL</div></div>
		DOCUMENT NO	REV	
		SHEET 59 of 83		

## **ANNEXURE – 2**

### **ACCESSIBILITY FOR VALVES AND INSTRUMENTS**


VALVES, INSTRUMENTS, EQUIPMENT TO BE OPERATED	CENTRELINE OF ITEM TO BE OPERATED, LOCATED LESS THAN 3.6m ABOVE GRADE, 2.75 m ABOVE FLOOR OR PLATFORM OR 1.8m ABOVE WING PLATFORM	CENTRELINE OF ITEM TO BE OPERATED, LOCATED MORE THAN 3.6m ABOVE GRADE, 2.75m ABOVE FLOOR OR PLATFORM OR 1.8m ABOVE WING PLATFORM
EXCHANGER HEADS	NIL	PLATFORM
OPER.VALVES 2" & SMALLER	FIXED LADDER	FIXED LADDER
OPER. VALVES 3" & ABOVE	PLATFORM	PLATFORM
MOTOR OPERATED VALVES	PLATFORM	PLATFORM
CONTROL VALVES	PLATFORM	PLATFORM
RELIEF VALVES 2" & SMALLER	FIXED LADDER	FIXED LADDER
RELIEF VALVES 3" & ABOVE	PLATFORM	PLATFORM
BLOCK VALVES 2" & SMALLER	PORTABLE LADDER	PLATFORM
BLOCK VALVES 3" & ABOVE	PLATFORM (NOTE-1)	PLATFORM (NOTE-1 )
BATTERY LIMIT VALVES	PLATFORM	PLATFORM
PRESSURE INSTRUMENT	FIXED LADDER IF ABOVE 2.2m HEIGHT	FIXED LADDER
TEMPERATURE INSTRUMENT	FIXED LADDER IF ABOVE 2.2 M Ht	FIXED LADDER
SAMPLE POINTS	PLATFORM	PLATFORM
GAUGE GLASSES	FIXED LADDER	FIXED LADDER
LEVEL CONTROLLERS	PLATFORM	PLATFORM
PROCESS BLINDS AND SPACERS 2" & SMALLER	PORTABLE LADDER / PLATFORM	PLATFORM
PROCESS BLINDS AND SPACERS 3" & ABOVE	PLATFORM	PLATFORM
MANWAYS/MANHOLES	PLATFORM	PLATFORM
HANDHOLES/INSPECTION HOLES	PLATFORM	PLATFORM
NOZZLES (process}	PLATFORM	PLATFORM

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 60 of 83		

VESSEL VENTS	PORTABLE LADDER	FIXED LADDER
LINE DRAINS & VENTS	PORTABLE LADDER	PORTABLE LADDER
ORIFICE FLANGES	PLATFORM (NOTE-1)	PLATFORM (NOTE-1)

NOTE-1: BLOCK VALVES / ORIFICE FLANGES, IF LOCATED, WITH CENTRE LINES GREATER THAN 2 METER FROM THE OPERATING FLOOR, OPERATING PLATFORM SHALL BE PROVIDED WITH PORTABLE PLATFORM OR CHAIN FOR OPERATION.

NOTE-2: PLATFORM SHALL BE PROVIDED FOR THE ORIFICE FLANGES ON PIPE RACK.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 61 of 83		

### MAXIMUM SPACING OF GUIDES FOR VERTICAL & HORIZONTAL PIPES

NOM PIPE SIZE IN INCHES	VERTICALSPACING METRES	HORIZONTAL SPACING METRES
1	6.0	6.0
1 ½	6.0	6.0
2	6.0	6.0
3	8.0	12.0
4	8.0	12.0
6	8.0	12.0
8	8.0	12.0
10	12.0	18.0
12	12.0	18.0
14	12.0	18.0
16	12.0	18.0
18	12.0	18.0
20	16.0	18.0
24	16.0	18.0
26 & ABOVE	16.0	18.0

#### NOTES:-

- These spacings may be varied to suit column spacing of rack. The above spacing is for straight runs of pipe & does not include guides which are used for control of thermal movements, as decided by stress group.
- The guide spacings given in the above table are indicative only.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 62 of 83		

## **ANNEXURE – 4**

### **CLEARANCES**

Minimum clearances for piping, equipment, structures, platforms, and supports shall be in accordance with the following table:

Item	Description	
Roads	Headroom for primary access roads wherever heavy duty crane movement is required.	9 M
	Headroom for primary access roads	7.5 M
	Width of primary access roads excluding shoulders.	Refer Civil
	Headroom for secondary roads	5 M
	Width of secondary roads excluding shoulders.	Refer Civil
	Clearance from edge of road shoulders to platforms, equipment, pipe associated with equipment, or similar features.	1.5 M**
Maintenance Aisles at Grade	Horizontal clearances for equipment maintenance by hydraulic crane (12t capacity)	3 M
	Vertical clearance for equipment maintenance by hydraulic crane (12t capacity)	3.6 M
	Horizontal clearance for fork lift and similar equipment (2500 kgs capacity)	2.4 M
	Vertical clearance for fork lift and similar equipment (2500 kgs capacity)	2.4 M
	Horizontal clearances for equipment maintenance by portable manual equipment (A-frames, hand trucks, dollies or similar equipment)	1 M
	Vertical clearances for equipment maintenance by portable manual equipment (A-frames, hand trucks, dollies or similar equipment)	2.4 M
Walkways	Horizontal clearance (not necessarily in a straight line)	750 mm
	Headroom (except for hand wheels)	2.2 M
Platforms	Minimum width	1200mm
	Headroom from stairwell treads.	2.2 M
	Minimum clearance around any obstruction on the platform.	500 mm
	Headroom	2.2 M
	Maximum vertical distance between platforms	6 M
	Minimum toe clearance behind a ladder.	210 mm

<div> पी डी आई एल <b>PDIL</b></div>	<b>DESIGN PHILOSOPHY- PIPING</b>	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 63 of 83		

Item	Description	
	Minimum handrail clearance.	100 mm
Equipment	Minimum maintenance space required between flanges of exchangers or other equipment arranged in pairs.	500 mm
	Minimum maintenance space required for structural members or pipe.	300 mm
	Clearance from edge of road shoulder (the extreme projection)	1.5 M
Fired Equipment	Horizontal clearance from hydrocarbon equipment (shell to shell)	15 M
	Exception: Reactors or equipment in alloy systems shall be located for the most economical piping arrangement.	
	Clearance from edge of road to heater shell.	3 M
Valve Hand wheels	Clearance between the outside of the hand wheel and any obstruction.	25 mm*
Pipe (aboveground)	Clearance between the outside diameter of the flange and the outside diameter of pipe insulation.	25 mm*
	Clearance between the outside diameter of the pipe, flange or insulation and a structural member.	50 mm*
	Clearance between the outside diameter of the flange and the outside diameter of bare pipe.	25 mm*
	Minimum distance from underside of pipe to grade or platform.	300 mm
Control Valve Arrangement	Centreline of control valve above grade or platform.	450 mm
	Minimum centreline of control valve from face of column or wall.	600 mm
	Where process conditions require steam or hydrocarbon vapours to be discharged to atmosphere at a safe location, the tail pipe shall terminate as below:	
	Distance above nearest operating platform.	3 M
	Within radius of nearest operating platform.	7.5 M

\*\* Verify conformance with local regulations.

\* With full consideration of thermal movements

## ANNEXURE-5

	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	
		DOCUMENT NO	REV	
		SHEET 64 of 83		

### JOB SPECIFIC REQUIREMENTS

SI No	ITEM	Job Requirement	Remarks
1	Equipment spacing (ISBL)	As per Piping Design basis.	
2	Minimum pipe rack width 4m/ 6m/8m/10m/12m in single bay	10 M for Main Rack 4M/ 6M/ 8M for Sub Racks.	
3	Spare capacity on Rack	Provision of 20% on each tier for future modifications.	
4	Cooling Water Lines	Generally on rack up to 16" Underground above 16"(in specific cases, lower sizes may also go Underground depending on layout)	
5	Minimum height of sleeper due to maintenance requirement	300 mm for pavement area 500 mm for unpaved area	
6	Fin-fan cooler location	On pipe rack and/or technological structure access to be provided	As per Equipment Layout.
7	Location of pumps: In units	- Inside pipe rack as far as possible with concrete slab below Air cooler. - For, smaller width (4M, 6M & 8M) rack, pumps shall be outside or on one side of rack portal.	Refer cl. 5.2.11.2
8	Requirements of monorail on Pumps: under pipe rack/shed- Open area-	Required for motor rating 45 KW and above for all pumps. None	
9	Requirement for exchanger bundle removal a) Hydro extractor  b) Monorail & chain pulley block	Monorail & chain pulley block required at Technical Structures.  Where Hydro extractor mobility is difficult in running plant.	However, required head Room for installing monorail shall also be kept in Technical Structures.
10	Battery limit valves operation a) At grade. b) At elevated Platform.	Elevated platform provided at Battery limit.	
11	Pipe way road crossing	Overhead pipe bridges	At B/L with access.



<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 65 of 83		

12	Electrical cable routing underground   Above ground: - ISBL - OSBL	Refer Electrical Design Basis.	
13	Any requirement of statutory approval.	All statutory requirements e.g. IBR/PCB/CCE and others	
14	Instrument cable routing ISBL & OSBL	Refer Instrumentation Design Basis.	
15	Safety shower / eye wash. (in case of chemical/catalyst handling system)	Required. As Per PID	
16	Requirement of elevators.	Yes.	
17	Connectivity of all platforms at higher elevations for tall columns (ie. between columns & technological structure and between columns & rack).	Yes.	Adjacent columns/ technological Structures/ rack must be connected at minimum two locations.
18	Compressor/blower house for ISBL as well as OSBL a) location b) Maintenance requirement	a) Under Shed b) E.O.T.	With additional auxiliary hook for light wt handling maintain ace platt shall be provided across full width with cat ladder at each end
19	Instrument Air Drier Shed	Yes	
20	Insulation material a) Hot /Tracing/safety b) Electrical tracing c) Cold	As per process design basis.	
21	Painting System	Refer Std Specification (Civil)	
22	Method of surface preparation a) Mechanical tools b) Blast cleaning	Blast Cleaning	
23	Sand blasting/Grit blasting	Grit Blasting	
24	Painting of SS pipes below insulation	****As Per Specification	Wherever painting is not specified, Aluminum/ SS foil as per piping design basis shall be used.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 66 of 83		

25	Specific colour coding requirements.	Client agreed	
26	Usage of IS grade material.	No	
27	Usage of asbestos gasket.	No	
28	Provision for high settlement in tank farm: a) Usage of dresser coupling in tank farms. b) Flexibility of piping.	Flexibility of Piping.	
29	Steam tracing type	Standard module for steam distribution and condensate collection manifolds with integral glandless piston valve & trap and carbon steel tracer pipe.	
30	Bulk Material	Client agreed vendor list.	
31	Engineering Drawing Mode	Electronic & Hard Copies also required	
32	Specific software package for engineering drawings -AutoCAD and AP-ISO -PDS/SP 3D with Isogen -Auto Plant Designer with Isogen or AP-ISO -PDMS with Isogen -AutoCAD	3-D Models, capable of model review and walk through.	
33	Material Control System		
34	Item Coding system		
35	Stress Analysis Package	CEASER II (Latest Version)	
36	Access to Nozzles of columns	Platforms for all Nozzles.	
37	Staircase / Ladders for tall column/reactors.	Ladders for columns/staircases for reactors	
38	Provision of breakup flanges for removal of tube bundles of heat exchangers.	Wherever necessary.	

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 67 of 83		

39	Height of pipe support pedestals	150 mm from FGL	
40	Mandatory Bulk Material Escalation	As per mandatory spares.	
41	Cathodic Protection of Tankage and U/G Piping	Required (Refer Electrical Design Basis)	
42	Cast iron valves	Cast Iron Valves not to be used.	
43	Pump Suction strainers	As per Cl. 5.3.6.6 & 5.3.6.7	However, licensor's requirements, if any, may be considered with approval from owner / PMC.
44	Two phase flow line analysis	Both static and dynamic analysis required.	
45	Connectivity of the technological structure	Technological structure to be Interconnected.	
46	Usage of check valves.	Wafer dual plate and swing check valves	Unless specifically required by process
47	Traps on steam lines.	Thermodynamic for line traps and Thermostatic for steam	
49	Valves for specific services	As per process drawings / documents, as applicable	

NOTE:- THE JOB SPECIFIC REQUIREMENTS GIVEN ABOVE SHALL BE CONSIDERED FINAL IN CASE OF ANY CONFLICT WITH THE MAIN BODY OF DESIGN BASIS.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> BHEL</div>
		DOCUMENT NO	REV	
		SHEET 68 of 83		

## ANNEXURE – 6

### DESIGN PHILOSOPHY FOR STRESS ANALYSIS

#### 1.0 PURPOSE

This design basis deals with the subject of Identification of Stress Critical pipelines and preparation of Critical line list. This procedure also defines the minimum requirements for performing stress analysis, design and location of spring, support and level of system analysis with the extent of documentation required for flexibility analysis.

Purpose of piping stress analysis is to ensure:

Safety of piping and piping components

Safety of connected equipment and supporting structure

Piping deflections are within the limits

#### 2.0 SCOPE

This specification covers the supply of engineering services to perform a complete piping and pipe support analysis for piping systems.

#### 3.0 DEFINITIONS

##### 3.1 CRITICAL LINES / CRITICAL LINE LIST

Critical lines or Critical Line List as referred to in this procedure relates to Piping Stress Critical Lines and does not include or refer to process critical lines.

##### 3.2 STRESS ANALYSIS TEMPERATURE

Stress Analysis Temperature refers to either “Maximum Operating Temperature” or “Steam-out temperature / hot nitrogen purging temperature” of the lines under review whichever is higher. In absence of the above values, it refers to the Design Temperature of the line under review. The Line List should be strictly followed in obtaining the above temperature values.

##### 3.3 DESIGN PRESSURE

Design Pressure refers to the “Design Pressure” of the line under review as indicated on the Line List. Design Pressure is as defined in clause 301.2 of ASME B31.3.

##### 3.4 TEMPERATURE FOR FLEXIBILITY ANALYSIS

The temperature to be used for the flexibility analysis shall be taken as the maximum / minimum temperature which the pipe will see under any combination of different normal / abnormal operating conditions, as defined in clause 301.3 of ASME B 31.3. Where piping is exposed to direct sunlight, solar radiation temperature of 70 0 C is considered in establishing the maximum temperature of piping. Even, for non-critical piping exposed to direct sunlight on pipe rack or elsewhere, expansion loops, wherever essential, are provided to take care of pipe movements resulting from piping skin temperature due to solar radiation.

In general, unless there is a difference of more than 50 0 C between working Temperature and the design temperature, the design temperature should be taken as Flexibility temperature. Ambient Temperature shall be considered as 21°C the assumed piping installation temperature. The displacement stress range from this installation temperature to the minimum recorded

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> भारतीय वोल्टीज एल BHEL</div>
		DOCUMENT NO	REV	
		SHEET 69 of 83		

ambient temperature of 00 C being less than the same from installation temperature to the maximum operating temperature of hot piping in most cases, the later governs as per clause 319.2.3 of ASME B 31.3

The temperature under fire condition is normally not considered for flexibility analysis.

#### 4.0 **SELECTION**

A line is selected and listed as a Critical Line provided it falls under any one of the categories defined below and is intended to include the special requirements of Piping Stress Engineer. It is hence defined as any line for which a flexibility review is required or where pipe supporting is deemed to be critical and needs review by a Stress Engineer. Line DN 50 and smaller is inherently flexible and is not normally considered critical unless built from non-metallic or non-ferrous materials. In case of more than one applicable line size, larger line size governs. Lines are classified as Level I, Level II & Level III according to the criteria listed below.

##### 4.1 Level I [EXTENSIVE ANALYSIS]

Piping systems or lines that meet Annexure-7A criteria are deemed to be extremely critical. These lines are categorized as Level I and require careful study to ensure that the code compliance is met and the accurate determination of nozzle and support loads have been made. The routing of these lines is very important. They must be analyzed in the early stages of the project during routing studies so that the impact on the location of less critical lines is minimized. Normally, these systems require computer analysis. The general intent of the Level I analysis criteria is to study lines size DN 80 & larger that are affected by thermal expansion and / or a dynamic response, and that can't be evaluated by a weight-only analysis (as per the general intent of Level II analysis). Consideration has to be given to other special situations that augment the Level I general intent guidelines such as for lines that are excessively large and stiff.

##### 4.2 Level II [NORMAL ANALYSIS]

Piping systems or lines that meet Annexure-7B criteria are moderately critical lines and often do not require such rigorous study to ensure code compliance or accurate determination of nozzle and support loads. These lines are smaller in size and operate at lower temperatures (in general) than the lines to be analyzed using Level I Criteria. Normally, only manual calculations, by use of appropriate monographs are required for analysis of these systems.

##### 4.3 Level III [MINIMUM ANALYSIS]

All lines that are outside the purview of Level I or Level II criteria will be classified as level III and shall be reviewed by the Piping Engineer during the squad check of the piping drawings and or fabrication Iso's. If more detailed analysis is required, the Piping Engineer may change the level of analysis during the squad check as applicable. Normally, only visual analysis is required for these systems.

##### 4.4 LINES DEEMED TO BE SUPPORT CRITICAL

Lines subjected to two-phase flow.

Cross country pipelines.

Lines with pipe thickness Sch 160 or greater.

Lines DN 400 and above with pipe thickness less than 8 mm.

Lines DN 250 and above with corrosion allowance 3 mm and above.

Lines with high concentrated loads such as heavy valves or fittings etc.

Lines downstream of Relief Valve / letdown Control Valves / bursting (rupture) discs.

Connecting to vent or flare systems or discharging to atmosphere

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 70 of 83		

Liquid Blow down Lines.

Lined pipes

Non-metallic pipes

#### 4.5 LINES NEEDING DYNAMIC ANALYSIS

There are instances where in the frequency of the applied load is comparable to the natural frequency of the piping system. Such systems tend to store the energy and release it according to certain scientific laws. Such a system is dynamic in nature and the study of the response of such a system is referred to as "Dynamic Analysis". Examples of such kind of systems are Relief Valve discharge lines, water hammer and surge in pipe lines, two phase flow in pipelines, reciprocating pumps and compressor piping, submarine piping etc.

#### 4.6 SPECIAL PIPING

Special piping forming part of heater internal piping, etc. are treated as proprietary piping and nozzle loading at the Interface connections are to be co-ordinated with vendor.

#### 5.0 RELATED DOCUMENTATION

##### 5.1 CRITICAL LINE LIST FORMAT

The critical line list shall be prepared from the project line list document by inserting following relevant fields such as Stress level, stress package no., stress analysis temperature, support critical nature of the line, dynamic loadings, steam out / purge temperature etc.

The list shall reflect analysis status of line that includes its input received date from design & output handover date to design and specific remark if any.

##### 5.2 LINES AFFECTING THE FLEXIBILITY OF CRITICAL LINES

Non-critical Lines found to affect the flexibility of critical lines which have not been included during the initial review are subsequently added to the Critical Line List.

Non-critical Lines on which advice may be sought by the Lead Piping Engineer are not normally entered into the Critical Line List but covered verbally, or by a memorandum if a record is required.

#### 6.0 PIPE STRESS ANALYSIS AND SUPPORTING

##### 6.1 Piping system shall be properly supported taking in to account of the following points:

Piping stress analysis shall follow ASME B 31.3 and shall be complete to prevent overstressing of the pipe during operating conditions with wind and seismic loadings. During sustained, occasional (wind and seismic) & thermal expansion loading on piping, the material allowable stresses shall be as per ASME B 31.3 for ASTM materials. For DIN material specifications the allowable stress values shall be calculated as per ASME B 31.3 clause 302.3.2(d), wherein yield strength and ultimate strength values at temperature shall be taken from DIN material standards. For DIN material specifications, the other material properties viz. elastic modulus, density, coefficient of thermal expansion shall be taken from the respective DIN material standards.

##### 6.2 Analysis shall include, but not be limited to the following; thermal, dead weight, internal pressure, wind and seismic, and a combination of these based on ASME B 31.3.

##### 6.3 Piping shall be designed in accordance with the Indian Standard criteria for earthquake resistance design for structures IS: 1893 for seismic zone-IV (refer project design basis). As a minimum, two (2) orthogonal horizontal components and a vertical component of ground motion will be considered in the seismic analysis. For American standard, loading applied to piping would be in accordance with uniform building code (UBC).

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> BHEL</div>
		DOCUMENT NO	REV	
		SHEET 71 of 83		

The equivalent horizontal static force method shall apply in general .The contractor shall also carry out special designs and provisions as necessary for piping which is considered to be dynamically sensitive to earthquake.

Seismic analysis to be performed for lines equal to and above 12". Seismic load case shall ALGEBRIC combination with operating cases.

Heavy rigid masses like valves shall be restrained in their vicinity to avoid large seismic movements. Guides or snubbers as the case may be used for this purpose.

Horizontal seismic coefficient (Ah) to be considered as 0.26 and Vertical (Av) to be considered as 0.173.

- 6.4 Wind loads shall be calculated in accordance with IS-875 code of practice for structural safety of building – Loading Standards for Indian code requirement using basic wind speed as mentioned in project design basis. For American standard, wind load in accordance to ASCE 07 shall be calculated. Reduction in velocity pressure due to apparent shielding afforded by buildings and structure or terrain shall not be permitted.

Wind loading shall only be considered for lines larger than 20" OD at elevation higher than 10m above grade. Displacements due to wind and earthquake should be limited to 50 mm.

Both the horizontal directions shall be analyzed independently in two cases

+X, -X, +Z, -Z

Wind and seismic loading will not occur simultaneously.

Analysis of all nozzles loading on vessels within the piping boundaries is covered in this specification. Nozzle analysis shall follow the guidelines of ASME Section VIII, Division 1, and WRC 297 & 107 (latest editions). Nozzle stresses shall fall within the allowable per ASME.

6.6 Piping system shall have sufficient flexibility to avoid leakage at joints. Flanged joints imposed by external moments may be analyzed and the stresses evaluated by using the methods of equivalent pressure given in the ASME boiler and pressure code section III. Flange leakage shall be assessed as per "Pressure Equivalent Method". In case of Failure in Pressure Equivalent Method, the Flanges shall be checked for leakage using Caesar Flange leakage Module. Flange leakage shall be assessed for all PSV flanges, Control valve flanges, High Pressure lines, and all steam lines. Also for equipment flanges where loads are high.

- 6.7 All forces on connections to equipment shall not exceed maximum allowable as specified by equipment vendor.

- 6.8 Pipe supports loads shall be based on the maximum loads determined by the piping analysis. Adjustments shall be made to the piping system and model such that the pipe supports loads are within a reasonable uniformity throughout the piping system.



<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> BHEL</div>
		DOCUMENT NO	REV	
		SHEET 72 of 83		

6.9 Bidder to specify load cases of flexibility analysis as per job specific requirement for Owner / PMC approval.

## 7.0 CODES AND STANDARDS

The following codes and standards shall apply in the design and analysis of the piping systems covered under this specification:

Allowable Stress: ASME B 31.3  
Piping: ASME B 31.3  
Nozzle Loadings: PMC's Standard, WRC297/107(Welding Research Council)/  
Allowable Vendor  
Wind Analysis: ASCE-07 and/or IS 875  
IBR piping system: ASME B31.1 & IBR

## 8.0 SOFTWARE USED

The package used shall be latest version of CEASER-II.

## 9.0 DOCUMENT REQUIREMENT

9.1 A written report shall be submitted on the piping and equipment analysis. The report shall include all pertinent information that shall include but not be limited to the following:

Location and type of pipe supports with loads and movements

Location of expansion joints and movements

Vertical and horizontal loads including moments at all support points.

Vertical and horizontal loads including moments on all equipment and Vessel connections.

Caesar II analysis report, which shall include as a minimum, restraint forces, movements and stresses for all load cases. For flange connection, loaded with high bending moments and/or tensile forces in piping or at equipment connections, Caesar II flange leakage report will be provided. For piping analyzed, if subjected to hydro test, hydro test load case will be made in Caesar II to check for loading under hydro test & the requirement of any additional temporary supports for hydro test.

Detailed nodal model used for the stress analysis

All assumptions and limitations applied to the analysis

9.2 All dimensions and analysis shall be performed using metric and SI units.

9.3 The final report / stress package folder shall be submitted as follows:

1. Front sheet with Approval status
2. Isometrics with following information

Node numbers

Type of supports selected by stress engineer

Springs / Bellows data required for procurement like spring rate, loads, tide/untied information and SM (special material) identification.



<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> BHEL</div>
		DOCUMENT NO	REV	
		SHEET 73 of 83		

Maximum Expansion and sustain stress values with node number

Nozzle/Anchors initial movements and piping imposed forces and moments on the same

Support loads (anchors, guides or rest) only they are above limit (The limit is defined in the beginning of the project in consultation with civil)

Design and maximum operating conditions

Coordinate axis system considered for inputs

Dimensional details for piping designer to locate supports in piping model/layout.

3. Checklist as per Work instructions

4. Following outputs

Load Cases

Restraint summary

Spring hanger report, if any

- 5 Stress critical line list extract for the lines analysed
- 6 Piping material specifications
- 7 Equipment drawings with allowable loads, if available
- 8 PID

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> BHEL</div>
		DOCUMENT NO	REV	
		SHEET 74 of 83		

### CRITERIA FOR IDENTIFYING EXTREMELY CRITICAL LINES (LEVEL I)

Temperature T, Degree C	Pipe Diameter DN (mm)	Piping Material	Service and Description
All	All	All	Piping which will undergo hydraulic shock, auto-ignition or is in service.
All	DN≥80	All	Category M (Lethal) fluid service per ASME B31.3 (No cyclic service).
All	DN≥80	All	Piping which is openly exposed to winds > 75 mph.
T<-29	DN≥80	Carbon Steel	All Services.
T<-45	DN≥80	All	All Services
T≥65	DN≥80	Non-Metallic	All Services
T≥65	DN≥80	All	Lines with pressure ≥ 900 psig.
T≥150	DN≥80	All	All Services
ALL	DN≥400	All	All Services.
T≥260	ALL	ALL	ALL Services.
-29≥T≥65 OR -7≥T≥50	DN≥80 DN≥100	All	Piping connected to nozzle load sensitive equipment, air-cooled exchangers and rotating equipment (see note 1).
ALL	ALL	All	Lines requiring expansion joints or flexible connectors.
DELTA T≥27 (NOTE 2)	DN≥80	All	Jacketed piping.
-29≥T≥65	DN≥100	All	Internally lined pipe (except glass).
All	ALL	All	Glass lined piping.
All	DN≥80	All	Differential Tank Settlement (Upto 3 supports from nozzle).
-40≥T≥80 -29≥T≥70	DN≥100 DN≥200	Metallic Metallic	Underground Piping

#### NOTES:

Load sensitive equipment include fired heaters, lined vessels with lining of brittle material, non-ferrous equipments, graphite heat exchangers, plate & frame heat exchangers, etc.

This criterion is not to be applied to auxiliary piping such as seal flush; bearing cooling, etc. delta T refers to the differential temperature between the process piping and jacket.

#### ANNEXURE-6-B

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 75 of 83		

### CRITERIA FOR IDENTIFYING MODERATELY CRITICAL LINES (LEVEL II)

Temperature T, Degree C	Pipe Diameter DN (mm)	Piping Material	Service and Description
All	DN<80	All	Lethal fluid service.
T<-29	DN<80	Carbon Steel	All Services.
T<-46	DN<80	All	All Services
95<T<150	80<DN<200	All	All Services
T≥65	DN<80	Non-Metallic	All Services
T≥65	DN<80	All	All Services
T≥65	DN<80	All	Lines with pressure≥900 psig.
T≥150	DN<80	All	All Services
ALL	200<DN<400	All	All Services.
T≥260	ALL	ALL	ALL Services.
ALL	ALL	ALL	Piping connected to nozzle load sensitive equipment, air-cooled exchangers and rotating equipment (see note 1 of Table-1).
DELTA≥27(NOTE 2 of Table-1)	DN<80	All	Jacketed piping.
All	ALL	All	Internally lined pipe (except glass).
All	DN<80	All	Differential Tank Settlement (Upto 3 supports from nozzle).
All	ALL	All	Underground Piping
All	ALL	All	Piping connected to pressure relief valves
All	ALL	All	Close coupled interconnecting piping between equipment with differential movement greater than 6.0mm.

### ANNEXURE-7

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> BHEL</div>
		DOCUMENT NO	REV	
		SHEET 76 of 83		

## DESIGN PHILOSOPHY FOR 3-D MODELLING

### 1.0 INTRODUCTION

The LSTK Contractor shall carry out Detailed Engineering of the plant areas specified in the scope elsewhere using 3D intelligent software.

### 2.0 SOFTWARE

Anyone of the following two software with Oracle database shall be used by the LSTK Contractor.

- i) PDS/SP3D by Intergraph USA on Windows with design review through dynamic walkthrough.
- ii) PDMS by AVEVA UK on Windows with design review through dynamic walkthrough.

Isometrics shall be generated using ISOGEN Software. Latest version of all the software released as on the date of ITB shall be used by the Contractor. The LSTK Contractor shall clearly specify in his bid the software to be used with version number.

### 3.0 OBJECTIVE

The objective of 3D modelling is to carry out detail engineering and produce deliverables using 3D tools and conduct reviews for obtaining approvals from Owner/PMC. 3D model shall be developed and demonstrated with dynamic walk through facility to check any interference requirements of operation and maintenance for getting the approval of the Owner. LSTK contractor shall deliver to Owner/PMC a complete 3D model which shall be utilised for all future maintenance, operation, revamping and any de-bottlenecking of the plant. The 3D Design Reviews through dynamic walkthrough, through LCD projector system shall assist the Owner's operation and maintenance personnel in reviewing the project prior to construction and suggest modifications for efficient operation of the plant. Owner/PMC/ shall use it for review of design.

### 4.0 DEFINITIONS

#### 4.1 EXACT GEOMETRY

The geometry of the object should be exactly as shown in vendor drawings or as per standard drawings as given in codes e.g. Pipes, Flanges, Valves, beams, etc. the geometry of the items to be modelled should be such that it serves the purpose of clash checking as well as identification of object in 3D.

#### 4.2 NEAR EXACT GEOMETRY

SPECIAL items like bellows, traps, etc does not call for exact geometry. The provision should be made for clash checking and 3D representation of the item. A box. instead of bellows, traps, etc is not acceptable.

#### 4.3 APPROXIMATE GEOMETRY

Items like transmitters, floor stand mounted instruments where boxes instead of exact shape can be shown. The nomenclature of such items should be clearly distinguishable for easy identification.

### 5.0 EXTENT OF MODELLING / SCOPE OF WORK

#### 5.1 PIPING

- 5.1.1 All design within Unit, Facility battery limit above ground and underground piping inclusive of fire fighting lines and sprinkler system, big bore and small bore, except tubing, for all piping materials shall be modelled. Details shall include all pipes, valves, flanges, fittings, reducers, spectacle blinds, drains, temperature/pressure connections, sample points, drip legs jacketed pipes, fittings and flanges etc. Existing lines inside the battery limit (If any) along with tie-in points shall also be modelled.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div> भारतीय वोल्टीज एल BHEL</div>
		DOCUMENT NO	REV	
		SHEET 77 of 83		

- 5.1.2 All in line instruments like control valves, safety valves, rotameters, orifice plate etc. with near exact geometry.
- 5.1.3 All piping special items like expansion bellows, slide valves, special valves with purge points, steam traps, strainers etc. with near exact geometry.
- 5.1.4 Complete vessel trims with level gauges, level switches, level transmitters, equipment, instrument, vent/drains utility connections, pressure gauges etc. with exact geometry.
- 5.1.5 Steam supply and condensate recovery stations up to the first valves in tracer lines
- 5.1.6 All pipe supports to be Physical modelled for all sizes with secondary steel sleeper way as follows.
- All spring hangers, roller supports to be modelled with all details.
  - Pipe supports along with concrete pedestals, Type of support
  - Details of the spring hanger's i.e. operating load, travel, spring constant should be keyed in as user-defined attributes.
  - Details of expansion bellows i.e. type, axial/lateral deflections, stiffness etc to be keyed in as user defined attributes.
  - Structural steel members used for the pipe supports to be modelled in complete details.
- 5.1.7 All equipment to be modelled with exact geometry including but not limited to: manholes with davits, pipe davits on top platforms, nozzles, stiffener rings, bellows, break flanges, platforms, ladders, handrails, lifting lugs, etc. for all the equipment in the plant like vessels, columns, reactor, receivers, pumps with motors, compressors with details of volume bottles, cylinders etc., blowers, centrifugal compressors, furnaces with soot blowers, fired heaters, burners and peep holes, air coolers with motors and fans, filters, blow down drums, all equipment within packages and heat exchangers etc.
- Maintenance areas around equipment, davit swing areas, swing elbows sweep areas, tube bundle removal areas for heat exchangers, rotor removal areas, drop out areas to be modelled as soft envelopes and should be used for clash detections.
  - Equipment supports: skirts, support legs/lugs, saddles to be modelled along with the equipment
  - Insulation type (hot, cold, tracing, jacketed, etc), Insulation thickness, operating/design Pressure /temperature, hydro test medium/pressure to be given.
  - Equipment 3D model shall include all attachments like platforms, nozzles, ladders, pipe supports, etc.
- 5.1.8 Skid mounted Equipment / Package units (if applicable) shall be modelled as a Block and Piping connections at Skid/Package unit battery limit to be precisely modelled depicting complete connectivity.
- Skid to be tagged as main equipment.
  - All sub-equipment of all skids to have skid tag as a prefix.
  - All sub-equipment to be modelled with exact geometry.
  - Complete internal Piping of the skid with all inline and online instruments to be modelled as per the details in 5.1.1 to 5.1.7
  - All pipe supports with the skids are to be modelled as per para 5.1.7
- 5.1.9 Tagging of all line nos., Instrument nos., special items, equipment nos. shall be as marked in the P&IDs.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 78 of 83		

5.1.10 Complete underground piping man hole vent piping to atmosphere. catch pits, cable trays etc. to be modelled. Envelopes to be modelled on top of manholes and catch pits and shall be used for interference detection.

5.1.11 Material handling equipment e.g. drums etc to be modelled in near exact geometry.

5.1.12 Hard stands, fabrication space for tall columns, erection access for tall structures considering crane boom and movement, crane access, unit approaches from main roads, main roads outside the units shall also be modelled.

5.1.13 Line information required in 3-D model;

The following attributes must be keyed in while modelling:

- a) Line operating/design, temperature/pressure in deg. C and kg/cm<sup>2</sup>g respectively
- b) Liquid state i.e. vapour, liquid, 2-phase.
- c) Insulation thickness and type i.e. IH/IC/IJ/IC etc.
- d) Hydro test pressure in kg/cm<sup>2</sup>g and medium.
- g) Line number label should be as per the P&ID with the following attributes: Line size + unit no + line sequence no + sub-line no + piping material specification + insulation type. User Defined Attributes (UDA's) to be generated for keying in this information in PDMS.
- h) Hydro test loop no.
- i) Piping stress analysis system number allocated at the time of generation of critical line list for stress analysis (through UDA's in PDMS)

5.1.14 Incorporation of site changes during fabrication and erection with 3D Model in order to deliver a complete as built model to Owner.

5.1.15 General Arrangement Drawing Extraction

- a) Piping General Arrangement Drawings are to be extracted from the 3D model on AO size with a scale of 1 :33 / 1 :50 for rack Vital installations and battery limits shall be marked with coordinates.
- b) All locating dimensions like spacing for equipment, structural columns, pipe-to-pipe etc. shall be marked on the GAD's. Equipment tag numbers, line numbers, instrument and speciality item tag numbers shall be marked on the GAD's. Electrical instrument ducts shall be marked and labelled. Access ways, maintenance corridors, dropout areas, bundle removal areas catalyst-handling areas shall be marked on the GAD's.

5.1.16 ISOMETRIC EXTRACTION

Isometrics shall be extracted from 3D model using ISOGEN Software along with Bill of Material and logical pipe supports.

5.1.17 Interference Detection shall take care of Hard-Hard clashes and Hard-Soft clashes for all the disciplines.

5.2 STRUCTURAL

The scope of modelling for structural shall include but not limited to the following:

- i) Main steel/secondary steel equipment support beams, bracing, columns with footings, stiffener plates, platforms, ladders, pipe racks, stair cases, walkways, supporting structure for all coolers with operating platforms ,handrails and staircase, monorails, EOT support including fire proofing shall be modelled in exact geometry. Existing structures inside the working battery limit to be modelled.

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 79 of 83		

- ii) Equipment and structure foundations, technological buildings, equipment supporting structure, flue gas stack and any other concrete structure to be modelled in exact geometry with exact locations of all insert plates.
- iii) Foundation and structure for platforms, gratings, handrails etc. for packaged item and items are also included.

### 5.3 INSTRUMENTATION

- i) Instrument ducts, cable trays greater than or equal to 300 mm width, Instrument Junction boxes to be modelled in exact geometry.
- ii) Transmitters and other floor stand mounted instruments on grade/platform to be modelled in approximate geometry with tag nos. as per P&ID's.

### 5.4 ELECTRICAL

- i) Electrical cable trays greater than or equal to 300 mm width. Electrical cable trenches all sizes, junction boxes to be modelled in exact geometry.
- ii) Electrical stop/start switches for motors, to be modelled in approximate geometry.
- iii) Lighting details, earth pits.
- iv) Fire alarm system, e.g. fire detection point, hooters, etc.

### 6.0 MODEL SPLIT

#### 6.1 Separate models to be generated for each discipline.

Sl.No.	Discipline	Model Identifier	Sl.No.	Discipline	Model Identifier
1	Piping above ground	P	5	Structural	S
2	Piping underground	U	6	Architectural	A
3	Equipment	E	7	Electrical	L
4	HVAC	H	8	Instrumentation	I

#### 6.2 Within each discipline, models are to be generated based on the area division in piping key plan. The naming conventions for model in the PDS and Database in PDMS shall be as follows.

X	X	=	XX
Model identifier as given in 6.1	Model Identifier as Levels (given below)	Under score	Area number form Key Plan

A – Grade	B – First Level above grade
C – Second Level above grade	X – All levels in one model
U – Under ground	

- Above ground and underground piping shall always be in different models.

### 6.3 Database Hierarchy in PDMS

#### i) Piping

##### a) PIPE NAME:

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 80 of 83		

Line no. Label	--	P X	XX

b) Branch Name:

PIPE NAME / B1, B2

c) TAX NOS. For all Inline Instruments, Special Items as component Name in PDMS. Same tag numbering philosophy to be followed in PDS.

XXX	XXX	XXXX	X
UNIT No.	INST. Type i.e. PSV, FV, PV	INST. No. / special item no.	Only if same no. is getting repeated.

- Comments to be written in components S Text attribute.

ii) Other Disciplines

Basis shall be similar to that given for piping. LSTK Contractor shall develop the Hierarchy and submit it for Owner/PMC approval prior to start of modelling

## 7.0 DELIVERABLES

7.1 Complete 3D model as built along with as built GADs, Piping layout, Isometrics, IBR network drawings, and MTO reports, all extracted from the model, nozzle orientations for Piping and 3D models for all disciplines as specified in 7.1 to 7.6 with any other document generated from 3D model and naming conventions as per 7.0 to 7.3 with "As built" updates along with complete reference databases, component catalogues for all the size range in the approved specifications shall be furnished by the LSTK Contractor in electronic form.

In addition, contractor shall submit the 3D model in electronic form after completion of final review of 3D model duly updated as per comments/observations and agreed of MOMs of review sessions.

7.2 Review Models shall be installed at site having latest version of design review software and all other pre requisite software and any other software required for smooth running) and minimum configuration as stated in by the Contractor sufficiently at start of Mechanical work and & plotter at site shall be decided in consultation with Owner.

Model and Isogen will not be installed at site. Only review data will be available on review station

In addition, LSTK Contractor to Minimum Install;

- ▶ One number of A3/A4 duplex laser printer
- ▶ One number of A0 inkjet plotter

## 7.3 Reference Data Bases

### 7.3.1 P.D.S.

The complete reference Data base developed for the FACILITIES by the LSTK Contractor on PDS and delivered shall include but not limited to the following:

#### 7.3.1.1 Piping

1. Piping material class
2. Piping Commodity data files.
3. Short or Long material description library.
4. Specialty material description library.
5. Standard note library.



<div><div>पी डी आई एल PDIL</div></div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div><div>बि एच ई लिमिटेड BHEL</div></div>
		DOCUMENT NO	REV	
		SHEET 81 of 83		

6. Label description library.
7. Piping assembly library.
8. Graphic commodity library.
9. Physical data library.
10. Formats files for MTO
11. Isometric set-up (option) files.
12. Piping job specification library.
13. Write-up of all project specific code lists, which have been, added to the standard code lists.

#### 7.3.1.2 Other disciplines

Complete reference database with all the libraries. LSTK Contractor shall prepare a comprehensive list of these files separately for each discipline and submit it for PMC review prior to start of 3D modelling.

#### 7.3.2 PDMS

The complete material specifications and component catalogues developed by the LSTK Contractor on PDMS and delivered shall include but not limited to the following.

##### 7.3.2.1 Piping

1. Piping material specifications.
2. Insulation specifications
3. Bolt specification
4. Nozzle specifications
5. Complete Piping component catalogues with write-up on naming conventions used for CATALOGUE references, component references for Property Database. Bolt References for single and multiples.
6. Detail texts along with the symbol keys & R Texts
7. Material texts with X Texts
8. Any symbol key library developed for special items where Isometric Symbols by CAD Centre were not available.
9. Property database with nominal bore and outside diameter developed for the project.

##### 7.3.2.2 Other Disciplines

Complete reference database with all the libraries. LSTK Contractor shall prepare a comprehensive list of these files separately for each discipline and submit it for PMC review prior to start of 3D modelling.

7.4 During the period of construction the above workstations and software at site shall be manned and maintained by LSTK Contractor personnel up to the completion of the Project.

7.5 Costs for all the hardware, software, networking, model transfers, ISDN link etc shall be borne by the LSTK Contractor.

#### 7.6 Review by PMC/Owner/Licenser

LSTK Contractor shall be responsible for arranging 3D review sessions at his design center with Dynamic walkthrough with overhead projector system, for Owner/ PMC/ Licenser comprehensive

<div> पी डी आई एल PDIL</div>	DESIGN PHILOSOPHY- PIPING	PNMP/PC288/E001/SEC-5.3.1	P	<div></div>
		DOCUMENT NO	REV	
		SHEET 82 of 83		

review of the 3D Models. Simultaneously a Technical Audit of the Reference Database, Component Libraries and Project Database shall be carried out by PMC. LSTK

Contractor shall make one workstation available for the entire duration of the Technical Audit to the audit team along with Contractors support team, without any extra cost to PMC/Owner. Incorporation of the comments of the Technical Audit shall be done by the LSTK Contractor without any cost or time impact. LSTK contractor shall send fortnightly updates of the model using latest version of 3D modelling software (compatible to the one at OWNER /PMC Office) for the review status monitoring of the models. LSTK Contractor shall propose the dates and duration at least 4 weeks in advance for these 3D reviews by Owner/PMC.

## 7.7 REVIEW STAGE

There shall be minimum 3 review stages to be done as follows. 4th and 5th further reviews shall be required after all comments are incorporated by the LSTK Contractor.

1. Equipment layout review from erection, construction, operation and maintenance point of view & Conceptual review of critical lines (thermal & process critical) (30%).
2. Before issue of model for engineering (60%).
3. Before issue of model for construction (before isometric generation commences) (90%).

3-D modelling review for sprinkler system for pumps where monorail is provided shall be done with sprinkler system in place.

3-D modelling review for material requirement has to be fine tuned as per 3D modelling and report of such material requirement shall be forwarded to PMC/OWNER for their information on regular interval.

Any operational requirements such as platforms, approaches for equipment & technological structure if required during the 3D model review as above, the same shall be provided by the LSTK contractor without any time delay and cost implications.

## 8.0 PROVEN TRACK RECORD

The LSTK Contractor or his Engineering sub-Contractor must have carried out extensive 3D modelling and data base management for a project of similar nature with the following as a minimum.

LSTK Contractor should demonstrate their capability through walk through of one such 3D model developed by them.

Owner/PMC reserves the right to verify the above at the premises (as applicable) including experience of personnel deployed on the project.

Owner/PMC decision shall be final and binding on the LSTK Contractor in this regard.

## **ANNEXURE-9**

**HYDROTEST DRAIN & VENT**

Fluid	Pressure rating	3/4" Vent	3/4" Drain
Gas	NP < = CLASS 2500		
Steam	NP < = CLASS 600		For steam trap installation See separate specification
	NP > = CLASS 900		
Liquid	NP < = CLASS 600		
	NP > = CLASS 900		

1. 3/4 " Thd. Cap.
2. 3/4" Branch Fitting acc. to Pipe Class.
3. 3/4" Nipple (P).
4. 3/4" Globe Valve (SW).
5. 3/4 "Gate Valve (SW).
6. 3/4" Nipple (P/T).

\* For Hydrostatic test only. For process purpose use installation as for liquid service.

 पी डी आई एल <b>PDIL</b>	<b>PROJECTS &amp; DEVELOPMENT INDIA LTD</b>	PNMM/PC288/E/001/5.3.2	0	 कोयला BHEL
		DOCUMENT NO	REV	
		Page 1 of 44		


## SECTION –5.3.2

### DESIGN PHILOSOPHY-STATIC EQUIPMENT

**PROJECT: SETTING UP OF HIGH ASH COAL-TO-AMMONIUM  
NITRATE PLANT IN MAHANADI COALFIELDS  
LIMITED (MCL)**

**PLANT : SYNGAS PURIFICATION UNIT FOR COAL TO  
AMMONIUM NITRATE PLANT**

**CLIENT : BHARAT COAL GASIFICATION AND CHEMICALS  
LIMITED**



	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PNMM/PC288/E/001/5.3.2	0
		DOCUMENT NO	REV
		Page 2 of 44	

## CONTENTS

SL. NO.	DESCRIPTION
1.0	DESIGN CRITERIA
2.0	MATERIAL OF CONSTRUCTION
3.0	TECHNICAL REQUIREMENT
4.0	FABRICATION
5.0	INSPECTION & TESTING
6.0	PICKLING AND PASSIVATION
7.0	PAINTING
8.0	INSULATION
9.0	SPARE PARTS
10.0	DOCUMENTATION
11.0	PACKAGING, IDENTIFICATION AND STORAGE INSTRUCTIONS
12.0	DISPATCH
13.0	VENDOR LIST
14.0	GUARANTEES
15	AS BUILT DOCUMANTATION

## LIST OF ATTACHMENTS

S.NO.	DESCRIPTION	ATTACHMENT NUMBER
1.	GUIDELINES FOR DYNAMIC WIND ANALYSIS	ANNEXURE - 1
2.	INSPECTION (GUIDELINES)	ANNEXURE - 2
3.	INDICATIVE ITP FOR EXCHANGER (ITP-01), PRESSURE VESSELS (ITP-02)	ANNEXURE - 3

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PNMM/PC288/E/001/5.3.2	0	
		DOCUMENT NO	REV	
		Page 3 of 44		



## 1.0 Design Criteria

- 1.1.1 This document defines the design philosophy to be applied for the complete design (Mechanical), procurement, fabrication, construction/erection, insulation, painting, Pickling & Passivation (for SS equipments), inspection and testing of static equipment i.e. Pressure Vessels, Heat Exchangers, filters, Towers/Column, Storage Tanks, Vessel Internals, Waste heat Boilers and all other items as applicable for Syn-gas Purification Unit For Coal to Ammonium Nitrate Plant for **Bharat Coal Gasification and Chemicals Limited** (JV of CIL & BHEL), Lakhanpur, Distt. Jharsiguda in accordance with this specification, standards specification, codes and other attachment etc. listed in NIT document.

The complete design, material of construction/fabrication (shop/site as applicable), inspection, testing, painting, supply, transportation and erection of equipment etc. at project site shall conform to the specifications, drawings and internationally accepted codes / standards duly accepted by the Owner. In addition, all statutory rules & regulations shall also be complied with.

- 1.2 The equipment shall be designed & constructed as per the latest edition (at the time of contract signing) of the following codes and standards:

Code**	Description
ASME Section VIII Div 1	Rules for construction of Unfired Pressure Vessels
ASME Section VIII Div 2	Rules for construction of Unfired Pressure Vessels (Alternative rules)
TEMA 'R'	Standards of Tubular Exchangers Manufacturer's Association For Shell & Tube Heat Exchanger
HEI	Heat Exchanger Institute standards for steam surface condensers and steam jet ejectors
API 650	Welded Steel Tanks for Oil Storage
API RP 2000	Venting Atmosphere And Low Pressure Storage Tank
API 2550	Method For Measuring and calibration of upright cylindrical Tanks
API 661	Air Cooled Heat Exchangers
API 662	Plate type Heat Exchangers
API 941	Steels for Hydrogen Service at Elevated Temperature & Pressure
API-934-A	Materials and Fabrication Requirements for 2-1/4Cr-1Mo & 3Cr-1Mo Steel Heavy Wall Pressure Vessels for High Temperature, High Pressure Hydrogen Service
API-934-C	Materials and Fabrication of 1 1/4Cr-1/2Mo Steel Heavy Wall Pressure Vessels for High-pressure Hydrogen Service Operating at or Below 825 °F (441 °C)
API 605	Metallic gaskets for raised face pipe flanges & flanged Connection (Double jacketed corrugated & Spiral wound)
EJMA *	Standard of Expansion Joint Manufacturers Association
ASME Section II A & B/ ASTM	Materials Specifications
ASME Section II PART C	Specification for welding rod, electrode & filler metal
ASME SEC II PART D	Material Properties
ASME Section V	Non-destructive Examination
ASME X	Fibre-Reinforced Plastic Pressure Vessels
BS EN 13121	GRP Tanks & vessel
ASME Section IX	Welding Qualification
ASME B 16.5	For Flanges
ASME B 16.47	For large diameter flanges

 <div>पी डी आई एल PDIL</div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div> <div>OWNER: Bharat Coal Gasification and Chemicals Limited</div> <div>DESIGN PHILOSOPHY-STATIC EQUIPMENT</div>	PNMM/PC288/E/001/5.3.2	0	
		DOCUMENT NO	REV	
		Page 4 of 44		

ASME B 16.20	Metallic Gaskets for Pipe Flanges: Ring-Joint, Spiral Wound, and Jacketed
ANSI	Pipes, Flanges, Fittings and Valves
IS: 875 / SITE DATA	Wind loads design consideration
IS: 1893 (Part 4) & IS: 1893 (Part 1) / SITE DATA	Seismic design consideration
BS 4994	Design & Construction of vessel & Tanks in Reinforced Plastics
IS:4682 (Part-1) with Amendment No. 3	Code of Practice for Rubber Lining of Vessels & Equipment for Chemical Process
Factory Act, 1948 BS CP 3003 (Part 1)	Factory Act & State Govt factory rules Code of Practice on lining of Vessels and equipment for Chemical Process.
IBR	Indian Boiler Regulation
NACE	National Association Of Corrosion Engineers
PESO	Petroleum And Explosives Safety Organisation

\*- Except for heat exchangers, while for heat exchangers the expansion bellows shall be designed as per TEMA standard.



\*\*Any conflicts between documents, including regulations and codes, shall be brought to the Purchaser's Attention for resolution.

#### NOTES:

- a) LSTK Contractor may select DIN, BS or any other well known international materials as substituted materials to ASTM/ASME ones, if they are equivalent or superior to ASTM / ASME ones. The chemical & mechanical properties of such equivalent or superior offered materials preferably comparison w.r.t. ASTM materials shall be furnished along the bid. LSTK Contractor shall also submit the references of past supplies of similar type of equipment w.r.t. the proposed materials offered by them in their bid.
  - b) Process licensors guidelines / standards may be adopted complying minimum requirements of this design philosophy of static equipment. Details of such selected guidelines/standards along with the list shall be furnished in the bid.
  - c) Specifications of all critical & proprietary equipments including those specified by the process licensor shall be furnished in the technical bid. List of such critical & proprietary equipment to be submitted along with bid.
- 1.3 Complete mechanical design of Equipment as per latest code /standard of construction shall be the responsibility of the LSTK Contractor. Strict compliance with the requirement of codes/equipment specification & any other referred document shall be ensured. In addition, all statutory rules & regulations shall also be complied with.
  - 1.4 Design conditions for all equipment shall be as per Process Licensor data sheet / Specification. Minimum required thickness to be calculated based on design parameters considering different types of loadings including effect of static head of liquid column. Equipment shall also be designed for hydrostatic condition. Final thickness is decided giving due consideration for corrosion allowance, tolerance e.t.c.
  - 1.5 Design pressure shall be at the top of vertical vessel or at the highest point of horizontal vessel. The design pressure at any lower point shall be determined by adding the maximum operating liquid head and any pressure gradient within the vessel.
  - 1.6 Wind analysis shall be performed as per IS-875 (Latest Edition). Wind forces shall be increased by 20% (over & above design code requirement) to cater the effect of piping system, platforms and ladders etc. Requirement mentioned in IS-875 (Latest Edition) to be followed w.r.t project site.



Vertical vessels with height/diameter ratio equal to or greater than 10 shall be analyzed for vibration due to vortex shedding when critical wind speed does not exceed 30m/s. For guidelines of Dynamic Wind Analysis refer **Annexure-I**.





 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PNMM/PC288/E/001/5.3.2		0	
		DOCUMENT NO		REV	
		Page 5 of 44			

- 1.7 Seismic analysis shall be performed by Response spectrum method (RSM) considering seismic as per IS-1893 part-1 & IS-1893 Part 4 (Latest edition) w.r.t project site.
- 1.8 Local load analysis, WRC 107/537 shall be used for nozzle on dish end, WRC 297 to be used for nozzles on shell. FEA analysis to be carried out for nozzles beyond scope of WRC.
- 1.9 All vessels/columns subject to internal pressure shall be designed to withstand a minimum external pressure of 0.175 kg/cm<sup>2</sup> abs.
- 1.10 Design of supports and anchor bolts shall be performed for compressive and tensile loading. In no case shall diameter of anchor bolts be less than M24 for skirt support and M16 for other type of support. Anchor bolts shall be hot dip galvanized.
- 1.11 Each Lifting lug shall be designed with shock factor 2.
- 1.12 Hydro testing of equipment shall be as per UG-99b of ASME Sec VIII Div-1. In order to safeguard against the risk of brittle fracture during hydrostatic test metal temperature during hydrostatic test be maintained at least 30°F (17°C) above the minimum design metal temperature, but need not exceed 120°F(48°C).  
Min duration of Hydro test shall be 60 min.  
Design pressure for each nozzle shall be sum of maximum allowable working pressure and static head of corresponding nozzles. Nozzle also to be checked in deaerated condition as per UG-44 of ASME Sec VIII div-1.
- 1.13 Maximum Allowable Working Pressure (MAWP) is the maximum gauge pressure at the top of a completed vessel, which is obtained from the calculations for every element of the vessel based on the actual thickness in the corroded condition. Supplier shall calculate the MAWP of each vessel, and the calculation shall be included in design calculations. MAWP shall not be assumed to be the same as the design pressure except for cases where MAWP cannot be determined by calculation to the applicable code. Accordingly calculate hydro test pressure as per UG-99b.
- 1.14 Bolt of size M48 and above shall be designed and spaced so as to permit tightening with a hydraulic stud-tensioner. The bolts shall have an extra threaded length at one end of approximately 1 bolt diameter, and shall be provided with threaded protection caps. Hex nuts shall have suitable holes for manual tightening. The requisite no. of hydraulic stud-tensioner device with necessary adopters/insertions based on varying sizes of studs shall be supplied by LSTK Contractor as per mechanical design of the equipment.
- 1.15 Orientation of longitudinal seams and position of circumferential seams shall be clearly marked in the fabrication drawing. Nozzles, support and other attachments shall be located clear of welded joints.
- 1.16 All process equipments shall be supplied with High purity nitrogen (HPN) filled. In case of equipment assembled and welded at site, it shall be filled with High purity nitrogen (HPN) N<sub>2</sub> after testing at site. Dry High purity nitrogen (HPN) shall be filled at a pressure of 0.5 Kg/cm<sup>2</sup>g and equipment shall be fitted with a pressure gauge and valve.
- 1.17 LSTK Contractor shall guarantee the equipment & their components against faulty design with regard to their mechanical adequacy, improper material of construction & poor workmanship for the period specified in contract.
- 1.18 Basic allowable stresses for shell, heads and other components etc. of vessels and shell, roof, etc. of tanks shall be the values specified in the design code.  
Maximum allowable "tensile stress" and "compressive stress" shall be as per UG-23 of ASME Sec VIII Div - 1. These stresses may be increased by 20% for earthquake & wind combination case in line with UG-23 (d).
- 1.19 All blind flanges and man way covers weighing 35kgs or more shall be fitted with handling Facilities such as davits.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PNMM/PC288/E/001/5.3.2		0	
		DOCUMENT NO		REV	
		Page 6 of 44			

- 1.20 As a General rule all nozzle attachment to shell/head shall be set in type.
- 1.21 As a minimum requirement, all vessels, Exchanger, Tanks e.t.c shall be spot radiographed.
- 1.22 Forces and moments acting on nozzles shall be considered in the equipment design.
- 1.23 LSTK Contractor shall mark tangent lines, the position of the main axis and the centre of gravity for orientation in a clearly identifiable and permanent way on the vessel. Centre of gravity shall be clearly marked.
- 1.24 Welding wherever specified, is to be done by qualified and approved welders using the suitable fillers and fluxes recommended for the materials in the fabrication drawings. For welding the stud on tray decks and support beams, use of stud welding gun with suitable flux is acceptable. In manually welding of studs, care should be taken to minimize the weld spatter and the outside diameter of the weld so that it should not foul with tray deck or washer. For stud welding, proper welding procedure shall be established. Torque required for welding failure shall be higher than the torque required for failure of the stud.
- 1.25 A proposed Welding Procedure Specification (WPS) shall be submitted to approved inspection agency for approval. On approval, a Procedure Qualification Test (PQT) shall be conducted which shall be witnessed by approved inspection agency. On acceptance of all tests as per ASME Section IX, a final WPS along with Procedure Qualification Record (PQR) shall be submitted. Production welding shall start only after approval of final WPS/PQR and qualification of welders as per ASME Section IX, approved inspection agency may accept previously qualified WPS/PQR at his sole discretion.
- 1.26 Longitudinal and circumferential welded seams shall not interfere with nozzle openings, reinforcement plates, saddle pads, and other attachments as far as possible
- 1.27 Gas or Carbon arc welding shall not be used.
- 1.28 Welding electrodes of composition similar to Internals material shall be used except austenitic electrodes of higher chromium and nickel content such as AWS A5.4, ASME SFA 5.4 class E309 and E310 may be used for 12-Cr stainless steel. For dissimilar material welding, electrode composition shall be similar to nobler material being welded. Following electrodes shall be used unless specified otherwise:
- |            |  |
|------------|--|
| E 7018     | For all CS materials   |
| E 308      | For all SS 304 to SS 304   |
| E 308L     | For all SS 304L to SS 304L   |
| E 309 Mol  | For SS 410S to SS 410S, SS to CS, SS 410S to SS 304, 304L, 316, 316L |
| E 316      | For all SS 316   |
| E 316L     | For all SS 316L  |
| E Ni – Cu7 | For Monel to Monel and Monel to CS/SS                                |
- 1.29 All parts fabricated shall be smooth, true, clean and free from burrs, grease and dents. Openings for passage of workman must have exposed edges rounded.
- 1.30 All parts shall be fabricated in accordance with good shop practice and in uniformity so that all corresponding parts will be inter-changeable.
- 1.31 For equipment coming under the purview of Static and Mobile Pressure Vessel rules, it shall be LSTK Contractor responsibility to get complete approval from Chief Controller of Explosives, PESO e.t.c, pertaining to design, drawings, material of construction, fabrication, inspection and testing etc.

 पी डी आई एल PDIL	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PNMM/PC288/E/001/5.3.2		0	
		DOCUMENT NO		REV	
		Page 7 of 44			

- 1.32 For equipment coming under the purview of Indian Boiler Regulations, it shall be LSTK Contractor responsibility to get approval from IBR authorities pertaining to design, drawings, material of construction, fabrication, inspection and testing etc.
- 1.33 Material test certificates shall comply with EN10204 Type 3.2 for high pressure equipment and EN10204 Type 3.1 for other than high pressure equipments for pressure parts.  
LSTK Contractor to consider equipment having design pressure equal or more than 100 kg/cm<sup>2</sup> G or thickness greater than 50 mm as high pressure equipment or specified by process Licensor as high pressure equipment.
- 1.34 Gaskets used during testing shall be same as specified for operating conditions. Gaskets shall be replaced only where flanges need to be opened after hydro test.  
Further, Welded, lip seal type, double conical gaskets, RTJ and Lens gasket will not be replaced after hydro test as the same are reusable. These gaskets to be replaced, if they are found damaged during or post hydro test.

Gasket selection for all equipment shall be as per Process Licensor recommendation/ standard.

- 1.35 In case of conflict between this specification and other specification, codes and data sheets. It shall be referred to PMC/ Owner for clarification and the decision of PMC/ Owner shall be final & binding on contractor without any cost & delivery implications.

#### 1.4 REGULATIONS



Besides codes & standards, LSTK Contractor shall follow National Laws and Regulations such as Indian Boiler Regulation, PESO and Department of Explosives, Nagpur, India together with Local by Laws for the state including statutory requirements as applicable. Static and Mobile Pressure Vessel (SMPV) rules as applicable shall also be complied with.

All local regulations related to India and the project site is applicable, even if they are not referred in this document or in the specifications.

#### PUBLICATIONS:

NACE MR 0103	Materials Resistant to Sulphide Stress Cracking in Corrosive Petroleum Refining Environments
NACE MR 0175 / ISO 15156	Petroleum and natural gas industries - Materials for use in H <sub>2</sub> S containing environments in oil and gas production
NACE RP 0296	Guidelines for Detection, Repair and Mitigation of Cracking of Existing Petroleum Refinery Pressure Vessels in Wet H <sub>2</sub> S Environment
NACE TM 0284	Evaluation of Pipeline and Pressure Vessel Steel for Resistance to Hydrogen Induced Cracking
NACE TM 0177	Laboratory Testing of Metals for Resistance to Sulphide Stress Cracking in Hydrogen Sulphide Environment
NACE RP0590	Recommended practice for Deaerator
WRC Bulletin # 107/537	Local Stresses in Spherical Shells due to External Loadings.
WRC Bulletin # 297	Local Stresses in Cylindrical Shells due to External Loadings on Nozzles

#### 1.41 DESIGN DOCUMENTATION

 पी डी आई एल PDIL	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PNMM/PC288/E/001/5.3.2		0	
		DOCUMENT NO		REV	
		Page 8 of 44			

1.41.1 Detailed design calculations considering different loadings shall be made as per code/standards and the additional requirements as mentioned below:-

1.41.2 Design of equipment inside the plant complex shall be in accordance with the process licensor's data sheets and specifications.

1.41.3 LSTK Contractor shall consider the interfaces with other engineering disciplines w.r.t.

- Piping Layout/Location Drawings
- Civil / Structural Drawings
- P & ID's
- Materials
- 3D PDS Model for Piping and Equipment Layout review at 30%, 60% and 90% stages.
- Hazardous Area Classification

1.41.4 Design philosophy of other disciplines shall be observed and shall be relevant to the extent applicable.

- Civil/Structural Design Criteria
- Piping Design Criteria
- Process Design Criteria
- Electrical and Instrumentation Design Criteria

#### 1.42 SITE CONDITIONS

Climatic and other site conditions as defined elsewhere in NIT.

#### 1.43 OPERATING DUTY



1.43.1 Service shall be twenty-four (24) hours per day, seven (7) days per week, and fifty-two (52) weeks per year. The equipment design life shall be 25 years.

#### 1.44 CONSTRUCTION & ERECTION

1.44.1 LSTK Contractor shall follow standard established procedures for handling storage, construction & erection. LSTK Contractor shall strictly follow Manufacturer's/Principal's instructions, approved drawings and procedures for construction & erection and satisfy Principal in all respects of storage, handling, construction & erection of Package. All erection work shall conform to the working/erection drawings (to be prepared by LSTK Contractor) and shall be in conformity with codes & standards as applicable. The LSTK Contractor shall supply & arrange all necessary construction & erection tools and tackles, machinery, scaffolding etc.

1.44.2 LSTK Contractor shall perform the following:

- i) Before installing the equipment, the foundations shall be checked and wherever Necessary, chipping shall be done by the LSTK Contractor. All grouting materials, packing plates/wedges required for the levelling and alignment of equipment, structures & pipelines etc shall be provided.
- ii) Top of the foundations shall be thoroughly cleaned to the satisfaction of Principal /LSTK Contractor before placing base plates.
- iii) All equipment & structure etc. shall be checked and inspected for its proper levelling and granting (grouting) shall be done with suitable grouting material as required.
- iv) After tightening the foundation bolts, the final level / alignment shall be rechecked and redone, if required.
- v) Installation of all supports and hangers, including concreting or welding as necessary.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PNMM/PC288/E/001/5.3.2		0	
		DOCUMENT NO		REV	
		Page 9 of 44			

vi) To check correctness of the piping, instruments and other connecting points in the equipment and piping installed.

vii) The welding joints shall be stress relieved wherever necessary as per applicable codes, Standards & specification.

1.44.3 The following shall be arranged and supplied by LSTK Contractor for completion of job. Any other item whatsoever required shall also be included by LSTK Contractor in their scope.

i) All construction & erection materials, equipment & machinery, scaffolding, consumable, and test equipment etc.

ii) Cranes/Hydra, temporary lifting beams and spreaders etc.

iii) Procedures for site assembly, construction & erection including lifting methodology for Owner/Third party approval

1.44.4 As a minimum contractor shall comply the requirements indicated below:

i) Fabricate, erect and align the equipment & internals as per applicable codes, standards & specifications. All internals shall be inspected before and after installation.

ii) Carry out all NDT's required. The Personnel performing NDT's should have a minimum qualification as "NDT LEVEL-II" in the relevant Technique, certified by American Society for Non-destructive Testing.

iii) Perform non-operating field pressure tests and leak tests on field fabricated equipment in accordance With the applicable codes, standards and specifications, ensuring disposal of test media in accordance with instruction/recommendations.

iv) Notify Owner / Third party of the test schedules for witness the tests by concerned inspector.

## 1.45 QUALITY ASSURANCE & CONTROL

1.45.1 The quality assurance shall be as per the approved procedures, test methods & facilities to be developed by the LSTK Contractor to ensure that the supplied equipment shall be of highest quality. The quality control shall mean that all the tests , measurements, checks & calibration which are to be carried out may be compared with the actual specified characteristics of the equipments/unit /system.



1.45.2 Quality Assurance (QA) shall mean the organizational set up, procedures as well as test methods and facilities developed by LSTK Contractor in order to assure that Equipment leaving LSTK Contractor's shop are of the highest possible quality i.e. either equal to or better than the requirement specified.

1.45.3 Quality Control (QC), shall mean all the tests, measurement, checks and calibration which are to be carried out in LSTK Contractor's shop in order to compare the actual characteristics of the equipment/unit/system with the specified ones, along with furnishing of the relevant documentation (certificates/records) containing the data or result of these activities.

1.45.4 LSTK Contractor shall submit a comprehensive description (manual) of QA/QC measures contemplated by him for implementation with regard to this specification. It is contractual obligation of the LSTK Contractor to develop and implement adequate QA/QC systems. QA/QC System shall cover all products and services required for the equipment as per scope of work including job sub contracted by the LSTK Contractor.

1.45.5 QA/QC system shall cover all products and services required for the equipment as per scope of work including job sub contracted by the LSTK Contractor.



## 2.0 Material of Construction

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PNMM/PC288/E/001/5.3.2		0	
		DOCUMENT NO		REV	
		Page 10 of 44			

- 2.1 The minimum requirement of the materials shall be as per the plant equipment metallurgy covered under specific process design guidelines. However superior materials as per the recommendation of Process Licensor's may be selected which shall be indicated in the bid by the LSTK Contractor.
- 2.2 All materials, whatsoever, required to complete the supplies shall be procured by LSTK Contractor and all such materials shall be covered with due identifiable material test certificate.
  - 2.2.1 All raw materials including bought -out items, whatsoever required, to complete the supplies shall be procured and supplied by LSTK Contractor with due identifiable mill material test certificates & inspection reports duly certified by third party inspection agency.
  - 2.2.2 For coarse grained and high tensile materials in carbon steel (UTS > 45 Kg/mm<sup>2</sup>) and low alloy steel, guaranteed impact strength shall be ensured at a temperature 15 degree C below envisaged hydraulic test temperature as a precaution against brittle fracture during hydraulic test.
  - 2.2.3 Carbon steel plates shall be procured in fully killed & normalized condition. CS plates shall be fully killed & normalized. All plates above 50mm thickness shall be vacuum-degassed and examined by Ultrasonic Testing (UT) as per applicable material specification code/standard. All LAS materials including forging used for pressure parts shall be procured as permitted in ASME sec. II part A.
  - 2.2.4 All Stainless Steel (SS) plates shall be hot rolled & solution annealed and pickled as per SA-480.
  - 2.2.5 All forgings except for flanges as per ANSI shall be UT tested as per ASTM A 388 for the thickness greater than 50 mm and shall be procured in normalized / annealed condition. Acceptance standards shall be as per 3.3.4 of ASME Section VIII Div. 2. In case any defect is found, no repair by welding shall be allowed.
  - 2.2.6 All forgings including nozzle flanges shall be examined for surface defects by MP/PT testing after machining as per applicable material specification code & standard.
  - 2.2.7 All external / internal attachments, pads/cleats for support directly welded to the equipment shall be of same materials (grade) as that of equipment, unless specified otherwise.
  - 2.2.8 All nozzles up to DN 10" size shall be made of seamless pipe. For sizes above DN 10" nozzle connection shall be rolled from plates with full radiography of plates and joints.
  - 2.2.9 Unless otherwise specified girth flanges shall be of forged quality and ultrasonically tested.
  - 2.2.10 Unless more restrictive prescription given by material specification the max. Content for carbon steel used for fabrication as shown by ladle analysis shall be 0.23% for plates, pipes & tubes 0.25% for forging.
  - 2.2.11 Top portion of skirt (min. 500 mm height) welded to the bottom dished head shall be of same material (Grade) as that of shell /head for LAS & SS materials.
  - 2.2.12 Heat treatment of formed parts shall be carried out as per following:

**For Carbon Steel:**

- a. Cold formed dished ends or knuckles up to 16 mm nominal thickness shall be stress relieved.
- b. Cold formed dished ends or knuckles above 16 mm nominal thickness shall be normalised.
- c. For Low alloy Steel: - Cold Formed Dish ends and Knuckles shall be stress relieved.
- d. Hot formed dished ends or similar parts, which have not been uniformly heated in the normalising range in the final stages of manufacture shall be normalised.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PNMM/PC288/E/001/5.3.2		0	
		DOCUMENT NO		REV	
		Page 11 of 44			

- e. When the completed vessel involves post weld heat treatment, heat treatment recommended in (a) above shall not be applicable.
- f. Vessels in caustic service, Amine or Sour gas service shall be stress relieved.
- g. All internal and external attachments, clips, insulation studs, name plate bracket, and the like shall be welded to the vessel before post weld heat treatment

2.2.13 Pressure part plates having thickness 16 mm to 50 mm (both inclusive) shall be ultrasonically Tested (UST) as per ASTM A-435. Pressure part plates having thickness above 50 mm and all Plates to be used shall be UST as per ASTM A-578 Level B. No laminations or inclusions shall be permitted.

2.2.14 The minimum thickness of weld overlay material shall be 1/8 inch (3 mm-undiluted) except clad or weld Overlay tube sheets and gasket surfaces.

2.2.15 Unless otherwise specified Copper & Copper alloys shall not be used. Copper content up to 0.4% are acceptable in carbon steel & 0.6% in stainless steel.

2.2.16 PWHT of complete vessel shall be carried out in one go in a furnace. Local stress relieving of Weld joint in piece meal shall be avoided as far as possible.

2.2.17 Gasket with flange rating  $\geq 900\#$  shall be octagonal ring joint gasket. Hardness of the gasket shall be 50BHN lesser than that of the mating flange gasket groove.

2.2.18 Tube sheets shall have a nominal clad or weld overlay thickness of 3/8 inch (10 mm) but not less than 5/16 inches (8 mm) regardless of shell side or tube side face. The minimum thickness of clad or weld overlay at a pass partition groove shall be 1/8 inch (3 mm) minimum.

2.2.19 Tube sheet and Girth flanges must be made in one piece. Segmental butt-weld construction shall not be accepted.

2.2.20 When post weld heat treatment is required for pressure vessels, all material for pressure holding components shall be simulation tested with minimum additional two (2) heat treatment cycles. Additional two heat treatments are; one for PWHT after shop repairing and the other for future PWHT at site.

2.2.21 All Carbon Steel (CS) and Low-Alloy Steel (LAS) pressure parts shall have 3 mm corrosion allowance unless specified otherwise. All internal CS & LAS parts shall have at least 1.5 mm Corrosion Allowance. No corrosion allowance shall be considered for SS In general, the recommendation of Process Licensor shall be adopted for construction if found more stringent..

2.2.22 Production Control coupons, when required as per code and specifications, shall be subjected to all tests like impact, inter granular corrosion test etc., in addition to mechanical test as required. In case of heat treated equipment test coupons shall be given similar heat treatment as for the equipment.

2.2.23 When design pressure is  $\geq 600\#$  class or shell thickness is 50 mm and above, Hydrogen service, cyclic service e.t.c self reinforced forged nozzle shall be provided. Shell to SR nozzle welding shall be set-in type welding.



2.2.24 Weld overlayed nozzle and girth flange gasket faces shall have a minimum thickness of 3/16 inch i.e. 4.8 mm (min. undiluted thickness of 3 mm) after machining.

2.2.25 In order to minimise the effect of temper embrittlement for material to 2¼ Cr 1 Mo specifications in the temperature range of 375-575 degree Celsius , the embrittlement factors 'X' & 'J' shall be limited to:

$$X = (10P + 5Sb + 4Sn + AS) / 100 \leq 15$$

The elements above are expressed as ppm



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		DOCUMENT NO	REV	
		Page 12 of 44		

$$J = (Si + Mn) (P + Sn) \times 10^4 < 160$$

The elements above are expressed as percentages

A stimulated PWHT followed by step cooling shall be performed on a sample of material. Acceptable toughness shall be demonstrated by means of a Charpy V Impact Test.

- 2.2.26 Unless otherwise specified, all internal parts shall be removal type. Internal shall be designed in units as large as can be installed through the nearest upper manhole or opening. The weight of unit shall not generally exceed 40 Kg. except for support beams.

Trays, distributors, baffles and support beams shall be designed in such a way that deformation of shell due to operating pressure and thermal expansion does not occur.

Bolts and nuts for fixing internals shall be 18/8 S.S and minimum size of bolts shall be M10. All internal bolts shall be provided with locking nuts.

- 2.2.27 Steel for Hydrogen service at elevated Temperature & pressure shall be selected as per API 941& API 934 along with full compliance of other requirements .The following special requirements shall be met with for Hydrogen/Sour gas.

- All pressure parts shall be post weld heat treated.
- All pressure retaining butt welds shall be 100% radio graphed. (Root run & Final Weld radiography is must)
- Self reinforced forged nozzle with LIP. Joint shall be 100% radiographed
- Tube sheet with Lip type construction, Tube sheet to shell/channel joint shall be 100% radiographed.

- 2.2.28 Gaskets for all medium with flange rating < 600 # (including girth flange) shall be SS spiral wound type with external & internal guide rings unless otherwise specified.

Gaskets used for high pressure equipment shall be of the following type unless otherwise specified by Process Licensor:

- Ring Joint - Double conical with graphite tape
- Diaphragm gasket
- Lip seal Gasket



- 2.2.29 No welding, hammering or deforming is permitted on the pressure retaining parts after post weld heat treatment except as permitted by the codes or standards and when approved by the purchaser.

- 2.2.30 Due provisions must be kept for venting out entrapped gases during welding of pads, flanges and liner plates etc.

- 2.2.31 All Equipment shall preferably be supplied in single piece. However, in exceptional cases, Site fabrication / Field assembly may be permitted. Prior written approval from Owner/PMC shall be obtained by the Contractor for the same.

**Additional requirements For Site fabricated Equipment:** Transportation, Loading/Unloading, handling of pre-fabricated/ pre- rolled components/ petals / subassemblies, fabrication, assembly, inspection (including inspection by approved TPIA per approved QAP (as applicable)), all NDT, PWHT as applicable, hydro testing, pickling & Passivation of SS internals, application of primer/finish paint on completed equipment to be carried out by equipment manufacturer.

{As far as possible, maximum fabrication activities shall be completed at shop including mock up assembly, rolling of plates, nozzles to flange connection, strip cladding (if applicable), Weld overlay/cladding of Nozzles etc.}

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		DOCUMENT NO		REV	
		Page 13 of 44			

## 2.2.32 CLADDING AND LINING

- a) Cladding & lining is allowed only if specified in Process data sheet of Process licensor for equipment /equipment parts subjected to Prior approval of owner. Integrally clad metal and weld overlays shall not be considered as contributing to the strength of the vessel wall thickness of the Equipment. It should not be considered in the minimum thickness calculation.
- b) Strip liners shall not be used in vessel shell for hydrogen service.
- c) Cladded plates shall be supplied as per ASTM A 264 material specification. All clad plate shall be UT examined at the steel works in accordance with ASTM A 578 level S8.

## 3.0 TECHNICAL REQUIREMENTS

### PART A - DESIGN PHILOSOPHY FOR PRESSURE VESSEL

#### 3.1 Vessel/Column/Reactor/Filter e.t.c

- 3.1.1 Design, materials, fabrication and inspection of welded pressure vessels shall comply with ASME Code Section VIII, Division 1 (latest edition) and code and standard specified in the NIT.

ASME Sect. VIII Div. 2 shall be used for pressure above 3000 psi or if specified by Process Licensor in equipment Process data sheet.

ASME Sect. VIII Div. 2 equipment shall be ASME U stamped.

Process licensors guidelines/standards may be adopted complying minimum requirements of this design philosophy of static equipment. Details of such selected guidelines/standards along with the list shall be furnished in the bid.

Unless specifically required by Process Licensor, ASME Code stamp is not required except ASME Sect. VIII Div. 2 equipment.

Vessels/Column will be sized according to inside diameter and 2:1 elliptical heads or hemispherical heads. Minimum inside diameter shall be 500 mm. Top cover shall be flanged if the ID is equal or less than 900 mm.



- 3.1.2 Design of equipment skirt shall be based on seismic/wind/thermal considerations and fire proofing/insulation requirements.
- 3.1.3. All nozzles above 24" NB shall comply with ASME B16.47 Series B (API 605).
- 3.1.4. Minimum nozzle thicknesses shall be Schedule Extra Strong above 2" NPS, and Schedule 160 for 2" NPS and below.
- 3.1.5 Stress calculations due to Local loads on vessel for external structural attachments, such as platform clips, pipe support clips and lifting lugs shall be performed.
- 3.1.6 Minimum thickness of shell & heads, including corrosion allowance shall be as indicated below:



Sr. No	Shell Diameter (mm)	Thickness (Min.) mm	
		CS / LAS	HAS
1.	ID < 500	5	3
2.	501 < ID < 1200	5	4
3.	1201 < ID < 2000	6	5
4.	2001 < ID < 2600	8	6
5.	ID > 2600	10	8

**CS = Carbon Steel, LAS = Low-Alloy Steel, HAS = High-Alloy Steel**

- 3.1.7 Equipment skirts for carbon steel vessels shall be designed from the same material (Grade) as the shell or the head. Equipment skirts for other than carbon steel shall be the same material (Grade) as the shell or the head for the top 500 mm.
- 3.1.8 Equipment with skirt support having eight or more anchor bolts shall be required to be supplied with an anchor bolt template. The template shall be of box type (no annulus type) to avoid problem during final erection and installation. The template shall have adequate strength against deformation
- 3.1.9 Maximum permissible deflection for vessel when subjected to design wind loadings shall not exceed 0.005 x Vessel/Column height. For guidelines of Dynamic Wind Analysis refer **Annexure-I**.
- 3.1.10 Minimum man way size shall be equal to 24" nominal pipe size.
- 3.1.11 Manhole/hand hole/blind holes covers shall be equipped with davits or hinges for ease of opening to facilitate handling.
- 3.1.12 Horizontal vessels of large size and thin wall shell on saddle supports shall be investigated for buckling, local circumferential bending and shear stress. The method of L. P. Zick (Supplement to Welding Research, 1971) may be used for this investigation.
- 3.1.13 Use of structural steel shall be limited to non-pressure parts only.
- 3.1.14 Local stress calculations for external structural attachments, such as platform clips, pipe support clips and lifting lugs shall be performed.
- 3.1.15 Dimensional tolerances shall be in accordance with the design codes or standards, whichever is more stringent.
- 3.1.16 For Equipment 24" manhole shall be used for all equipment with internal diameter more than 900 mm. Equipment of internal diameter below 900 mm shall be flanged at one head for access with a 12 "hand hole on the other end. Larger size manhole will be specified when required to accommodate internals or critical for equipment entry.
- 3.1.17 In vertical vessels with demister, manholes shall be provided on to access both sides of the demister. Demisters shall be securely fastened to support ring by bolting or clamping.
- 3.1.18 In horizontal vessels, the manhole shall be located on one of the heads, which is away from internals such as displacers, baffles etc. The vent connection on the horizontal vessels shall be on the opposite end of the manhole. Large vessels with diameter of more than 3000 mm TI- TI, an additional 4" vent nozzle with blind shall be provided.
- 3.1.19 The extent of radiographic examination of the shell and head seams shall be spot examination, as minimum.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PNMM/PC288/E/001/5.3.2		0	
		DOCUMENT NO		REV	
		Page 15 of 44			

3.1.20 Vessels/Column stresses during hydrostatic tests shall not exceed 90% of the minimum ambient yield strength (tensile) of the material. However compressive shall be as per applicable code.

3.1.21 Vessels/Column to be hydrostatically shop tested in the horizontal position shall be supported adequately to keep local stresses in the shell not exceeding 90% of the yield strength of the material.

3.1.22 The lifting lug, trunion, tailing lug etc. shall be designed with shock factor 2.

### 3.1.23 CORROSION ALLOWANCE

- For an intermediate head, corrosion allowances shall be added to both sides.
- For the inside of shells, heads, nozzles and manholes, the specified corrosion allowances shall be added.
- For non removable internal parts, the specified corrosion allowances shall be added to both sides.
- For removable internal parts, the specified corrosion allowances shall be added to one side only.

### 3.1.24 HEAD / DISHED ENDS

- A formed head shall generally be made of single plate. The use of multiple piece head shall be subjected to Owner approval only in specific cases where availability of single piece is an issue.
- Whenever a dished end is made of more than two plates, it must have a crown and petal construction. Whenever a nozzle or a manhole is positioned at the centre of the dished end, the crown plate should be larger than the nozzle /manhole reinforcing pad. For heads which are not one-piece construction all head welds shall be subject to 100% radiography.
- Torispherical heads shall be used for Pressures up to 6.86 bar (g). For Torispherical heads, ratio of Knuckle to Inside Crown Radius shall not be less than 6 %.
- Beyond 6.86 bar g, heads shall be of ellipsoidal type having a ratio of major axis to minor axis 2:1 or hemispherical type. Alternatively, Hemispherical Heads with minimum weld joints may also be used.

## 3.2 INTERNALS

3.2.1 For Tray design worst of the following conditions shall be considered:

- For tray design minimum loads of 100 kg/m<sup>2</sup> in active areas and 320 kg/m<sup>2</sup> in down comer area shall be considered.
- For atmospheric, pre flash & vacuum distillation columns for trays under flash area uniform load of 500 kg/m<sup>2</sup> shall be considered. This loading shall be applicable to first three trays above flash section.
- A concentrated live load of 150 kg at any point on the installed assembly independent of other design live loads.
- Maximum horizontal deflection at effective tray loading shall not exceed 1/900 of the span or 7 mm. whichever is less.
- Corrosion allowance shall be added to both sides of trays, support rings and other fixed internal non pressure parts.

3.2.2 All internal bolting shall be of corrosion resistant material.

3.2.3 Support for packing and internal shall be designed for the worst condition. In the condition of packing liquid hold up of minimum 20% of packing volume shall be considered. Tray support beams shall have height not exceeding 20% of distance between trays for diameter up to 2400 mm and 15% of the distance between trays for higher diameters.

3.2.4 Each tray shall be so designed as to ensure liquid tight construction. Each tray shall be provided with a man-way suitable for opening both from top and bottom unless otherwise specified.

3.2.4.1 Trays will be numbered from the bottom.

3.2.5. **MINIMUM THICKNESS OF INTERNALS SHALL BE AS FOLLOWS:**

S. No.	Parts	CS & LAS (MM)	HAS (MM)
1.	Chimney tray	10	6
2.	Tray decks partition, down comers, weirs pans etc.	3.5	2.0
3.	Tray support rings & bolting bars	6.0	6.0
4.	Bubble caps	3.5	1.5
5.	Valves for trays	1.5	1.5
6.	Non-integral main & secondary supporting beams	5.0	2.0

Note: -1) All bolting size shall be minimum of M10. All nuts shall be hexagonal.

2) The min. thickness of Trays shall be as per the recommendation of Process Licensor

3) Allowable stress criterion for design of internals shall be as per ASME Section VIII Div 1.

3.2.6 All necessary approval on Hydraulic design and internal drawings shall also to be obtained from Process Licensor as applicable.

3.2.7 All removable internals shall be designed so that they can pass through the vessel man-way internal diameter / shell flange if any.

3.2.8 The LSTK Contractor shall meet the process and hydrodynamic guarantee of towers along with their Internals. All instruments including of special instruments required to verify the above requirements shall be arranged by the LSTK Contractor.

3.2.9 Each tray shall be so designed as to ensure liquid tight construction. Each tray shall be provided with a man-way suitable for opening both from top and bottom unless otherwise specified.



3.2.10 Internal distribution pipes shall have flanged connections with gaskets unless otherwise specified. Internal pipes shall be divided into suitable lengths to pass freely through the vessel manholes and internal man ways, and shall be suitably supported from shells or tray decks.

3.2.11 Internals (trays, distributors, support beams) shall be so designed that any expansion of it wouldn't affect Shell deformation.

3.2.12 Hiccups load in vapour flow up the column shall be taken into account in the tray design.

3.2.13 Total draw-off trays shall be designed for zero leakage construction and may be seal welded (if required) at Site to attain zero leakage.

3.2.14 All stainless steel tray assemblies/internals and their components (e.g. Bubble caps, valves etc.) Shall be pickled and passivated. Pickling and Passivation shall be as per ASTM 380.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PNMM/PC288/E/001/5.3.2		0	
		DOCUMENT NO		REV	
		Page 17 of 44			

3.2.15 All support rings, bolting bars, beams support brackets and other components which are integral and therefore welded to the column shell inside, shall be supplied and installed by column fabricator.

3.2.16 Demisters shall be securely fastened to support ring by bolting or clamping. all demisters to be in double density configuration

3.2.17 Seal welds shall have a throat thickness at least equal to the specified Corrosion allowance.

### 3.3. ACCESSORIES

3.3.1 Clips for platforms, ladders and piping supports shall be furnished and attached to the vessel by the Vessel manufacturer.

3.3.2 Top davits of vertical vessels shall be so designed and fabricated so that heavy valves around the vessels and internal parts of vessels can be removed and grounded without being interrupted by piping and steel structures. Minimum load bearing capacity of Top davit shall be 1 Ton.

#### 3.3.3 INSULATION SUPPORT RINGS:

- 1) Insulation support rings shall be suitable provided as per the specified insulation thickness.
- 2) Maximum longitudinal interval of insulation support rings shall be 3600 mm when preformed Insulating Materials are used.
- 3) Stiffening rings may be used as insulation support rings.

3.3.3.1 Lifting lugs of appropriate size shall be provided to ensure complete safety during erection of the Vessel.

3.3.3.2 Grounding lugs shall be attached to the vessel support for the ground connection.

#### 3.3.4 TEMPLATES

- 1) Templates for vertical vessels with skirts shall be provided for lying out of anchor bolts at site. The template shall have adequate strength against deformation. Template shall be identical to the Vessel Base Frame having double ring.
- 2) It shall be confirmed that markings of the bolt hole orientation on the templates coincides With those shown on the approved drawings.



#### 3.3.5 PLATE LAYOUT

- a) Shell plate shall be laid out so that there will be minimum of welded seams.
- b) Longitudinal and circumferential welded seams shall not interfere with nozzle openings, reinforcement plates, saddle pads, and other attachments as far as possible
- c) Longitudinal welded seams on adjacent shell segments shall be separated by at least 4 times the wall thickness of the thicker plate but not less than 100 mm.

#### 3.3.6 CONNECTIONS

3.3.6.1 Unless shown in data sheets, nozzles, manholes, and hand holes shall be ground flush and smooth inside the vessel. The edges of internal projections for both nozzles and manholes shall be rounded to a radius of 3 mm minimum. Reinforcement pads shall be external.

3.3.6.2 Main vessel seams shall not pass through openings for connections as far as possible. When unavoidable, the portion of the weld seam covered by a reinforcing pad shall be ground flush with the parent metal and 100% radio graphed prior to attachment of the pad.

 पी डी आई एल PDIL	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PNMM/PC288/E/001/5.3.2	0	
		DOCUMENT NO	REV	
		Page 18 of 44		

3.3.6.3 All reinforcing pads shall be provided with at least one telltale hole of NPT 1/8".

### 3.3.7 FABRICATION TOLERANCE

Dimensional tolerances shall be in accordance with the design codes or standards, whichever is more stringent.

### 3.3.7 HEAT TREATMENT

3.3.8.1 Fabricated vessels shall be post weld heat treated in accordance with ASME Code Section VIII, Division 1, and requirements specified in the data sheets.

3.3.8.2 The complete post weld heat treatment procedure including temperature and holding time shall be submitted to the purchaser for review. All machined surfaces shall be protected against scaling during post weld heat treatment.

3.3.8.3 All internal and external attachments, clips, insulation studs, name plate bracket, and the like shall be welded to the vessel before post weld heat treatment.

3.3.8.4 No welding, hammering or deforming is permitted on the pressure retaining parts after post weld heat treatment except as permitted by the codes or standards and when approved by the purchaser.

3.3.8.5 Simulation Heat Treatment for the Alloy Steel Material shall be carried out as per the CODE Requirement.

### 3.3.9 PICKLING

When specified, all internal / external surfaces of stainless steel shall be cleaned by pickling before hydrostatic test.

- 1) Care shall be taken so that stainless steel surfaces shall not be subject to any scratch or damage during pickling.
- 2) Weld scale and other foreign material deposited on the surfaces shall be removed.
- 3) Pickled surfaces shall be completely neutralized, and washed by freshwater

### 3.3.10 PREPARATION FOR SHIPMENT

3.3.10.1 All vessels shall be drained, clean, and free of grease, oil, scale, weld spatter, and any other foreign substance.

3.3.10.2 All flange faces and other exposed machined surfaces shall be properly protected with substantial metal shields or covering against damage during shipment.



3.3.10.3 All inside surfaces and internal parts of carbon steel shall be coated with suitable rust preventive before shipment.

3.3.10.4 All openings shall be provided with metal closures.

3.3.10.5 Test holes of reinforcing pads for nozzles and manholes shall be plugged with steel or plastic plugs.

3.3.10.6 Vent holes of saddle pads shall be plugged with plastic sealant or hard grease prior to shipment.

3.3.10.7 All threaded connections shall be plugged with threaded round bars or covered with standard pipe caps of the same material as the equipment. Covers, flanges, gaskets, bolts, and nuts furnished by the fabricator shall be shipped in place.

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		DOCUMENT NO		REV	
		Page 19 of 44			

Internals shall be tied or braced as necessary to avoid damage or dislodgment during Shipping and installation.

Baselines indicating four directions with figures of 0°, 90°, 180° and 270° shall be marked by paint on the shell. The paint colour shall be white for carbon steel and black for stainless Steel.

## PART B - DESIGN PHILOSOPHY FOR HEAT EXCHANGERS

### 3.4 SHELL AND TUBE HEAT EXCHANGERS

#### General

#### a) SCOPE

This specification covers the minimum requirements for the design, materials, fabrication and Inspection of shell and tube type heat exchangers.

- b) The Design Philosophy for the Shell & Tube Heat Exchangers shall be read in conjunction with the Design Philosophy for Pressure Vessels, as per Part – A above.

- 3.4.1 Process Shell and Tube Exchangers will comply with the requirements TEMA (Latest) Class 'R'. The tube sheet shall be analysis by Appendix "UHX" of ASME Section VIII, Div. 1 & TEMA whichever is more stringent.

(TEMA Class 'C' may be used for auxiliary heat exchangers for rotating and packaged equipment exchangers.)

- 3.4.1.1 Gaskets for Synthesis Gas, Hydrogen & other lethal services shall be of "LIP seal gasket, Diaphragm gasket, Double conical e.t.c" design unless otherwise specified by Process Licensor.

- 3.4.1.2 Tubular heat exchangers of auxiliary component for machine units such as lube oil coolers is to be designed, fabricated, inspected and tested in accordance with the manufacturer's standards and ASME Code Section VIII, Division 1, provided written approval is obtained from the purchaser.

- 3.4.2 Heat exchangers tubes thickness shall be minimum (and not average).

- 3.4.3 Mean metal temperature of tube & shell be considered in the design of fixed tube sheet exchangers.

- 3.4.4 Parts such as tubes, tube sheets, floating heads etc. which simultaneously come in contact with both shell side and tube side fluids, shall be designed considering pressure acting on one side only or the combination of pressures, whichever results in higher thickness of parts.

- 3.4.5 Exchanger saddle and foundation design shall include additional loadings generated from bundle pulling. The saddle and foundation design for all exchanger for which tube bundle pulling is foreseen during maintenance, shall be designed for longitudinal force acting at the exchanger axis. Pulling force shall be 1.5 times the bundle weights:

Further wind load and piping load shall also consider on the exchanger supports and foundation.



- 3.4.6 Tube sheets in vertical exchangers shall be provided with drain and vent arrangement with threaded plug seal welded.

- 3.4.7 Shell side "hot" nozzles shall be located at the top of the shell at the channel end whenever possible.

- 3.4.8 Lifting lug for heads or bonnets shall be provided wherever frequent dismantling is required.



- 3.4.9 Bundle weights shall be limited to 10 tonnes. In case the bundle weight increases by 10 Tones, Bidder shall take care necessary precaution in the design and fabrication of exchanger e.g. by Providing rollers



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PNMM/PC288/E/001/5.3.2		0	
		DOCUMENT NO		REV	
		Page 20 of 44			



arrangement, support plates etc. to avoid excessive loading on shell while Pulling of tube bundle, proper reinforcement in equipment support etc. Necessary arrangements for pulling/handling the tube bundle during maintenance at plant to be provided by contractor.

- 3.4.10 Saddle wear plate material shall be the same as the shell material.
- 3.4.11 Tube sheets and Girth Flanges shall be shall be of Forged Quality & Ultrasonically tested. It shall not have any segmental joint.
- 3.4.12 All heat exchanger tubes shall be seamless, cold drawn and formed from single length. CS tubes shall be normalized. LAS tubes shall be normalized and tempered.
- 3.4.13 The minimum radius of U tubes shall be not less than 2xOD of tube. Thickness of 2 inner most rows will be higher than other rows with minimum difference of 2 gauges.
- 3.4.14 For U tube bundle, the following requirements shall also be met:
- Each U tube shall be formed from a single straight length
  - All U tubes shall be cold bent
  - All C.S, C-Mo, Cr-Mo tubes shall be heat treated after bending
  - Bent portion of all U tubes shall be examined by PT and hardness check on four opposite points of bent portion shall be carried out
  - Unless otherwise specified, after bending each tube shall be tested hydraulically
- 3.4.15 Where fixed tube sheet heat exchangers are specified, thermal stress shall be checked in accordance with the TEMA standard to determine if an expansion joint is necessary.
- 3.4.16 Tube to tube sheets joints shall be leak tested with air & soap solution at pressure of 2.0 kg/cm<sup>2</sup> g wherever specified by Licensor leak testing with halogen shall be carried out.
- 3.4.17 Pass partitions shall be provided with a weep hole of about 6 to 12 mm in diameter at low points of pass partitions.
- 3.4.18 Minimum SS 304 as MOC for tubes shall be used for Heat Exchangers having Cooling Water. All tubes shall be seamless only.
- 3.4.19 After testing, all exchangers shall be completely dried.
- 3.4.20 Flow induced vibration analysis shall be carried out for all process heat exchangers.
- 3.4.21 While deciding the location of heat exchanger in the equipment layout it should be ensured that there is no restriction in complete opening of the channel, shell and floating head cover, bundle removal e.t.c. sufficient unobstructed space shall be provided in between two exchangers so as to allow a man to pass through for maintenance.
- 3.4.22 Unless otherwise stated inlet nozzles on shell side shall be provided with impingement plate in Compliance with TEMA requirement. The flow area around solid impingement plate shall be at least equal to the inlet nozzle cross-section. In case of two phase flow impingement baffle shall be perforated. Impingement baffle plate shall extent at least 25 mm beyond the projection of the nozzle bore. The clear distance from the nozzle (at the inner surface) to the impingement plate shall be at least 0.25 x nozzle diameters. The nominal thickness of the impingement baffle shall be at least 6 mm.
- 3.4.23 Where heat treatment of U-bends is required, the heat treated portion shall be extend at least 150 mm beyond the point of tangency.
- 3.4.24 All heat exchanger tubes shall be 100% eddy current tested in supplement to hydro test.

 <div>पी डी आई एल PDIL</div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div> <div>OWNER: Bharat Coal Gasification and Chemicals Limited</div> <div>DESIGN PHILOSOPHY-STATIC EQUIPMENT</div>	PNMM/PC288/E/001/5.3.2	0	
		DOCUMENT NO	REV	
		Page 21 of 44		

- 3.4.25 Attachment of tube to tube sheet will be rolled and expanded (with seal welding), strength welded or seal welded as specified on data sheets. However, as a minimum following shall be adopted:  
For tube sheet joint, tubes shall be expanded in grooved holes into the tube sheets. The expanding operation shall extend from the outer face of the tube sheets to a depth not < 90% of the tube sheet thickness. Welding shall be done in minimum two passes and each pass shall be DP checked. For tube-to-tube sheet joint GTAW (Gas-Tungsten Arc Welding) welding is required.
- (A) Tubes shall be expanded and light seal welded if all the following conditions occur simultaneously:
- Design pressure of shell/tube < 20 kg/cm<sup>2</sup>
  - Shell / Channel design temperature < 350 °C
  - Fluid not containing lethal substances.
  - Hydrogen partial pressure < 7 bars
- (B) Tubes shall be strength welded & light expanded for any condition other than listed under (A).
- 3.4.26 Mock-up test for tube to tube sheet shall be carried out for high pressure heat exchangers, Hydrogen service, Temperature above +400°C e.tc to establish all the requirements.
- Procedure shall be qualified for tube-to-tube sheet joints. The sample for tube sheet and tube for mock up test shall be drawn from the same heat Material from which the equipment shall be fabricated.
- 3.4.27 Removable tube bundle shall be provided with pulling York and suitable sliding arrangement.
- 3.4.28 Tube sheets shall have the corrosion allowance on each side. Tube Sheets from Plates shall not be used.
- 3.4.29 Floating head exchangers with test ring shall be procured as per TEMA for locating tube leaks. Drawing and calculations for test rings and test gland shall be provided by vendor for all Exchangers of applicable type
- 3.4.30 In horizontal exchanger cross baffles and support plates shall be provided with notches for draining and venting.
- 3.4.31 Dowels or match marks shall be provided to prevent misassembly of floating head covers and channels with pass partitions, channel covers with grooves, and stationary tube sheets to shell flange.
- 3.4.32. Expansion joints shall be designed for the most severe conditions of differential expansion that can occur during normal operations, start up, shutdown, or upset conditions
- 3.4.33 Expansion joints shall be of the single layer standard one-piece construction unless otherwise approved by purchaser. Length of the bellow and preset shall be specified on the manufacturer's drawings.
- 3.4.34 Expansion bellows shall be designed for min. 5000 cycle, as per TEMA
- 3.4.35 Each heat exchanger shall be hydro tested in accordance with applicable codes and standards. Service bolts shall be used in all shop hydrostatic tests. After testing, all exchangers shall be completely dried.
- 3.4.36 The shell side test shall be performed in such a manner that the Tube-to- tube sheet joints can be adequately inspected during testing.
- 3.4.37 For stacked heat exchangers, maximum two shells shall be stacked.
- 3.4.38 For stack type Heat Exchangers, complete assembly shall be hydraulically tested as a single unit except when the test pressures for individual heat exchangers are different.
- 3.4.39 Stacked exchangers shall have the lower shell(s) designed to withstand the superimposed load of the upper exchanger(s) full of water without distorting the shell and causing binding of tube bundle(s).



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		DOCUMENT NO		REV	
		Page 22 of 44			

3.4.40 The lower fixed support of stacked exchangers shall be designed for bundle pulling loads for removal of the upper bundle.

3.4.41 When two or more exchangers are stacked, the entire stack shall be shop-assembled and checked for accuracy of saddle and nozzle fit-up.

3.4.42 Bolts for connecting nozzles of stacked exchangers shall be removable without moving exchangers.

#### **3.4.44 PASS PARTITIONS**

3.4.44.1 All pass partitions shall have a gasket contact surface of 9 mm width minimum, and shall be machined to a common plane at the gasket face.

3.4.44.2 The depth of pass partition grooves in tube sheets and flat cover plates shall be a minimum of 5 mm. For alloy cladding or facing, there shall be at least 3 mm of alloy after machining beneath the pass partition groove or gasket face.

3.4.44.3 When space permits, pass partitions shall be continuously welded from both sides. In cases where space is too small for both side welding, weld shall be continuous on one side in so far as possible.

3.4.44.4 Pass partitions shall be provided with a weep hole of about 6 to 12 mm in diameter at low points of pass partitions.

#### **3.4.45 TEST RINGS**

Floating head type heat exchangers as well as U-tube type without full diameter stationary tube sheets shall be provided with test rings and test gland so that the exchanger shells may be pressure tested with the channels removed. Drawing and calculations for test rings and test gland shall be provided by vendor for all exchangers of applicable type.

#### **3.4.46 HYDRO TESTING**

3.4.46.1 Each heat exchanger shall be hydro tested in accordance with applicable codes and standards. Min duration of Hydro test shall be 60 min.

3.4.46.2 The shell side test shall be performed in such a manner that the Tube-to- tube sheet joints can be adequately inspected during testing.

3.4.46.3 Hydro Testing sequence & procedure for testing Exchangers having Lip Seal Gasket shall be approved by the Purchaser.

3.4.46.4 Stacked units shall be hydraulically tested in the fully assembled condition.

3.4.46.5 Each heat exchanger shall be air leak tested & helium leak tested (if specified by Process Licensor) at the pressure specified in the data sheet.



3.4.46.6 After testing, all exchangers shall be completely dried.

3.4.46.7 Service bolts shall be used in all shop hydrostatic tests.

3.4.46.8 a) Gaskets used during testing shall be same as specified for operating conditions. However all joint Gaskets shall be replaced by new gasket which will be opened after Hydro testing.

#### **b) Testing Requirement of Heat Exchanger / Cooler / Condenser Testing at Site:**

Over and above the shop testing, minimum 10% or at least one no. (Whichever is higher) of a particular type of Heat Exchanger / Cooler / Condenser of a Vendor to be tested (Cover Test) at site

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PNMM/PC288/E/001/5.3.2		0	
		DOCUMENT NO		REV	
		Page 23 of 44			



after installation / before commissioning. If there is any leakage observed during testing, all Hydro tests (shell test/Tube test/cover test) are to be performed for particular Heat Exchanger / Cooler / Condenser and all other Heat Exchanger / Cooler / Condenser shall also be cover tested to ensure the integrity of equipment before start-up of plant.

### 3.5 PLATE TYPE HEAT EXCHANGER



- 3.5.1 The plate type exchanger shall be designed in accordance with "API 662"
- 3.5.2 All plates shall be pressed from a homogeneous single metal sheet in one placing and normal thickness of plate being pressed shall not be less than 0.5 mm
- 3.5.3 Nozzle neck attachments shall be with full penetration weld. Set on nozzles are not permitted.
- 3.5.4 Lock washers shall be provided for all rotated nuts.
- 3.5.5 SS plate shall be of SA 240 specification.
- 3.4.6 For gasket type PHE, vendor shall be responsible for the compatibility of gasket material & Glue, selected for specified fluids and design conditions.
- 3.5.7 All components in contact with process fluids shall be as per Process data sheets (PDS).
- 3.5.8 Equipment shall be hydro tested at test pressure limits (as differential pressure) for 30 Minutes minimum. Also mechanical strength of the frame shall be tested by raising the Pressure on both side equivalents to test Pressure (i.e. 1.3 times design pressure) for 90 Minutes minimum.
- 3.5.9 All nozzles of Heat exchanger shall be of extended type. Studs connections are not acceptable.
- 3.5.10 The plate shall be fully supported by carrying bar and only guided by the guide bar.
- 3.5.11 The carrying bar shall be designed to support at least 1.5 times the total weight of movable cover and plate pack filled with water or process fluid whichever is having greater density.
- 3.5.12 Bidder shall furnish the complete details of the offered system like features, properties of the Descalant, system description, operating details etc.
- 3.5.13 Vendor to develop methodology or device to get the entrapped gases escaped during welding and also to ensure that no processed fluid should get entrapped during operation in such area otherwise it may lead to crevice Corrosion.

### 3.6 Storage Tanks

- 3.6.1 The following design codes shall be adopted for tank design as applicable:
  - i) API 650 Welded Steel Storage Tanks for Oil Storage
- 3.6.1.1 For fixing the nominal capacity of the cone roof tank, allowance for free board (minimum 500 mm), vapour space and dead liquid space at the bottom shall be taken in to account. Tank diameter and height shall be firmed up based on nominal capacity (Cylinder volume).
- 3.6.2 For Carbon Steel storage tanks the minimum thickness shall be based on stability considerations. Minimum thickness for roof & shell shall be 5 mm, and bottom plate 6 mm.
- 3.6.3 Storage tanks up to 4meter in diameter shall be shop fabricated items. Tanks with diameters greater than 4 meter shall be field erected.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PNMM/PC288/E/001/5.3.2		0	
		DOCUMENT NO		REV	
		Page 24 of 44			

- 3.6.4 Tanks constructed of stainless steel shall comply with API 650, Appendix S.
- 3.6.5 Shell seams shall be located to clear openings to the maximum extent possible in accordance with API 650.
- 3.6.6 Bottom plates may be lap-welded with the lap toward the direction of drainage. Butt welded bottom plates shall be furnished when specified on the tank drawings or data sheets or when tanks are specified to have rubber lining.
- 3.6.7 For each surface in contact with product/vapour, the specified corrosion allowance shall be added to the required thickness of all load-carrying components including shell, roof, bottom and roof supports. & One-half the specified corrosion allowance shall be added to each surface of no-load-carrying internal components.
- 3.6.8 All walkways, stairways, and platforms shall be furnished with handrails on open or exposed sides. All the nozzles/manholes on roof shall be accessible through platform.
- 3.6.9 Anchor bolts shall be provided based on design considering wind/seismic loads, uplift due to internal pressure etc. However, tanks having diameter  $\leq 10$  meter shall be provided with anchor Bolts and shall be spaced at approximately 1.8M of circumference.
- 3.6.10 Maximum height of unstiffened shell shall be calculated based on the corroded thickness of shell courses. Section modulus of wind girders shall also based on corroded thickness of shell courses.
- 3.6.11 All storage tanks shall be designed considering liquid height up to top curb angle of shell Using one foot method for tanks less than and equal to 60 meter. However for seismic design, operating liquid level may be considered. All design calculation shall be carried out in corroded condition.
- 3.6.12 Unless otherwise specified bottom plate slope shall be 1:100 from the centre of the tank towards shell.
- 3.6.13 Butt welded annular ring below shell (minimum 8 mm thick excluding corrosion allowance) shall be provided for all tanks of diameter 12 m and above.
- 3.6.14 Fabrication tolerance on shell, bottom, and foundation e.t.c. shall be as per applicable code.
- 3.6.15 Anchor bolt shall be provided if required by calculation for uplift or stability for wind and Seismic load. Minimum anchor bolt size shall be M24. Tanks with diameter  $\leq 10$  m shall be provided with anchor bolt at spacing of maximum 1.8 m, however minimum 4 nos of M24 shall be provided for all tanks with diameter  $\leq 10$  m.
- 3.6.16 All tanks shall be provided with under tank leak detection and sub grade protection system as per appendix-I of API-650 for applicable foundation Type.
- 3.6.17 Thickness of tank bottom shall be determined as per API-650 Appendix –I for tank bottom Supported by Piers/grillage. Maximum deflection of Corroded bottom plate shall not be more than half of the thickness.
- 3.6.18 The roof plates shall be self supported or supported by structure. Column supported roof shall not be acceptable. The roof and its supporting structure shall be designed to carry the dead Load, internal and external pressure as specified in process data sheet and live load as per design code.
- 3.6.19 Inside/outside painting of tanks shall be carried out based on product stored and as per Process data sheet enclosed elsewhere in NIT package.

 <div>पी डी आई एल PDIL</div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div> <div>OWNER: Bharat Coal Gasification and Chemicals Limited</div> <div>DESIGN PHILOSOPHY-STATIC EQUIPMENT</div>	PNMM/PC288/E/001/5.3.2	0	
		DOCUMENT NO	REV	
		Page 25 of 44		

### 3.7 FRP/GRP TANKS

#### Codes of Construction

- ASME X Rule for Construction
- BS EN 13121

#### Materials and material testing

- ASTM C-581 Chemical resistance of Resins
- ASTM D-2150 Woven roving Laminated FRP
- ASTM D-2583 FRP hardness test
- ASTM D-2584 Ignition loss of cured FRP
- ASTM D-2990 Flexural creep and Creep-rupture
- ASTM D-2997 Machine made FRP pipe
- ASTM D-3299 Filament-wound reinforcing
- ASTM D-3892 Resin and FRP packaging
- ASTM D-4024 Machine made FRP flanges
- ASTM D-4097 Contact-molded FRP tanks
- ASTM D-5421 Contact-molded FRP flanges
- ASTM D-618 Plastics testing conditions
- ASTM D-638 Plastics tensile properties testing.
- ASTM D-695 Plastics compressive testing
- ASTM D-883 Plastics terminology
- ASTM F-412 Plastics piping terminology

#### Equipment testing

- ASME V Non-destructive examination



#### Flange Drilling and bolting

- ASME/ ANSI B 16.5 Flanges and flange fittings
- ASME/ANSI B 16.47 Large diameter steel flanges

- 3.7.1 Graphite powder/ Resin paste shall be applied behind all welds to provide a permanent earth Path for spark testing. Permanent metal foil strips shall not be permitted.
- 3.7.2 Flange face (Front & back) shall be smooth & flat. If the flange faces are machined, the full Chemical liner shall be reinstated.
- 3.7.3 The Barcol Hardness of FRP/GRP wall shall be tested according to ASTM D2583.
- 3.7.4 The difference in the glass content of FRP/GRP between the samples shall not be more than 5% wt.
- 3.7.5 All items shall be cured in accordance with the resin supplier's instructions. wherever possible curing shall be done at Manufacturers works.
- 3.7.6 High frequency sparks testing

All production thermoplastic welds shall be examined visually & by high frequency spark test equipment at the following stages:

- Completion of first weld run
- Completion of external run

 <div>पी डी आई एल PDIL</div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div> <div>OWNER: Bharat Coal Gasification and Chemicals Limited</div> <div>DESIGN PHILOSOPHY-STATIC EQUIPMENT</div>	PNMM/PC288/E/001/5.3.2	0	
		DOCUMENT NO	REV	
		Page 26 of 44		

- After pressure or static head test
- After any boil out test

3.7.7 Reinforcing materials used on the inner surface shall be in compliance with the latest edition of ASTM D3299.

3.7.8 For FRP/GRP tanks, thickness of Corrosion barrier of the thermoplastic lining shall not be included in the thickness calculation, to withstand design condition.

### 3.8 WASTE HEAT BOILER

3.8.1 The following as a minimum are included in the scope of work: Material selection, provision of proper corrosion allowance, all necessary piping, valves, filling and instrumentation etc., provision of access for maintenance and operation, refractory lining and anchor nuts etc., thermal and mechanical design and calculation, stress analysis of piping and pressure parts, loading data for civil design, engineering for plot plan, equipment layout, P&ID, process flow diagram, utility and chemical consumption etc., fabrication including forming, welding, heat treatment, testing etc., transportation, site erection and performance guarantee, over pressure protection, compliance with regulatory inspection requirements etc.

3.8.2 Material of construction shall be selected by manufacturer considering service conditions and special conditions with respect to prevention against metal dusting and nitriding.

3.8.3 In addition to requirements of ASME Sec VIII Div 1 & UHX tube sheet shall be analysed using finite element analysis method (FEM) along with design calculation and other fabrication drawings of boiler.

3.8.4 Calculations showing adequacy of tube bundle against flow induced vibration shall be the responsibility of LSTK Contractor.

3.8.5 Thin stiffened tube sheet design with lip joint between tube to tube sheets is not acceptable. The weld joint between tube to tube sheet shall be full penetration weld.

3.8.6 IBR Approval for Design Calculations drawings, documents. Testing as per IBR requirements & Certification shall be in the scope of LSTK Contractor. All vendors, sub-vendors, fabricators & welders etc should be IBR approved.

### 3.9 Safety



3.9.1 Safety standards and features which are inherent in the specific mechanical equipment design codes, standards and regulations are applicable.

3.9.2 Safety features to be incorporated into the design include, but are not limited to, the following features for equipment:

- Ladder cages
- Safety chain across platform access
- Step-off platforms where necessary
- Platform grating
- Toe plates

### 3.10 OPERABILITY AND MAINTENANCE

3.10.1 Equipment design and layout shall provide for ease of access, operability and maintenance

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PNMM/PC288/E/001/5.3.2		0	
		DOCUMENT NO		REV	
		Page 27 of 44			



#### 4.0 Fabrication

- 4.1 The Bidder shall comply in all respects with the provision of the applicable codes, standards and specification during fabrication with respect to tolerances, welding, fabrication, forming of heads, radiography, heat treatment, inspection, testing and quality control etc. unless & otherwise specified.
- 4.2 Plates of different thicknesses shall be made flush with the inner surfaces of equipment unless otherwise stated.
- 4.3 All flange bolts & skirt-bolts shall straddle centre line unless otherwise stated.
- 4.4 Due provisions must be kept for venting out entrapped gases during welding of pads, flanges and liner plates etc.
- 4.5 All welding shall be carried out by qualified welders using approved procedures in compliance with the requirements of codes, standards & specifications and shall be duly certified by the concerned inspecting authority. All welding procedures must be got approved from authorised inspecting authority before starting any fabrication job. Welding of all parts must be completed before heat treatment.
- 4.6 All welds shall be full penetration welds with back chipping and re-welding from the second side. For those joints which are inaccessible for back chipping the root run shall be carried out with TIG process. Single side welding with backing strips shall are not permitted.
- 4.7 All parts shall be fabricated in accordance with good shop practice and in uniformity so that all corresponding parts will be inter-changeable.
- 4.8 All sharp corners shall be rounded off with smooth radius. Inside edge of manhole and hand hole at the internal surface shall be rounded to minimum radius 3 mm.
- 4.9 In case of nozzle with butt-end construction, extra length shall be provided to facilitate hydraulic testing and subsequently cutting and edge preparation to suit piping welding at site.
- 4.10 All nozzles less than or equal to NB 65 mm shall be stiffened with three equispaced plate ribs of the same material as that of shell.
- 4.11 Flange facing and thread connection shall be protected against oxidation during HT
- 4.12 Longitudinal and circumferential welded seams shall not interfere with nozzle openings, reinforcement plates, saddle pads, and other attachments as far as possible.
- 4.13 Welding wherever specified, is to be done by qualified and approved welders using the suitable fillers and fluxes recommended for the materials in the fabrication drawings.

#### 5.0 Inspection & Testing

- 5.1 Equipment shall be inspected and tested in accordance with the relevant codes, standards and specifications by TPIA (owner approved). Cost of TPIA shall be under LSTK Contractor scope. The Inspection and testing shall be in accordance with the relevant codes, standards, specifications, including mandatory NDT requirements indicated under Inspection and Testing clause 5.3 & Inspection guidelines (Annexure-2). All equipment & bought -out items shall be inspected during various stages of manufacturing starting from identification of materials to final completion as per agreed QAP which shall be prepared by LSTK Contractor and shall duly approved by Owner/ It's authorised representative. In case of site fabricated/assembled equipment same inspection agency shall be responsible for inspection and testing at site. The guidelines for minimum inspection requirements are listed in **Annexure-2** & also defined under Inspection & Testing clause of the design philosophy.





 <div>पी डी आई एल PDIL</div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div> <div>OWNER: Bharat Coal Gasification and Chemicals Limited</div> <div>DESIGN PHILOSOPHY-STATIC EQUIPMENT</div>	PNMM/PC288/E/001/5.3.2	0	
		DOCUMENT NO	REV	
		Page 28 of 44		

- 5.1.1 The final Inspection & Test Plans (ITPs) based on the indicative ITP (**Annexure-3**) shall be developed by the contractor as per contract specifications & codes and shall be submitted to PMC/Owner for approval. Inspection and Test Plan shall include detailed manufacturing/inspection activities including those of sub-supplied/ bought out items. The indicative ITPs enclosed in the NIT are for guidance to the LSTK Contractor and may not cover some of the activities to be performed during execution of works under the scope of this contract.
- 5.2. The equipment shall be inspected by Third party inspection agency (TPIA) (owner approved) as defined elsewhere as inspection agency. It shall be the responsibility of the bidder to make available to the inspector all the drawings, calculations and other documents. However the Principal shall have free access for inspection at vendor's/sub-vendor's shop and at site during project execution.
- 5.2.1 The equipment shall be considered acceptable for despatch only after final certification for acceptance is issued by concerned inspector.
- 5.2.2 All parent material (Primary & Secondary Components), welds and HAZ shall be impact tested at Minimum Design Metal Temperature (i.e. minimum service temperature or the temperature to be computed as per applicable codes, standards & specifications) by Bidder and shall have impact energy values as per the applicable codes, standards & specifications.
- 5.2.3 Production control coupons, when required as per codes & standards shall be subjected to impact test, corrosion test etc. in addition to mechanical tests as required. In case of heat treated equipment test coupons shall be given similar heat treatment as for the equipment.
- 5.2.4 Formed heads when fabricated in pieces shall be normalised and weld seams fully radio graphed after forming.
- 5.2.5 Vessel containing lethal, toxic and highly inflammable substance shall be fully radio graphed and stress relieved.
- 5.2.6 All nozzle reinforcing pads shall be tested pneumatically at 0.5 Kg/cm<sup>2</sup>g pressure with soap solution on attachment welds. Vent holes shall be plugged with non hardening mastic to prevent ingress of water.
- 5.2.7 All completed equipment shall be tested hydraulically as per the requirements of codes, standards & specifications in presence of the inspecting authority. Pneumatic test of completed equipment shall be carried out only when specially mentioned in the specification sheets. Chloride content in water used for testing shall not exceed 30 ppm for SS equipment and 40 ppm for CS and low alloy steel equipment. Duration of test shall be as minimum 1 hour. Hydrostatic test shall be done prior to painting at weld and/or coating on weld.
- 5.2.8 The temperature of test water shall comply with requirement of Fabrication code.
- 5.2.9 Unless otherwise stated gaskets used during testing shall be same as specified for operating conditions.
- 5.3 The following NDT requirements are mandatory in addition to codes, standards & specification requirements:

#### **A) UT examination**

- i) All butt - welds in thickness greater than 50mm as supplement to radio graphed.
- ii) FPW of nozzle attachments of thickness above 50mm as supplement to radiography
- iii) Clad Plates and formed heads from clad plates in all thicknesses
- iv) All forgings
- v) RT-1/ 100% radiographed equipment , Welds including nozzle -to-shell joints that cannot be radiographed, shall be 100% UT examined.
- vi) All butt welds after hydro test (for CS and LAS).

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PNMM/PC288/E/001/5.3.2	0	
		DOCUMENT NO	REV	
		Page 29 of 44		

### **B) MP / PT examination**

- i) All edges of plates and opening in shell of CS having thickness equal to & above 40mm and LAS / SS having thickness more than 25mm
- ii) Root and final layer of all butt welds
- iii) Fillet welds of SS
- iv) All weld surfaces after PWHT
- v) Each layer of weld deposit in SS overlay
- vi) Knuckle surfaces of dished ends, expansion bellows and pipe bends
- vii) All forgings after machining
- viii) Skirt to head joint
- XI) All welds of SS and non ferrous materials and welds for vessels with design temp. (-) 45 degree C and below after hydro testing.
- x) All welds of SS over ¾ inch thk. after hydro testing.

### **C) Radiography:**

- i) All weld seams of formed head, if made in more than one segment shall be full radio graphed after forming.
- ii) When spot radiography is specified, all T – Joints & minimum 10% of total weld length excluding T joints shall be radio graphed.
- iii) All nozzles fabricated from plates shall be 100% radio graphed.
- iv) Radiography of welds in C - 1/2 Mo & Cr - Mo - Steel shall be carried out after heat treatment.
- v) Vessel containing lethal, toxic and highly inflammable substance shall be full radio graphed.

Hardness test on welds of Cr-Mo, Materials after final heat treatment. The value shall not exceed to:

- i) 215 HB for steel having Cr content less than 2%
- ii) 240 HB for steel having Cr content more than 2%

**Note:** If a vessel is not 100% radio graphed and/or UT tested, then a minimum examination of butt, corner & T-joints shall be made.

## **6.0 Pickling and Passivation**

6.1 All SS material shall be Pickled & Passivated as per following procedures:



### **6.1.1 Pickling**

Aqueous pickling solution shall be as follows:

Nitric acid (Tech. grade) 10 to 25% plus Hydrofluoric acid 1 to 8% (to be used only for stabilised SS grades). Temperature 50 to 60° C for 10% Nitric acid and 20° C for 25% Nitric acid. When size and shape of product permit, total immersion in the pickling solution is preferred. Where immersion is impractical, pickling may be accomplished by wetting the surface by

- i) Swabbing or spraying
- ii) Partial filling the item with pickling solution and rotating or rocking so that all the surface receives the required chemical treatment.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PNMM/PC288/E/001/5.3.2		0	
		DOCUMENT NO		REV	
		Page 30 of 44			

The maximum period for which the pickling solution shall be allowed to remain on the surface is 30 minute. During pickling removal of oxides may be hastened by brushing with a hard fibre or SS wire brush. Over pickling shall be avoided.

The pickling agent shall be washed off with plenty of water so as to leave no trace behind.

#### 6.1.2 Passivation

After pickling and water rinsing, an aqueous caustic permanganate solution containing NaOH 10 weight % and KMnO<sub>4</sub> 4 weight % shall be used for neutralising pickling solution. This shall be followed by thorough water rinsing.

Water used for pickling and washing shall not have chloride contents exceeding 30 ppm.

#### 7.0 Painting

7.1 All CS external surfaces of shop fabricated equipment shall be primer and final painted as Listed elsewhere in NIT document.

#### 8.0 Insulation & Fire Proofing

8.1 The equipment shall be insulated as Listed in NIT document.

8.2 Fire proofing, if required shall be considered as per Process Licensor's recommendations.

#### 9.0 Spares Parts (Erection & commissioning, Mandatory spares)

##### 9.1 Erection & commissioning Spares

9.1.1 All commissioning spares shall be included by LSTK Contractor in their scope of supply and shall be part of the main equipment.

##### 9.2 Mandatory spares

9.2.1 Mandatory spares shall be supplied by the LSTK contractor as per Section-10 of ITB.

#### 10.0 Documentation Schedule

Documents shall be submitted as per "Documentation schedule" in Section-9 of ITB

#### 11.0 PACKAGING, IDENTIFICATION AND STORAGE INSTRUCTIONS



11.1 All equipments shall be properly packed/ crated to provide adequate protection during shipment to site.

11.2 Detailed packing list in waterproof envelope shall be inserted in the package together with the equipment.

11.3 The equipment shall have an identification plate giving salient equipment features such as make, year of manufacture, equipment no., name of manufacturer etc.

11.4 Packaging shall be, unless otherwise stated suitable for prolong storage at site to prevent undue corrosion and damage before erection and commissioning of the equipment. Bidder shall also furnish the procedures/instructions for long time storage of the equipment.

11.5 All equipment, internals shall be properly stored at site within temporary shed by LSTK Contractor.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PNMM/PC288/E/001/5.3.2	0	
		DOCUMENT NO	REV	
		Page 31 of 44		

## 12.0 DISPATCH

- 12.1 Equipment intended for ship transportation shall be transported in the hatch of the ship. Suitable seaworthy packing/painting shall be applied to avoid any damage during transportation.
- 12.2 The complete transport, packing & forwarding of equipment shall be the responsibility of bidder. In case of inland transportation, equipment shall be properly lashed/fixed on the wagon/trailer to avoid any damage due to shocks during transport. In case of ODC (Over Dimensional Consignment) movement, ODC sanction for movement either by rail/road shall be arranged by bidder from appropriate authorities.
- 12.3 All spares shall be properly packed, marked & sent separately along with equipment.
- 12.4 Equipment shall be despatched with High purity nitrogen (HPN) filling. Dry nitrogen shall be filled at a pressure of 0.5 kg/cm<sup>2</sup>g and equipment shall be filled with a pressure gauge and a valve along with nitrogen cylinder.

## 13.0 Vendor List

All equipment shall be procured/ fabricated as per approved vendor list (Section -15). Any equipment for which vendor list is not enclosed, the LSTK Contractor may furnish a list of their proposed vendors along with their references for supply of similar type of equipment along with bid. However all the additional proposed vendors shall have well proven track record and shall be subjected to consultant/owner's approval.

## 14 Guarantees

### 14.1 Mechanical Guarantee



LSTK Contractor shall guarantee the equipment & their components against faulty design with regard to their mechanical adequacy, improper material of construction & poor workmanship for the period specified in contract.

### 14.2 Performance Guarantee

LSTK Contractor shall stand Guarantee of equipment as per respective technical specifications/Process Data sheet.

## 15.0 AS BUILT DOCUMENTATION

Shop changes made by LSTK Contractor/ fabricator after approval of drawings under Code-1 by PMC/ Owner and deviations granted in deviation permits, if any, shall be marked in hard copy of drawings which shall then be stamped 'As-built' by the LSTK Contractor. These 'As built' drawings shall be reviewed and stamped by Authorized Inspector also. LSTK Contractor shall prepare scanned image files of all marked-up 'As-built' drawings. LSTK Contractor shall also incorporate the above changes in the native soft files of the drawings. Authorized Inspector shall ensure/certify completeness of Final/As-built documents before equipment dispatch. In addition, LSTK Contractor shall also incorporate site changes, if any, based on mismatch observed at site and resubmit the 'As-built' documents.

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		DOCUMENT NO	REV	
		Page 32 of 44		

**ANNEXURE-1**  
**CALCULATION METHOD**  
**DYNAMIC WIND ANALYSIS (GUIDELINES)**  
**FOR VERTICAL EQUIPMENT**

Check of the towers for dynamic wind moments due to vortex shedding shall be performed based on following assumptions:

$$V_{cr} = f \cdot D / St$$

$V_{cr}$  = Critical wind velocity  
 $D$  = Outside diameter of tower  
 $f$  = First natural frequency of tower considering foundation complete rigid (s-1)  
 $St$  = Strouhal number, may be taken as 0.15 for  $Re > 10^6$  and 0.2 for  $Re < 10^6$   
 $Re$  = Reynolds number at critical wind velocity

For  $V_{cr} < 30$  m/s following shall be considered :

The tower shall be checked for additional moments due to vortex shedding in 2 cases.

1. Operating condition
2. Shut down condition

Dynamic wind moment shall be calculated as follows:

$$M_d = P_d \cdot C_k \cdot S \cdot \pi / d \cdot H$$

$P_d$  = Wind pressure at critical velocity =  $0.5 \cdot \rho \cdot (V_{cr})^2$   
 $C_k$  = Crosswind oscillatory force coefficient may be taken as  **$0.5 + (4 - \log_{10} Re)/5.7$  for  $Re < 10^6$  and  $0.17$  for  $Re > 10^6$**   
 $d$  = The logarithmic decrement of damping. For towers with trays or packing it is estimated 0.035  
 $S$  = Surface on which dynamic wind forces are acting (height \* diameter)  
 $H$  = Height from base ring of point of application for dynamic wind force  
 $\pi$  = 3.14  
 $\rho$  = Density



For tapered construction only the tip diameter shall be considered in calculation.

Moments to be considered for dynamic wind:

$$M_{res} = \sqrt{(M_d)^2 + (M_{st})^2}$$

$M_{st}$  = Static wind moment at critical wind velocity

Only if  $M_{res}$  exceeds moments due to static wind or earthquake moments, it shall be considered for equipment design.

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		DOCUMENT NO	REV	
		Page 33 of 44		

## **ANNEXURE-2**

### **INSPECTION GUIDELINES**

#### **1.0 GENERAL**

The min. Inspection to be carried out by Authorized approved Inspection agency:



#### **1.1 VESSELS**

- a) All carbon steel plates shall be identified against mill-test certificates at the VENDOR'S works before commencement of fabrication.
- b) Establish that welding procedure and welders are qualified and welding electrodes are approved before commencement of fabrication.
- c) Check fit-up and witness chipping-back of welded seams.
- d) Wherever applicable, select spots for radiography, D.P and M.P Tests.
- e) Witness any crack detection, hardness checks, ultrasonic tests etc. which may be specified. (1)
- f) Review radiographs and in case it is unsatisfactory re-radiograph. (1)
- g) Witness hydrostatic test.
- h) Dimensionally check and carry out final internal and external inspection for quality of workmanship.
- i) Check that all material test certificates and, where applicable, heat treatment charts are in order. Ensure that VENDOR is familiar with the requirements regarding data books and ensure that the documentation is submitted without any delay.
- j) Check internal lining of reactors and vessels (if applicable) to specifications.
- k) Witness any further test recommended by Process Licensor/Inspection agency and/or OWNER.

Note (1): X or Gamma rays

#### **1.2 VESSEL INTERNALS**

- a) Leak testing & final inspection is required.
- b) Check one tray of each diameter and type, mock assembled in the tray vendor shop.
- c) Spot check for interchangeability of parts, where applicable.
- d) Ensure that any uncommon down comers are fully assembled and offered along with their respective trays.
- e) Where new designs and/or new VENDOR's are concerned, check that any applicable leakage tests have been carried out on prototype.
- f) Check that materials including welding electrodes are in accordance with the requirements of the order and all applicable specifications and standards.

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		DOCUMENT NO		REV	
		Page 34 of 44			

### 1.3 HEAT TRANSFER EQUIPMENT

#### 1.3.1 SHELL AND TUBE EXCHANGERS

- a) All carbon steel plates shall be identified against mill test certificates at the VENDOR'S works before commencement of fabrication.
- b) Establish that welding procedure and welders are qualified before commencement of fabrication.
- c) Check fit-up and witness chipping-back of welded seams.
- d) Wherever applicable, select spots for radiography.
- e) Witness any crack detection, hardness checks, ultrasonic tests etc. which are specified in drawing, specification, data sheet etc.
- f) Review radiographs. (1)
- g) Witness all hydrostatic tests on shell and tube sides.
- h) Complete dimensional check for stacked units. This is to be carried out in the full assembly stage.
- i) Check that all material test certificates and where applicable, heat treatment charts are in order. Ensure that VENDOR is familiar with the requirements regarding data books and see that the documentation is submitted without any delay.
- j) Witness any further test recommended by Process Licensor/ Inspection agency and/or OWNER.

Note (1): x or Gamma rays



#### 1.3.2 DOUBLE PIPE EXCHANGERS

- a) Welding procedure and welders to be qualified.
- b) Check fit-up of pipes.
- c) Witness hydrostatic, D.P. & M.P. tests.
- d) Check material certificates and identify the same.
- e) Carry out final inspection and dimensional checks, review radiographs (note (1)) and check material test certificates.

Note (1): X or Gamma rays


### 1.4 STORAGE TANKS

- a) Shell plates to be dimensionally checked (including diagonals for square-ness) before rolling to curvature.
- b) All shell plates to be inspected and dimensionally checked after rolling to curvature.
- c) Check material test certificates and ensure that all shell plates are clearly stamped with the cast and plate number, so that they can be identified against the relevant test Certificates.

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		DOCUMENT NO	REV	
		Page 35 of 44		

- d) Check material test certificates for roof and bottom plates.
- e) Select the spot radiographs, D.P & M.P test as per codes.
- f) Review the radiographs. (1)
- g) On completion of inspection of shell plates ensure that vendor provides a chart giving all plate numbers, tier by tier.
- h) Inspect fabrication of all fabricated fittings. This is to include checking of material test Certificates also.
- i) Inspect tank gauging equipment.
- j) For shop fabricated tanks, witness hydrostatic tests to applicable standards.
- k) Check welding material electrodes.

Note (1): X or Gamma rays

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>		PNMM/PC288/E/001/5.3.2	0
			DOCUMENT NO	REV
	<b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>		Page 36 of 44	




## ANNEXURE-3

### INDICATIVE ITP

### FOR

### SHELL AND TUBE HEAT EXCHANGER (ITP-01)



### PRESSURE VESSELS (ITP-02)

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>		PNMM/PC288/E/001/5.3.2	0
			DOCUMENT NO	REV
	<b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>		Page 37 of 44	



**INDICATIVE QAP/ITP –**  
**SHELL AND TUBE HEAT EXCHANGER**  
**(ITP-01)**




 <div>पी डी आई एल PDIL</div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div> <div>OWNER: Bharat Coal Gasification and Chemicals Limited</div> <div>DESIGN PHILOSOPHY-STATIC EQUIPMENT</div>	PNMM/PC288/E/001/5.3.2	0	
		DOCUMENT NO	REV	
		Page 38 of 44		

**INDICATIVE QAP/ INSPECTION AND TEST PLAN- SHELL AND TUBE HEAT EXCHANGER (ITP-01)**



**Shell and Tube Heat Exchanger**

Sl. No.	DESCRIPTION OF ACTIVITY	INSPECTION BY					
		VENDOR	TPIA	LSTK CONTRACTOR	LICENSOR	OWNER/ PMC	RECORD
01	Detailed Inspection & Test Plan after issue of PO/PR/PS by LSTK contractor (including for bought out items)	P	R	A		R	X
1.1	Design & Drawing Approval	P	I	A		R	
02	Inspection & Test Procedures such as NDT, PWHT, Pressure test, Hardness, PMI, Painting, etc.	P	A	A		I/R	X
03	Pre inspection meeting	P	H	H		I/H	X
04	Welding Procedure Specification (WPS) & Procedure Qualification Record (PQR) with weld map	P	H	A		I	X
05	Welders Qualification Record	P	R	R		I	X
06	Welding Consumable Batch Certificate	P	R	R			X
07	Mock up test for tube to tube sheet joint	P	W	W/R		I	X
08	Sub order verification						
	a Material Identification	P	W/R	R			X
	b Sampling for test	P	W/R	R			X
	c Mechanical/Corrosion Testing	P	W/R	R			X
	d Relevant NDT	P	W/R	R			X
	e Hydro test as applicable	P	W/R	R			X
	f Final Visual/Dimension	P	W/R	R			X
09	Material for Pressure Parts after receipt – Inspection, Identification w.r.t. Mill / Manufacturer's Test Certificate, Review of MTC	P	H	W/R			X
10	Material for Non Pressure Parts / Structural – Inspection, Identification with Test certificate & Review of certificate.	P	R	R			X
11	Formed Components such as Dished ends, Cones etc.						
	A Visual, Dimensional, Profile, Thickness checks	P	W	R			X
	b NDE of weld joint	P	W/R	R			X
	c PT on inside & outside surface	P	W/R	R			X
	d Heat treatment chart (if applicable)	P	R	R			X
	e Testing of Test coupon as applicable	P	W/R	R			X
	f UT for lack of bond in formed shell, cone etc. For Cladded equipment	P	W/R	R			X

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>			PNMM/PC288/E/001/5.3.2	0
				DOCUMENT NO	REV
				Page 39 of 44	




12		Inspection for Weld Overlay					
	a	PT after first layer of weld overlay	P	W/R	R		X
	b	PT after final layer of weld overlay	P	W	R		X
	c	Check of effective thickness of weld overlay	P	W	R		X
	d	Check of Chemical composition at required depth as applicable	P	W	R		X
	e	Ferrite check of weld overlay (if applicable)	P	RW	R		X
13		Weld edge preparation & set up of pressure retaining weld joints					
	a	Visual & Dimensional	P	W/R	R		X
	b	MT / PT of weld edges	P	W/R	R		X
14		ISR, DHT for LAS as applicable during welding	P	W/R	R		X
15		PT of root run for single side weld / back chipped surface of weld for pressure retaining weld joints	P	R	R		X
16		Inspection of completed pressure retaining weld joints					X
	a	Visual check for reinforcement, undercuts, surface defects etc.	P	W	R		X
	b	NDE before PWHT as applicable	P	W/R	R		X
	c	Dimensional check before PWHT	P	W	R		X
	d	Clearance for PWHT	P	H	R		X
	e	PWHT	P	R	R		X
	f	NDE after PWHT as applicable	P	W/R	R		X
	g	Hardness check after PWHT (as applicable)	P	RW	R		X
	h	Testing of Production Test coupon as applicable	P	W	W/R		X
17		NDE of Non pressure weld joints	P	R	R		X
18		Pull through test of shell	P	H	W/R		X
18.1		Tube Bundle Assembly					
	a	Tube to Tube sheet joint mock up procedure & qualification	P	H	W/R		X
	b	Inspection of Tube sheet after machining	P	W	W/R		X
	c	Skeleton assembly of Tube bundle before tube insertion	P	H	W/R		X
	d	Hydro testing of U tubes	P	W	W/R		X
	e	Final inspection after tube insertion	P	W	W/R		X
	g	Tube to Tube sheet expansion check (Thinning, Length of expansion, Go / No – Go gauge check etc.	P	H	W/R		X
19		PMI of all pressure parts and welds for AS/SS material	P	RW	R		X
20		Final visual & Dimensional check, including internal, external & alignment, match markings for site joints etc.	P	H	H		X
21		Trial assembly of internals if	P	W	W/R		X

 <div>पी डी आई एल PDIL</div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div> <div>OWNER: Bharat Coal Gasification and Chemicals Limited</div> <div>DESIGN PHILOSOPHY-STATIC EQUIPMENT</div>	PNMM/PC288/E/001/5.3.2	0	
		DOCUMENT NO	REV	
		Page 40 of 44		



	any						
22	Pneumatic test of pads and Tube to Tube sheet joint and Helium leak test (as applicable)	P	W	R			X
23	Hydrostatic test – Shell side, Tube side outside shell, Shell & Tube side after assembly, in condition (if applicable)	P	H	H			X
24	Check Chloride content of Hydro test water	P	R	R			X
25	NDE after Hydro test as applicable	P	RW	R			X
26	Vacuum Drying of equipment	P	W	R			X
27	Pickling and Passivation (Inside & Outside surface) for SS Equipment	P	W	R			X
28	Surface Preparation and Painting						
	a Adhesion check for individual coat & final coat	P	R	R			X
	b WFT check of intermediate coat	P	R	R			X
	c DFT check of final coat	P	W	R			X
	d Visual check of final coat	P	W	R			X
29	Foundation Template, Gage plate for base ring & foundation bolt – Visual/Dimension	P	W	R			X
30	Review of final documents including MDR of AI (as applicable)	P	W	R		I	X
31	Final stamping & issue of Inspection release certificate	P	W	R		I	X
32	Rust Prevention (N2 purge,)	P	W/R	W/R			X
33	Packing & Marking inspection	P	W/R	W/R			X

<b>LEGEND</b>		1) LSTK CONTRACTOR , 2) PMC – PROJECT MANAGEMENT CONSULTANT, 3) TPIA – THIRD PARTY INSPECTION AGENCY 4) H - HOLD, 5) A - APPROVE, 6) W - WITNESS, 7) RW – RANDOM WITNESS 8) R - REVIEW, 9) P - PERFORM
<b>NOTE</b>	1)	<b>CROSS (X) INDICATES REQUIREMENT OF RECORD</b>
	2)	This is only an indicative ITP and covers major inspection stages only. LSTK Contractor shall submit detailed ITP for all manufacturing/inspection activities including bought out items in line with above and specific technical requirements of NIT/design code.
	3)	Responsibility Of Performing/ Coordinating All Inspection Activities As Per ITP is with LSTK contractor only irrespective of the place of inspection i.e. Vendor shop / sub vendor shop / sub-sub vendor shop/contractor facility/site etc
	4)	Inspection Stages Of OWNER/PMC/Licenser Would Be Informed During Order Execution/Pre-Inspection Meeting.
	5)	Owner/PMC reserves the right to involve in all inspection activities irrespective of whether it is witness point or not.
	6)	For Sub-Vendor Items, Main Vendor Shall Be Involved In The Inspection Prior To Offering To LSTK/TPIA/Owner/PMC.
	7)	LSTK Contractor/Vendor shall ensure that all test and measuring instruments are duly calibrated and calibration shall be valid at the time of inspection. Calibration records shall be reviewed by TPIA.
	8)	For 'R' No Issue Of Inspection Call Is Required
	9)	For "W" & "H" Points – Inspection Call To Be Issued By Vendor/LSTK contractor.
	10)	Approved Third Party Inspection Agencies as per NIT.
	11)	Wherever "W/R" Is Mentioned for TPIA, It Is At The Sole Discretion Of Owner To Decide "W" Or "R" While Approval of ITP During Order Execution
	12)	Heat exchanger Tubes shall be hydro tested and eddy current tested at manufacturer's works.

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>		PNMM/PC288/E/001/5.3.2	0
			DOCUMENT NO	REV
	<b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>		Page 41 of 44	




**INDICATIVE QAP/ ITP**  
**PRESSURE VESSEL**  
**(VESSELS, REACTORS, COLUMNS, FILTER, etc)**  
**(ITP-02)**

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PNMM/PC288/E/001/5.3.2	0	
		DOCUMENT NO	REV	
		Page 42 of 44		

**INDICATIVE QAP/ INSPECTION AND TEST PLAN- PRESSURE VESSELS, REACTORS, COLUMNS, FILTER, etc**



PRESSURE VESSELS, REACTORS, COLUMNS, FILTER, etc							
Sl. No.	DESCRIPTION OF ACTIVITY	INSPECTION BY					
		VENDOR	TPIA	LSTK CONTRACTOR	LICENSOR	OWNER/PMC	RECORD

01		Detailed Inspection & Test Plan after issue of PO/PR/PS by LSTK contractor (including for bought out items)	P	R	A		R	X
02		Design & Drawing Approval	P	I	A		R	X
03		Inspection & Test Procedures such as NDT, PWHT, Pressure test, Hardness, Painting, etc.	P	A	A		I	X
04		Pre inspection meeting	P	H	H		I/H	X
05		Welding Procedure Specification (WPS) & Procedure Qualification Record (PQR) with weld map	P	H	A			X
06		Welders Qualification Record	P	R	R			X
07		Welding Consumable Batch Certificate	P	R	R			X
08		Inspection of Bought out items at Sub vendor's works for Flanges / Forgings, Fitting, Pipes, Fasteners, Plates, dished ends, Expansion Bellows, Clad plates, etc.	P	R	R			X
09		Sub order verification						
	a	Material Identification	P	W/R	R			X
	b	Sampling for test	P	W/R	R			X
	c	Mechanical/Corrosion Testing	P	W/R	R			X
	d	Relevant NDT	P	W/R	R			X
	e	Hydro test as applicable	P	W/R	R			X
	f	Final Visual/Dimension	P	W/R	R			X
10		Material for Pressure Parts after receipt – Visual/Dimension Inspection, Verification of Marking and Correlation w.r.t. Mill / Manufacturer's Test Certificate, Review of MTC	P	H	W/R			X
11		Material for Non Pressure Parts / Structural – Inspection, Identification with Test certificate & Review of certificate.	P	R	R			X
12		Formed Components such as Dished ends, Cones etc.						
	a	Visual, Dimensional, (Profile, Thickness, ovality, diameter etc.)	P	W	R			X
	b	NDE of weld joint	P	W/R	R			X
	c	PT on inside & outside surface	P	W/R	R			X
	d	Heat treatment chart (if applicable)	P	R	R			X
	e	Testing of Test coupon as applicable	P	W/R	R			X



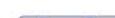
	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>				PNMM/PC288/E/001/5.3.2	0
					DOCUMENT NO	REV
	<b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>				Page 43 of 44	



	f	UT for lack of bond in formed shall, cone etc. for Cladded equipment	P	W/R	R			X
13		Inspection for Weld Overlay						
	a	PT after first layer of weld overlay	P	W/R	R			X
	b	PT after final layer of weld overlay	P	W	R			X
	c	Check of effective thickness of weld overlay	P	W	R			X
	d	Check of Chemical composition at required depth as applicable	P	W	R			X
	e	Visual & Dimensional	P	RW	R			X
14		Weld edge preparation & set up of pressure parts						
	a	Visual & Dimensional	P	W/R	R			X
	b	MT / PT of weld edges	P	W/R	R			X
15		ISR, DHT for LAS as applicable during welding	P	W/R	R			X
16		PT of root run for single side weld / back chipped surface of weld for pressure retaining weld joints	P	R	R			X
17		Inspection of completed pressure retaining weld joints						X
	a	Visual check for reinforcement, undercuts, surface defects etc.	P	W	R			X
	b	NDE before PWHT as applicable	P	W/R	R			X
	c	Ferrite check of weld	P	W	R			X
	d	Dimensional check before PWHT	P	W	R			X
	e	Clearance for PWHT	P	H	R			X
	f	PWHT	P	R	R			X
	g	NDE after PWHT as applicable	P	W/R	R			X
	h	Hardness check after PWHT as applicable	P	RW	R			X
	i	Testing of Production Test coupon as applicable	P	W	W/R			X
18		NDE of Non pressure weld joints	P	R	R			X
19		PMI of all pressure parts and welds for AS/SS material	P	RW	R			X
20		Final visual & Dimensional check, including internal, external & alignment, match markings for site joints etc. (before PWHT as applicable)	P	H	H			X
21		Trial assembly of internals / trays and column/vessel section etc. as applicable.	P	W	W/R			X
22		Pneumatic test of pads	P	W/R	R			X
23		Hydrostatic test	P	H	H			X
24		Check Chloride content of Hydro test water	P	R	R			X
25		NDE after Hydro test as applicable	P	RW	R			X
26		Vacuum Drying of equipment	P	W/R	R			X
27		Pickling and Passivation (Inside & Outside surface) for SS Equipment						
	a	Visual check	P	W	R			X
28		Surface Preparation and Painting						
	a	WFT check of intermediate coat	P	R	R			X
	b	DFT check of final coat	P	W	R			X
	c	Adhesion test as applicable	P	W/R	R			X
	d	Visual check of final coat	P	W	R			X
29		Visual/Dimension of Foundation Template, Gage plat for base ring & foundation bolt as applicable	P	W/R	R			X

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PNMM/PC288/E/001/5.3.2		0	
		DOCUMENT NO		REV	
		Page 44 of 44			

30		Review of final documents including MDR of AI (as applicable)	H	R	R		I	X
31		Final stamping & issue of Inspection release certificate	P	H	H		I	X
32		Rust Prevention (N2 purge, VCI)	P	W/R	R			X
33		Packing & Marking inspection	P	W/R	R			X
<b>LEGEND</b>		1) LSTK CONTRACTOR , 2) PMC – PROJECT MANAGEMENT CONSULTANT, 3) TPIA – THIRD PARTY INSPECTION AGENCY 4) H - HOLD, 5) A - APPROVE, 6) W - WITNESS, 7) RW – RANDOM WITNESS 8) R - REVIEW, 9) P - PERFORM						
<b>NOTE</b>		1) <b>CROSS (X) INDICATES REQUIREMENT OF RECORD</b>						
	2)	This is only an indicative ITP and covers major inspection stages only. LSTK Contractor shall submit detailed ITP for all manufacturing/inspection activities including bought out items in line with above and NIT/ design code e.t.c						
	3)	Responsibility Of Performing/ Coordinating All Inspection Activities As Per ITP is with LSTK contractor only irrespective of the place of inspection i.e. Vendor shop / sub vendor shop / sub-sub vendor shop/contractor facility/site etc						
	4)	Inspection Stages Of OWNER/PMC/Licensor Would Be Informed During Order Execution/Pre-Inspection Meeting						
	5)	Owner/PMC reserves the right to involve in all inspection activities irrespective of whether it is witness point or not						
	6)	For Sub-Vendor Items, Main Vendor Shall Be Involved In The Inspection Prior To Offering To LSTK/TPIA/Owner/PMC.						
	7)	LSTK Contractor/Vendor shall ensure that all test and measuring instruments are duly calibrated and calibration shall be valid at the time of inspection. Calibration records shall be reviewed by TPIA.						
	8)	For 'R' No Issue Of Inspection Call Is Required						
	9)	For "W" & "H" Points – Inspection Call To Be Issued By Vendor.						
	10)	Approved Third Party Inspection Agencies as per NIT.						
	11)	Wherever "W/R" Is Mentioned for TPIA, It Is At The Sole Discretion Of Owner To Decide "W" Or "R" While Approval Of ITP During Order Execution.						

 पी डी आई एल PDIL	<u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u>	PNMM/PC288/E/001/ SEC-5.3.3	0	 कोयला इंडिया Coal India	 बी एच ई एल BHEL
		Document No.	Rev		
		Sheet 1 OF 17			

## PART II: TECHNICAL




### SECTION – 5.3.3

#### DESIGN PHILOSOPHY – ROTATING EQUIPMENTS

**PROJECT: SETTING UP OF HIGH ASH COAL-TO  
AMMONIUM NITRATE PLANT IN  
MAHANADI COALFIELDS LIMITED (MCL)**

**PLANT : SYNGAS PURIFICATION UNIT FOR  
COAL TO AMMONIUM NITRATE PLANT**







 पी डी आई एल <b>PDIL</b>	<u>SYNGAS PURIFICATION UNIT FOR COAL TO</u> <u>AMMONIUM NITRATE PLANT</u>	PNMM/PC288/E/001/ SEC-5.3.3	0	 
		DOCUMENT NO	REV	
		SHEET 2 of 17		

## TABLE OF CONTENTS

SL. NO.	DESCRIPTION
1.0	SCOPE
2.0	DESIGN PHILOSOPHY FOR MACHINERY
3.0	DESIGN REQUIREMENTS
4.0	INSPECTION AND TESTING
5.0	SPARES
6.0	PAINTING
7.0	VENDOR LIST
8.0	LSTK CONTRACTOR/ VENDOR DOCUMENTATION

## LIST OF ATTACHMENTS

ATTACHMENT NUMBER	DESCRIPTION	NUMBER OF SHEETS
ANNEXURE - 1	INSPECTION & TESTING GUIDE LINES – ROTATING EQUIPMENT	2

 पी डी आई एल <b>PDIL</b>	<u>SYNGAS PURIFICATION UNIT FOR COAL TO</u> <u>AMMONIUM NITRATE PLANT</u>	PNMM/PC288/E/001/ SEC-5.3.3	0	 कोयला इंडिया Coal India	 बी एच ई एल BHEL
		DOCUMENT NO	REV		
		SHEET 3 of 17			

## 1.0 SCOPE

### 1.1 General

- 1.1.1 This Philosophy states that contractor's scope of work shall include basic & detailed engineering, procurement, supply, manufacturing, fabrication, transportation, loading, unloading, insurance during transit, storage, construction, erection / installation of all **Mechanical Rotating Equipment** with allied electrical, instrumentation and civil works, obtaining all necessary statutory approvals from concerned government authorities as applicable, testing, mechanical completion, pre-commissioning, commissioning, performance guarantee test runs including total project management and handing over of syngas purification unit for Coal to Ammonium Nitrate Plant at Lakhanpur, Distt. Jharsiguda for **Bharat Coal Gasification and Chemicals Limited** (JV of CIL & BHEL).
- 1.1.2 In addition, all statutory rules & regulations shall also be complied with.




## 2.0 DESIGN PHILOSOPHY FOR MACHINERY

### 2.1 Codes and Standards




The ***Latest Edition*** of codes and standards as listed below shall be followed for design and manufacturing of different machinery items. Generally the manufacturer will comply with these codes and standards as indicated therein with minor deviations that are normally adopted by manufacturer and are reasonably accepted as per good engineering practice.

A list of such deviations, if any, may be furnished by the LSTK Contractor along with offer. Deviations / exceptions against API requirement/ guidelines, if any, furnished by successful bidder are subject to owner's review and approval during detail engg.

Code	Description
API 610	Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industry
ANSI/ ASME B 73.1 M	Horizontal, End Suction centrifugal Pumps for Chemical Process
International Standard	Horizontal Centrifugal Pumps for Clear Cold Water
API 611	General-Purpose Steam Turbines for Refinery Service.
API 612	Petroleum, Petrochemical and Natural Gas Industries Steam Turbine - Special Purpose application
API 613	Special Purpose Gear Units for Petroleum, Chemical and Gas Industry Services
API 614	Lubrication, Shaft-Sealing, and Control Oil System for

 <div>पी डी आई एल PDIL</div>	<u>SYNGAS PURIFICATION UNIT FOR COAL TO</u> <u>AMMONIUM NITRATE PLANT</u>	PNMM/PC288/E/001/ SEC-5.3.3	0	 
		DOCUMENT NO	REV	
		SHEET 4 of 17		

	Petroleum, Chemical and Gas Industry Services
API 616	Gas Turbine for Petroleum, Chemical and Gas Industry Services
API 617	Axial, Centrifugal Compressors and Expander Compressor for Petroleum, Chemical and Gas Industry Services
API 618	Reciprocating Compressors for Petroleum, Chemical and Gas Industry Services
API 619	Rotary Type Positive Displacement Compressors for General Refinery Services.
API 670	Vibration, Axial-Position, and Bearing- Temperature Monitoring Systems.
API 671	Special Purpose Coupling for Refinery Services, Petrochemical and Gas Industry .
API 673	Special Purpose Centrifugal Fans for General Refinery Services.
API 674	Positive Displacement Pumps-Reciprocating
API 675	Positive Displacement Pumps-Controlled Volume
API 676	Positive Displacement Pumps-Rotary.
API 678	Accelerometer based Vibration Monitoring Systems.
API 682	Shaft sealing Systems for Centrifugal and Rotary Pumps.
API 685	Sealless Pump (Magnetic & Canned)
ISO / DIN	Centrifugal Pumps for smaller size & Non Critical Services.
International Standard, ASHRAE / ISHRAE	HVAC
<b><u>Performance Testing (ASME Codes)</u></b>	
PTC 8.2	Centrifugal Pump
PTC 6	Steam Turbines
PTC 9	Displacement Compressors
PTC 10	Centrifugal Compressors
PTC 11	Centrifugal Fans
PTC 22	Gas Turbines
<b><u>AGMA Standard</u></b>	

 पी डी आई एल <b>PDIL</b>	<u>SYNGAS PURIFICATION UNIT FOR COAL TO</u> <u>AMMONIUM NITRATE PLANT</u>	PNMM/PC288/E/001/ SEC-5.3.3	0	 
		DOCUMENT NO	REV	
		SHEET 5 of 17		

420	Practise for Enclosed Reducers or Increasesers using Spur, Helical, Herringbone and Spiral Bevel Gears.
421	Practise for High Speed Helical Gear Units.
<b><u>NEMA Standards</u></b>	
SM 23	Steam Turbine for Mechanical Drive Service.

## 2.2 Design Life

All equipment shall be designed for a minimum service life of 25 years and at least 2 years of uninterrupted operation under normal operating conditions. This requirement excludes specialised components requiring periodic maintenance and replacement.

## 2.3 Essential Project Reference Documents

The following documents shall be observed, and relevant aspects incorporated into specifications and datasheets:

- Process Description, Specifications and Data Sheets from Licensor
- Hazardous Area Classification
- Electrical and Instrumentation Design Criteria

## 2.4 Regulations




Besides codes & standards, LSTK Contractor shall follow National Laws and Regulations together with Local by Laws for the state including statutory requirements as applicable.

## 2.5 Site Conditions

Site conditions shall be as defined elsewhere.

## 2.6 Material of Construction

Generally Materials of construction shall be as per the process licensor's recommendation. However, API guideline may be adapted to the extent applicable.

 पी डी आई एल <b>PDIL</b>	<u>SYNGAS PURIFICATION UNIT FOR COAL TO</u> <u>AMMONIUM NITRATE PLANT</u>	PNMM/PC288/E/001/ SEC-5.3.3	0	 
		DOCUMENT NO	REV	
		SHEET 6 of 17		

Use of equivalent & superior material may be selected & shall be furnished with the offer along with chemical composition.




## 2.7 Quality Assurance & Control

- 2.7.1 The quality assurance shall be as per the approved procedures, test methods & facilities to be developed by the LSTK Contractor to ensure that the supplied equipment shall be of highest quality. The quality control shall mean that all the tests , measurements, checks & calibration which are to be carried out may be compared with the actual specified characteristics of the equipments/unit /system.
- 2.7.2 Quality Assurance (QA) shall mean the organizational set up, procedures as well as test methods and facilities developed by LSTK Contractor in order to assure that the machines & associated auxiliaries leaving LSTK Contractor's shop are of the highest possible quality i.e. either equal to or better than the requirement specified.
- 2.7.3 Quality Control (QC), shall mean all the tests, measurement, checks and calibration which are to be carried out in LSTK Contractor's shop in order to compare the actual characteristics of the equipment/unit/system with the specified ones, along with furnishing of the relevant documentation (certificates/records) containing the data or result of these activities.
- 2.7.4 LSTK Contractor shall submit a comprehensive description (manual) of QA/QC measures contemplated by him for implementation with regard to this specification. It is contractual obligation of the LSTK Contractor to develop and implement adequate QA/QC systems.
- 2.7.5 QA/QC system shall cover all products and services required for the complete machine unit as per scope of work including job sub contracted by the LSTK Contractor.

## 3.0 DESIGN REQUIREMENTS

### 3.1 General

- 3.1.1 All machines shall be directly coupled to their prime movers. Gears/any other forms of transmission shall be avoided. If not, specifically mentioned, the drivers shall have rated output at least 10% greater than the power requirement at design operating condition of the driven equipment.
- 3.1.2 Copper (Cu) or Cu-alloy to be avoided for any components in Ammonia Plant & in other plant for ammonia services.
- 3.1.3 All process pumps shall have Mechanical Seals. Single seals will be used in most cases, however, for ignitable or hazardous fluids, double, or Inside Wet and Outside

 पी डी आई एल <b>PDIL</b>	<u>SYNGAS PURIFICATION UNIT FOR COAL TO</u> <u>AMMONIUM NITRATE PLANT</u>	PNMM/PC288/E/001/ SEC-5.3.3	0	 
		DOCUMENT NO	REV	
		SHEET 7 of 17		




Dry running seals will be used. Non-process/ non-critical pumps shall also have mechanical seal.

- 3.1.4 Special tools and wrenches required for installation and maintenance shall be provided.
- 3.1.5 LSTK Contractors have to submit the reference list for similar equipment's models (minimum 2 nos.) supplied in past for similar / higher duty conditions. Reference list must contain at least the following: Fluid handled Capacity, Suction Pressure, Discharge Pressure, Model No., Power consumption, Client Name, Address, and Year of supply.
- 3.1.6 Coast down tank shall be provided in the Lube Oil System. Lube oil system shall have Main oil pump, auxiliary oil pump and emergency oil pump with power back-up arrangement. Lube oil system to also comply API-614.
- 3.1.7 Dedicated portable oil clarifiers with all hose & piping connection for each compressor trains to be provided.
- 3.1.8 Compressors shall also be provided with permanent mounted vibration sensors and allied system for safe operation.
- 3.1.9 Noise level for all rotating equipment shall be limited to 85 dBA measured at 1meter distance from the equipment.

### 3.2 Centrifugal compressors

The centrifugal compressors shall conform to API 617, latest edition. In addition, following points shall be applicable:

- 3.2.1 All machines shall have stable operating characteristics. The head generated shall rise continuously from choke point to surge point.
- 3.2.2 The manufacturer's criteria for suction and discharge piping shall be incorporated into the piping design and layout.
- 3.2.3 Torsional and lateral critical speed analysis shall be carried out and it shall be ensured that no critical speed (Torsional or lateral) shall be within 15% of any operating speed.
- 3.2.4 Casings shall be preferably centre line supported.
- 3.2.5 Vertical split (Barrel type) compressors shall have the inner casing designed for easy withdrawal from the outer shell and easy reassembly for inspection or replacement of parts.
- 3.2.6 Impellers shall be welded or electrochemically eroded. Tip speed of the impeller shall not exceed 310 m/s.




 पी डी आई एल <b>PDIL</b>	<u>SYNGAS PURIFICATION UNIT FOR COAL TO</u> <u>AMMONIUM NITRATE PLANT</u>	PNMM/PC288/E/001/ SEC-5.3.3	0	 
		DOCUMENT NO	REV	
		SHEET 8 of 17		

- 3.2.7 Diaphragm type coupling of proven make, Shim pack dry flexible coupling from reputed coupling manufactures like M/s Turboflex, Euroflex & KOP Flex shall be used. The couplings shall be designed as per API-671.
- 3.2.8 Dry Gas seals shall be provided for centrifugal compressor
- 3.2.9 Combined lubrication and seal oil system (as applicable) shall be provided as per API 614 (latest edition) for each compressor and drive turbine. All the lube oil piping shall be made of SS.
- 3.2.10 Twin oil cooler and twin oil filter shall be provided.
- 3.2.11 For machines with oil seals, two seal oil traps shall be provided with each casing - one for each seal. These traps shall be sized and interconnected so that each trap is capable of accepting the flow from both the seals while one trap is removed for maintenance.
- 3.2.12 Complete Anti-Surge control system with computerised calculations with compressor characteristics shall be provided for each machine.
- 3.2.13 Shaft vibration monitoring instruments (both radial and axial) shall be provided to trip the machine in case of high radial vibration or axial movement.
- 3.2.14 All the trip interlock shall be two out of three voting logic. Instrumentation design philosophy of NIT to also to be referred.
- 3.2.15 All the transmitters shall be smart type and suitable for communication with DCS.

### 3.3 Reciprocating Compressors

The reciprocating compressors shall conform to API-618, latest edition. In addition to the above, the following shall be applicable:

- 3.3.1 Machine shall be balanced to minimise lateral loads.
- 3.3.2 The piston speed for lubricated cylinder shall not exceed 4 m/s and for non-lubricated cylinders it shall be limited to 3 m/s.
- 3.3.3 Distance piece of non-lubricated compressor shall of sufficient length to ensure that no oil is in contact with gland packing.
- 3.3.4 The design of compressor valve shall be such that the valve assembly cannot be inadvertently reversed e.g. Suction valve cannot be fitted into the discharge port.
- 3.3.5 Valve plates and springs shall be made of stainless steel. PEEK may be used for valve plates in case the vendor has experience of using it for similar service and duty conditions.
- 3.3.6 Cylinders shall be water cooled.

 पी डी आई एल <b>PDIL</b>	<u>SYNGAS PURIFICATION UNIT FOR COAL TO</u> <u>AMMONIUM NITRATE PLANT</u>	PNMM/PC288/E/001/ SEC-5.3.3	0	 
		DOCUMENT NO	REV	
		SHEET 9 of 17		

- 3.3.7 The maximum piston rod loading shall be calculated considering safety valve set pressure.
- 3.3.8 Non-lubricated compressors shall be provided with piston rings, packing made of carbon filled PTFE or equivalent.
- 3.3.9 The packing boxes shall be provided with atmospheric vents to minimize gas leakage.
- 3.3.10 Pulsation dampeners shall be provided for meeting the residual pulsation requirements as per API.
- 3.3.11 For API compressors the requirements for acoustic study shall be in accordance with the API recommendation.
- 3.3.12 To minimise the need for heavy overhead pipe structures, suction and discharge piping to and from the knockout drums should run close to grade, supported on sleepers.
- 3.3.13 Frame lubrication system shall be provided with auxiliary pump driven by electric motor for initial lubrication.
- 3.3.14 Cylinder lubrication, if required, shall be provided by a separate forced feed mechanical lubricator complete with necessary tubing/piping, check valve and sight flow indicator.
- 3.3.15 Manufacturer's standard based on national / international standards can also be accepted for special duty like passivation Air Compressor and other Non-Critical smaller machines.
- 3.3.16 Full flow twin oil filter shall be provided.

### 3.4 Screw Compressor




The screw compressors shall conform to API-619, latest edition. If not, specifically mentioned the screw compressor may be manufacturer standard. In addition to the above, the following shall be applicable.

- 3.4.1 Each compressor together with its driver, oil system, inter-connecting piping, all auxiliary items, such as heat exchangers, separators, pumps, valves, etc., and instrumentation, shall be one integrated unit
- 3.4.2 All drains on the process side shall have double block valves
- 3.4.3 Manufacturer shall provide adequate relief and venting at suction and discharge

### 3.5 Centrifugal Pumps

The process pumps shall be designed as per API 610, latest edition. The pumps shall be of robust design to ensure long service life and minimum maintenance



 पी डी आई एल <b>PDIL</b>	<u>SYNGAS PURIFICATION UNIT FOR COAL TO</u> <u>AMMONIUM NITRATE PLANT</u>	PNMM/PC288/E/001/ SEC-5.3.3	0	 कोयला इंडिया Coal India	 बी एच ई एल <b>BHEL</b>
		DOCUMENT NO	REV		
		SHEET 10 of 17			

requirement. The pumps shall be designed for easy access for inspection and maintenance. All continuously running pumps shall have a spare pump.




In addition to codes & standards, following points shall also be applicable:

- 3.5.1 All pumps shall have continuously rising head curve from any specified operating point to shut off point. Pumps running in parallel shall have equal head rise to shut off point.
- 3.5.2 The pumps should have stable operating characteristics. The pump head at shut off shall be approximately 110% of head at rated capacity and not exceeding 120%.
- 3.5.3 Best efficiency point shall be as close as possible to normal operating point.
- 3.5.4 Impellers of multistage pumps shall be secured positively against axial movement.
- 3.5.5 For multistage pumps, a lateral critical speed analysis shall be carried out.
- 3.5.6 Pumps with centre line support shall be provided for pumps handling fluids of operating temperature more than 177°C.
- 3.5.7 The maximum calculated axial load shall not in any operating condition exceed 50% of bearing manufacturer's load rating.
- 3.5.8 Flexible coupling shall be used. Coupling guard shall be non-sparking for pumps located in hazardous area.
- 3.5.9 Mechanical seal of John crane / Flowserve / Eagle-Burgmann make only shall be provided. Only balanced mechanical seal shall be used.
- 3.5.10 For pumps with forced lubrication system, the lubrication system shall be designed as per API 614 latest edition.
- 3.5.11 All continuously running pumps shall have a stand-by pump. In some instance, Intermittent operational pumps may also be sought for stand-by pumps as per owner's discretion.
- 3.5.12 Cooling water pumps shall be horizontal split casing type with mechanical seals.

### 3.6 Reciprocating Pump / Metering pumps

Reciprocating pump shall be designed as per API 674 latest edition and metering pump shall be designed as per API 675 latest edition.




- 3.6.1 The metering pumps shall be suitable for continuous capacity variation from 0 to 100%. The capacity variation should be possible while the pumps are working.
- 3.6.2 All continuously running pumps shall have a stand-by pump. In some instance, Intermittent operational pumps may also be sought for stand-by pumps as per owner's discretion.

 पी डी आई एल <b>PDIL</b>	<u>SYNGAS PURIFICATION UNIT FOR COAL TO</u> <u>AMMONIUM NITRATE PLANT</u>	PNMM/PC288/E/001/ SEC-5.3.3	0	 
		DOCUMENT NO	REV	
		SHEET 11 of 17		

### 3.7 Steam Turbine

Steam turbine shall be designed as per API 611 or API 612, latest edition, as specified in Specification sheet.

- 3.7.1 Turbine driver and driven equipment shall be mounted on a common base plate unless otherwise specified on turbine specifications sheet. Turbine manufacturer shall provide dimensional and load data to driven equipment supplier for design and supply of common base plate by driven equipment supplier.
- 3.7.2 Piping connected to turbine shall be designed to limit forces, stresses, vibration and noise to acceptable limits as per relevant codes (API 611 and API 612) on account of flow, pressure and temperature conditions of fluid flowing through them. Adequate anti-vibration supports, springs, etc. shall be provided to limit vibrations and accommodate thermal movements.
- 3.7.3 Noise level shall be limited to 85 dBA at one metre distance by provision of silencers/acoustic insulation and/or noise hood as may be necessary.
- 3.7.4 Special provisions for emergency lube oil supply to bearings and gears shall be made in case of power failure. This shall require overhead reserve oil tank to supply lube oil at adequate pressure when there is breakdown of power. Necessary control circuit shall also be provided for this system.
- 3.7.5 All main and auxiliary piping shall be laid out in neat fashion to allow adequate clearances for operation and maintenance (Min 900 mm), and head rooms (Min 2200 mm) for working personnel. Design shall allow maintenance of parts without dismantling piping or supports.
- 3.7.6 The turbine and auxiliary equipment shall be designed for outdoor operation totally unprotected from weather, but due to grouping of equipment they may be installed in a common building for convenience in operation. Several compressors, turbines shall be placed at common operating platform and maintained by an overhead travelling crane. The crane capacity shall be decided based on maximum weight of maintenance part to be lifted. A loading bay shall be kept open for erection and maintenance purposes.
- 3.7.7 Local control panel shall be adjacent to turbine for easy operation.
- 3.7.8 All valves and controlling devices shall be within easy reach for convenient and quick attention by operators.
- 3.7.9 Turbine auxiliaries such as lubrication circuit with tanks and exchangers, stage heaters, safety valves, etc. shall be arranged with economising space and provided with suitable devices for removal and maintenance.

 <div>पी डी आई एल PDIL</div>	<u>SYNGAS PURIFICATION UNIT FOR COAL TO</u> <u>AMMONIUM NITRATE PLANT</u>	PNMM/PC288/E/001/ SEC-5.3.3	0	 
		DOCUMENT NO	REV	
		SHEET 12 of 17		




### 3.8 Centrifugal Fans

Centrifugal fans shall be designed as per API 673, latest edition for critical services and for non-critical services manufacturer's standard based on national / international standards may be applicable.

- 3.8.1 Forced and induced draught fans shall be coupled to drivers through shim pack dry flexible coupling, and the complete assembly shall be mounted on a substantial bedplate.
- 3.8.2 First critical speed of the rotor shall be higher than 120% of rated speed.
- 3.8.3 Capacity control shall be achieved by means of dampers (Preferably on suction side) specially for constant speed fans.
- 3.8.4 The fan casing shall be suitably split such that impeller assembly can be removed for maintenance without disturbing inlet and outlet ducting.
- 3.8.5 SS bolts and nuts shall be provided for the split casing joints of fans for corrosive service.
- 3.8.6 The drive motors of the fans should be designed with additional capacity to take care of surge loading. However Motor rating shall be minimum 125 % of shaft power for shaft power up to 22 KW, 115 % of shaft power for shaft power between 22 – 55 KW and 110 % of shaft power for shaft power above 55 KW.
- 3.8.7 Bearing shall be preferably oil lubricated.




### 3.9 Agitator

- 3.9.1 Assembly shall be such as to enable replacement of bearings, shaft sealing devices, gear unit and driver without dismantling other major parts of unit and without emptying or depressurising the vessel.
- 3.9.2 First critical speed of the rotor shall not be less than 140% of rated speed.
- 3.9.3 Adequate space shall be provided for packing replacement without removing or dismantling of any part other than the gland and the seal cage.
- 3.9.4 Motor rating shall be minimum 125% of shaft power.
- 3.9.5 Shim pack dry flexible coupling shall be provided between the power drives and agitator shaft or gear, and shall have minimum service factor of 2.
- 3.9.6 Spacer type coupling shall be provided for units provided with Mechanical Seals. The spacer shall be of sufficient length to permit replacement of the seal assembly without removing the driver / gear.
- 3.9.7 Gear unit shall be provided in accordance with AGMA standard. Gear box rating shall be selected based on minimum service factor of 1.5.

 पी डी आई एल <b>PDIL</b>	<u>SYNGAS PURIFICATION UNIT FOR COAL TO</u> <u>AMMONIUM NITRATE PLANT</u>	PNMM/PC288/E/001/ SEC-5.3.3	0	 
		DOCUMENT NO	REV	
		SHEET 13 of 17		

### 3.10 HVAC System

- 3.10.1 LSTK to assure that HVAC system and auxiliaries shall be complete in all aspect complying to national / international / statutory requirement
- 3.10.2 Air conditioning system & air flow ventilation rate should be sufficient to satisfy not only air removal specification, but also to maintain over pressure and temperature specification. It should be also capable to avoid wind penetration in order to meet the requirements of a conditioned space, simultaneous control of temperature, humidity, cleanliness, contamination and air distribution should be considered in design & selection of HVAC equipment.
- 3.10.3 Complete design of air-conditioning system (heat load calculations for all three seasons, i.e. summer, monsoon & winter with psychometric plots specifying the design TR capacity, dehumidified air quantity and monsoon/winter heating capacity).
- 3.10.4 R-134a / equivalent and Eco-friendly refrigerant to be supplied & filled in the chiller units by bidder
- 3.10.5 LSTK Contractor shall provide suitable HVAC system for all process / non-process buildings/ facilities as well as for other buildings /structures . All civil buildings / facility, Control room, substation, labs etc to be equipped with suitable HVAC system with 100 % redundancy. For chiller base central air-conditioning system preferably water cooled. Complete HVAC system shall be designed for providing optimum cooling & heating during summer & winter season vice versa.
- 3.10.6 Central AC system with complete auxiliaries with 100% stand-by chillers & AHUs are required with chemical filters.
- 3.10.7 Chiller's unit shall have proven track record of satisfactory operation for a minimum period of 8000 hours for similar application
- 3.10.8 Chemical filters shall be designed & selected by bidder for the indoor condition for Control room(s) and Sub-station(s) considering the worst surrounding atmosphere of plant. Chemical filter shall be selected for the chemical media life of minimum 2 years.
- 3.10.9 In case of portable AC such as split / window type, 1 no. Stand-by AC unit/system shall be considered / installed for working AC system/units up to 3 nos. However, 2 nos stand by AC system/units shall be considered between for 4 to 6 working AC units/systems.
- 3.10.10 Ventilation system with adequate stand-by equipment to be provided for AHU room, Pantry room, All Toilets, Locker rooms, Store rooms, Change rooms etc.
- 3.10.11 Site related temperature, humidity shall be considered for adequate design & selection of HVAC system along with compliance to National / international codes and standards viz. ISHRAE/ ASHRAE.

 पी डी आई एल <b>PDIL</b>	<u>SYNGAS PURIFICATION UNIT FOR COAL TO</u> <u>AMMONIUM NITRATE PLANT</u>	PNMM/PC288/E/001/ SEC-5.3.3	0	 
		DOCUMENT NO	REV	
		SHEET 14 of 17		

- 3.10.12 One full charge of refrigerant for each air condition system to be provided as a spare.
- 3.10.13 All applicable/ replaceable parts of rotating equipment such as pump blower etc shall be provided as per NIT

### 3.11 EOT Cranes




LSTK Contractor to provide EOT Cranes of adequate capacity in various Pump Houses, Compressor & turbine House and other location wherever required for ease in operation and maintenance activities. Cranes to be provided in nearest multiple of 5 Metric Tonnes considering maximum weight to be lifted. Relevant Indian/ ISO Standards to be applicable for EOT Crane. All statutory guidelines to be complied by the contractor/ sub-contractor.

## 4.0 INSPECTION & TESTING

Machines shall be inspected by Third Party Inspection Agency. The Inspection and testing shall be in accordance with the all relevant codes, standards, specifications, including the minimum guide line given in Annexure – 1 (attached).

- 4.1 All testing accessories, measuring instruments including NDT testing equipment, etc. shall be arranged by LSTK Contractor.
- 4.2 In general, following tests shall be conducted for all rotating equipments:
- Material test
  - Non-destructive test
  - Hydrostatic test for all the pressure containing parts
  - Dynamic balancing of rotor
  - Over speed test of impeller (only for compressors)
  - Helium leak test of compressor casing (if required as per API Code)
  - Mechanical running test of compressor and turbine
  - Barring over check for reciprocating compressor
  - NPSHR test for pumps
  - Performance Test
  - Disassembly Test

The tests required to be conducted and witnessed shall be specified in the equipment data sheet. Disassembly test for Fans, Blowers & small Pumps can be waived –off in case no problem occurs during mechanical / performance Test.

 पी डी आई एल <b>PDIL</b>	<u>SYNGAS PURIFICATION UNIT FOR COAL TO</u> <u>AMMONIUM NITRATE PLANT</u>	PNMM/PC288/E/001/ SEC-5.3.3	0	 कोयला इंडिया Coal India	 बी एच ई एल <b>BHEL</b>
		DOCUMENT NO	REV		
		SHEET 15 of 17			

## 5.0 SPARES

- 5.1 All erection & commissioning spares shall be supplied by LSTK Contractor & cost shall be included in the cost of main equipment.
- 5.2 2 years operation spares / recommended spares, Mandatory spares etc shall be supplied by the contractor as per NIT.

## 6.0 PAINTING

- 6.1 All exterior non-stainless steel surfaces subject to atmospheric corrosion with the exception of machined surfaces shall be epoxy painted.
- 6.2 All exterior machined surfaces shall be coated with suitable rust preventives.




## 7.0 VENDORS LIST

All equipment shall be procured / fabricated as per approved vendor list. However, LSTK contractor may have to furnish Proven track record / reference record of any vendor opted for specified services / equipment, if, owner desires.

Any equipment for which vendor list is not enclosed, LSTK Contractor may furnish a list of proposed vendors along with their references for supply of similar type of equipment along with bid. However all proposed additional sub-vendors shall have well proven track record and shall be subjected to owner's / consultant approval during detail engg.

## 8.0 LSTK CONTRACTOR/VENDOR DOCUMENTATION:

Drawings & Documents of machinery items/ rotating equipment shall be as mentioned elsewhere in the NIT.

 पी डी आई एल <b>PDIL</b>	<u>SYNGAS PURIFICATION UNIT FOR COAL TO</u> <u>AMMONIUM NITRATE PLANT</u>	PNMM/PC288/E/001/ SEC-5.3.3	0	 कोयला इंडिया Coal India	 बी एच ई एल <b>BHEL</b>
		DOCUMENT NO	REV		
		SHEET 16 of 17			

## **ANNEXURE-1**

### **INSPECTION & TESTING GUIDE LINES – ROTATING EQUIPMENT**

#### **1.0 SCOPE**




This document covers the minimum guide lines for the Inspection & Testing for the rotating Equipments.

All rotating Equipments shall be inspected by Third Party Inspection Agency .The Inspection and testing shall be in accordance with the all relevant codes, standards, and specifications as specified in Specification sheet.

#### **2.0 PUMPS, TURBINES AND DRIVERS**

- 2.1 Pump and turbine casings to be identified against foundry test certificates and thickness checked to conform to approved drawings.
- 2.2 Witness hydrostatic test on casings.
- 2.3 Dynamic balancing of rotor
- 2.4 Witness running tests on pumps including N.P.S.H. where applicable.
- 2.5 Non- destructive test
- 2.6 Strip inspection of pumps on completion of running tests. Wearing surfaces to be checked and recorded. As a general principle, mechanical seals will not be dismantled after running tests. This necessity will be discussed on a case to case basis if abnormal noise or temperature has need records during testing. All materials to be checked against test certificates or VENDOR'S bill of materials.
- 2.7 Final inspection and dimensional check of pump (including driver, when mounted on base plate).
- 2.8 Heat run or standard abbreviated tests, as specified, to be witnessed on electric motor drives.
- 2.9 Final inspection and dimensional check to be carried out on motor drivers.
- 2.10 For steam turbine drivers, hydrostatic test on pressure parts to be witnessed.
- 2.11 Running tests on steam turbines to be witnessed.
- 2.12 Final inspection and dimensional check on steam turbines to be done.



 पी डी आई एल <b>PDIL</b>	<u>SYNGAS PURIFICATION UNIT FOR COAL TO</u> <u>AMMONIUM NITRATE PLANT</u>	PNMM/PC288/E/001/ SEC-5.3.3	0	 कोयला इंडिया Coal India	 बी एच ई एल <b>BHEL</b>
		DOCUMENT NO	REV		
		SHEET 17 of 17			

2.13 Check all test certificates.

### 3.0 COMPRESSORS / BLOWERS AND DRIVERS

3.1 Material of casings or cylinders to be checked against test certificates.

3.2 For fabricated casings, inspection shall be as per API 617/API 618.

3.3 Hydrostatic test on casings or cylinders to be witnessed.

3.4 Dynamic balancing of rotor

3.5 Non- destructive test

3.6 For fabricated impellers, welding procedure and welder's qualifications to be established and impellers to be inspected before assembly. Impellers overspeed, NDT after overspeed and dimensional inspection.

3.7 Ensure that overspeed tests on impellers have been carried out and related certificate for dynamic balancing of impellers and subsequently the complete rotating assembly shall be provided. The over speed test shall be carried out to prove the impeller proper balancing and relevant certificate shall be provided.

3.8 Witness leakage test on lube oil tank and carry out internal and external inspection. Tank to be finally inspected after internal coating and /or painting.

3.9 Inspect prefabricated lube oil piping.

3.10 Witness performance tests shall be done and check all safety and alarm devices when contact instrumentation is fitted.

3.11 If spare rotating assembly is ordered, any running tests with spare fitted or the dropping of the spare into the casing, as may be specified, to be witnessed.

3.12 Strip inspection on completion of running tests. To include examination of all running surfaces, checking of critical clearances, and examination of lube oil filters in the tests.

3.13 Final inspection and dimensional check of compressors mounted on base plates.

3.14 Gearing, pinion forgings and main wheel forgings or castings to be inspected at forge shop or foundry.

3.15 Any dynamic balancing of gearing rotors to be witnessed.

3.16 Fabricated gear cases to be inspected at sub-supplier's works.

3.17 Light or full load running tests, as specified to be witnessed on gearing.

3.18 Final inspection and dimensional check of gearing to be done at manufacturer's works.



 <b>पी डी आई एल</b> <b>PDIL</b>	<b>PROJECTS &amp; DEVELOPMENT INDIA LTD</b>	PNMP/PC288/E001/SEC-5.3.4	P	
		DOCUMENT NO.	REV	
		SHEET 1 of 15		

## SECTION – 5.3.4

### DESIGN PHILOSOPHY – FIRE FIGHTING SYSTEM

**PLANT : SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE.**

**PROJECT : SETTING UP OF HIGH ASH COAL-TO-AMMONIUM NITRATE PLANT IN MAHANADI COALFIELDS LIMITED (MCL).**

**CLIENT : BHARAT COAL GASIFICATION AND CHEMICALS LIMITED**


<div><div> पी डी आई एल PDIL</div></div>	DESIGN PHILOSOPHY-FIRE FIGHTING	PNMP/PC288/E001/SEC-5.3.4	P	<div><div> बी एच ई एल BHEL</div></div>
		DOCUMENT NO.	REV	
		SHEET 2 of 15		

## TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	Purpose
2.0	Scope
3.0	Design Criteria
4.0	Fire Protection Systems
5.0	Material specifications
6.0	First aid fire fighting equipments
7.0	Safety equipments/ Personnel protective equipments
8.0	Execution, Inspection & Testing
9.0	Quality assurance system
10.0	Inspection
11.0	Testing
12.0	Documentation

## LIST OF ATTACHMENTS

ATTACHMENT NUMBER	DESCRIPTION	NUMBER OF SHEETS
PNMP-TS-PPE	Technical specification of Personal Protective Equipment	12

<div><div>पी डी आई एल PDIL</div></div>	DESIGN PHILOSOPHY-FIRE FIGHTING	PNMP/PC288/E001/SEC-5.3.4	P	<div></div>
		DOCUMENT NO.	REV	
		SHEET 3 of 15		

## 1.0 PURPOSE

The purpose of this document is to establish the requirements of the fire fighting system for applicable facilities of the package plant.

This document is a general specification providing typical requirements of layout, material, testing, etc. for various fire fighting systems.

This specification covers design basis and execution requirements for fire protection system for fertilizer plant. The provisions shall be made, in order of precedence, as per statutory regulations, TAC guidelines, job specifications and safe engineering practices.

## 2.0 SCOPE

Contractor shall provide fire fighting system as mentioned in this document in accordance with TAC/NFPA/NBC 2016 (and/or Latest Edition) for applicable facilities of the package plant.

## 3.0 DESIGN CRITERIA

The Fire Protection Philosophy is based on Loss Preventive and Control. The adequacy of fire protection facilities for fertilizer plant is very important because of the inherent hazard it carries. A fire in one part/section of the plant can endanger other sections of plant as well. If fire breaks out, it must be controlled / extinguished as quickly as possible to minimise the loss to life and property and to prevent further spread of fire. In this job, the design of the package plant is a part of Ammonia plant/facilities , which is considered in high hazard ( B), as per NBC 2016.

Unless otherwise specified in the NIT the design shall meet requirement of applicable standard over and above the standards mentioned below:

IS 3034: 1993 - Fire Safety of Industrial Buildings: Electrical Generating and Distributing Stations - Code of Practice [CED 36: Fire Safety]

IS 12459: 1988 Code of Practice for Fire Safety in Cable Runs [CED 36: Fire Safety]

IS 1646: 1997 Code of Practice for Fire Safety of Buildings (General): Electrical Installations CEA (Measures relating to Electrical Safety) Regulations 2010

IS 15394: 2003 - Fire Safety in Petroleum Refineries and Fertilizer plants

IS 3844: Installation and maintenance of internal fire hydrants and hose reels on premises

National Building Code 2016 (and/or Latest)

## 4.0 FIRE PROTECTION SYSTEMS

The following fire protection facilities shall be provided depending upon the nature or the installation and risk involved wherever applicable.

- Fire hydrant system
- Water spray/sprinkler system
- Gas flooding system
- Fire detection, alarm & communication system
- First aid fire fighting equipments including Portable fire extinguishers
- Personnel protective equipments (PPE)

<div> पी डी आई एल <b>PDIL</b></div>	DESIGN PHILOSOPHY-FIRE FIGHTING	PNMP/PC288/E001/SEC-5.3.4	P	<div></div>
		DOCUMENT NO.	REV	
		SHEET 4 of 15		

#### 4.1 Fire Hydrant System

Fire water network shall consist of mostly aboveground and/or underground, if required, piping systems.

Around units the fire water mains shall be laid aboveground and directly buried and/or in trenches, if it is laid underground. The underground ring main network system shall be laid at minimum one meter earth cushion. Top of casing pipe (RCC Hume pipe) of underground piping crossing roads (peripheral road, package unit road, access road/ways) shall be at min. 1.5 metre depth.

All underground fire water piping shall be externally protected from corrosion by wrapping and coating of cold tape as per attached specification, for underground CS pipe which shall extend up to min. 500 mm, above / beyond grade wherever applicable.

Above ground fire water piping shall be painted as per painting specification and the paint shall be conforming to shade as per IS 5.

Wherever fire water line will cross the roads, same shall be put under a suitable hume pipe or culvert, with proper wrapping, coating as a anticorrosive treatment (Cold Tape Type, as per detailed specification provided elsewhere in NIT).

Flushing point with isolation gate valve and pressure gauge points (approx at the rate 300mtr. and at all battery limit tie in points) with isolation gate valve shall be provided on all headers.

Network shall be laid in closed loops to ensure multidirectional flow. Isolation valve to be provided at every 300m (max) and at crossings (Junctions) to ensure easy maintenance and uninterrupted water supply in case of break down and shall be planned in such a way that outage of any section of fire water line should not affect other section.

Hydrant posts shall be installed with a branch "L" shape piping to avoid directly fall of leaking water on main header.

RCC slabs (Minimum 1500mmX1500mmX100mm thk.) shall be provided at the grade level beneath of each Hydrant/Monitor/HVLR/ 3way- 4 way fire brigade connection post and respective hose box.



Up to 2.0 m portions of the headers (if above ground) on both sides of hydrant branching and the entire branch piping near of hydrants shall be epoxy painted.

Isolation valves (gate valves, rising spindle) shall be provided below monitors and at all hydrants. Suitable restriction orifice shall be provided at downstream of isolation valve of hydrant post to maintain the pressure requirements as per TAC / IS15394.

Fire water pressure at the farthest point shall be a minimum of 7 kg/cm<sup>2</sup> after installation of headers and sub headers.

All fire water piping shall be tested to hydraulic test pressure of 18 kg/ cm<sup>2</sup> (g) and/or as calculated considering pump shut-off pressure.

Radiography requirements shall be as per TAC (minimum 10%).

<div> पी डी आई एल <b>PDIL</b></div>	DESIGN PHILOSOPHY-FIRE FIGHTING	PNMP/PC288/E001/SEC-5.3.4	P	<div></div>
		DOCUMENT NO.	REV	
		SHEET 5 of 15		

For process units, external ring header with hydrants and an internal distribution with monitors and hose reels shall be installed. Hydrant heads shall be placed at a minimum distance of 15m from process equipment.

Monitors around heater areas, if any, shall be necessarily provided and located in such a manner that the heater can be isolated from the plant.

Monitors shall be provided to cover the high rise columns, equipments etc. of height 15 mtr. and above, unless otherwise specified in layout drawing.

There may be cases where due to horizontal obstruction, a particular vessel/ process column may not be approachable by ordinary monitor or hydrant, elevated monitors shall be provided to take care of such conditions.

Tall columns, structure, towers and equipment where it may not be possible to provide access staircases with hydrants on landing, will be considered as protected by hydrants at ground level, provided they are less than 15 m in height. When the height exceeds 15 m, the concerned hydrants shall be replaced by monitors.

Alternate hydrants for protection of loading unloading bays, rail/truck gantries shall be replaced by water/foam monitors.

Number of hydrants shall be based on one hydrant post with two hydrant valves for every 30m (max.) of external perimeter of process units and storage tank area. For utility and other building areas, this distance shall be a maximum of 45m.

Hydrants and/or water monitors shall be located keeping in view the different risks within the premises which are to be protected and ensuring effective coverage.

Double hydrants (IS: 5290 type A, hydrant valve with single outlet) on each hydrant post (i.e. two hydrant valves mounted on each stand post) and at every 30m centre to centre, along the hydrant mains, shall be provided.

Extension of hydrants/monitors for spill fire (as required by TAC/ IS15394) shall also to be provided.

Indoors hydrants with hydrant valves (landing valves), hose reels and hose box containing accessories, for plant buildings and non-plant buildings, shall be provided as per IS-3844. In case of buildings, hydrants shall be located at not be less than 2 m and not more than 15 m from the face of building.

Double headed landing valves (two numbers, type-A, Landing valves on single stand post), shall be provided on the landing of first floor and above on all the buildings/Tech structure/platforms etc. with isolation valve at each tapping for landing valve assembly.

The monitors shall have isolation valve. Monitor location shall be given special consideration for protection of cluster of towers, heaters and other high structures, where it may not be possible to approach the higher levels. Minimum of two monitors shall be provided for each such area.

Field adjustable variables flow type remote operated monitors shall be provided for the protection of inaccessible equipment.

<div> पी डी आई एल <b>PDIL</b></div>	DESIGN PHILOSOPHY-FIRE FIGHTING	PNMP/PC288/E001/SEC-5.3.4	P	<div></div>
		DOCUMENT NO.	REV	
		SHEET 6 of 15		

Contractor to finalise hydrant layout on plot plan, with all the requirements such as number of Hydrants, Monitors, Foam system, sprinkler system etc., based on all statutory requirements & Code Guidelines, considering ease of maintenance and safe approach for fire fighting. Due consideration is to be given for providing Emergency escape routes also. Hydrants are to be strategically located to obtain maximum advantage of layout.

Fire brigade connection (3 way & 4 way) points with Isolation gate valve as per TAC/ IS shall be provided at strategic locations

Above ground pipe shall be supported on RCC pedestals (refer attached drawing). wrapper plate (thickness same as pipe & covering approx. 120 degree at bottom portion of pipe) shall be provided at each support for above ground pipe (6" NB and above). Supports for piping system and structures shall be provided as per support specifications of NIT. If support specification not provided in NIT, safe adequacy calculations shall be submitted by bidder for review/approval by PMC/owner.

#### 4.1.1 Buried Pipes

The following points to be considered in designing of buried pipes


- i) All underground buried metallic piping shall be coated and wrapped with cold tape and laid at minimum one meter earth cushion.
- ii) Underground pipe at crossing roads, access ways shall have RCC casing pipe (Culvert or Hume pipe). Underground piping at rail crossing shall be as per Indian railways.
- iii) Valve chamber wherever required shall be made of brick or concrete. Valve chamber should be spacious to attend valves during operation/maintenance.
- iv) All U.G. headers shall clear equipment foundations.
- v) Provide break flange at + 500 MM from floor level to isolate underground pipe from above ground piping with insulating gasket kit.
- vi) Pipes shall be laid below electrical cables, if any.
- vii) Buried Pipes shall be laid in trenches after excavation, covered with 150mm sand bed all around them, backfilled and properly rammed.
- viii) RCC thrust blocks shall be provided as per engineering requirement.
- ix ) Cathodic protection shall be provided for buried pipes.

#### 4.1.2 Piping in Trenches

The following points to be considered in designing of trench pipes:

- i) Piping located below grade, requiring inspection, servicing or provided with protective heating.
- ii) Fire water lines/Process lines.
- iii) Drain lines requiring gravity flow trenches.
- iv) Sump for valves and trenches shall be provided.
- v) Suitable draining scheme for trenches shall be provided.
- vi) Valves in trenches shall be provided with extended stems. If hand wheels of the valves are located more than 300 mm below the cover plate, the valves shall be provided with extended stems extending to within 100 mm below the cover plate.
- vii) The trenches shall be lined with RCC, then provided with 150mm sand bed and also shall be covered with RCC cover after laying of wrapped and coated pipes in them. Top of pipe shall be at min one meter depth.



<div> पी डी आई एल <b>PDIL</b></div>	DESIGN PHILOSOPHY-FIRE FIGHTING	PNMP/PC288/E001/SEC-5.3.4	P	<div></div>
		DOCUMENT NO.	REV	
		SHEET 8 of 15		

- Chemical room/storage area.

Sprinkler system (wet type with QBD), shall be installed at the following Location:

- All buildings as per NBC 2016 (and/or latest edition)
- Admin Building
- Workshop building
- Technical Building
- Meeting Room/Hall
- Canteen
- Fire brigade building.

### 4.3 Foam System

Foam system shall be provided for transformer area and hydrocarbon oil tank area.

The transformer area shall be surrounded by at least 2 foam monitors strategically installed.

Hydrocarbon oil tank area and LPG/NG gas skid area shall be surrounded by at least 3 foam monitors strategically installed, so that each tank or each gas skid is fully covered within the monitors throw range.

Water cum foam monitors (SS304 body & nozzle, fixed stand post type, manual operation, 500-750 USGPM variable type flow, self inducing foam induction mechanism) along with portable type foam cans (each 200 Litres capacity) with 3% AFFF Foam, shall be provided for above areas.

### 4.4 Clean agent flooding system

Gas flooding system with clean agent, diverter valve (if feasible), detectors & accessories for Control Room, Computer room, Computer console room, UPS room, Battery room, server/database rack room etc. shall be protected by clean agent system as per NFPA-2001(Inergen/ Argonite/ Novec 1230).

### 4.5 Pump House & Pumping System

#### 4.5.1 Pumps


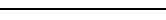
Wherever practicable pumps shall be arranged in rows with the centre line of the discharge on a common line. In general, pumps shall be kept inside the pipe rack / Shed. However in case of smaller racks, pumps shall be kept on one side or outside the pipe rack to provide clear access under the rack.

Pump foundation height shall be 300 mm above H.P.P.

Gap between each pump foundation / and foundation of technical structure should be sufficient for easy removal of equipment after piping. Clearance between two adjacent pumps shall be such that clear 900 mm aisle is available.

All pumps, Engines. Motors along with their accessories shall be inside Pump house & provided with EOT crane, and lifting device of suitable capacity. (Min 10 Ton)



<div><div></div><div>पी डी आई एल PDIL</div></div>	DESIGN PHILOSOPHY-FIRE FIGHTING	PNMP/PC288/E001/SEC-5.3.4	P	<div><div></div></div>
		DOCUMENT NO.	REV	
		SHEET 9 of 15		

## 4.6 Pump Piping

- 4.6.1 Pump drives shall have clear access.
- 4.6.2 Pump suction piping shall be as short as possible and shall be arranged with particular care to avoid vapor pockets.
- 4.6.3 Reducers immediately connected to the pump suction shall be eccentric type flat side up to avoid the accumulation of gas pocket.
- 4.6.4 For end suction pumps, elbows shall not be directly connected to the suction flange. A straight piece minimum 3 times the line size shall have to be provided at the suction nozzle.
- 4.6.5 Unless otherwise specified T -type strainers shall be used on pump suction piping for sizes 2" and above.
- 4.6.6 All small bore piping connected to pump shall have provision for break up flanges for removal of pumps.
- 4.6.7 Piping shall be so arranged that forces and moments imposed on the pump nozzle do not exceed the allowable values as per API 610.
- 4.6.8 Pump discharge should preferably be routed away from the pump rather than towards the motor / Engine side.
- 4.6.9 Pump cooling water connection if any, shall be taken from the circulating cooling water header.

## 5.0 MATERIAL SPECIFICATION

- Materials & equipments used for fire protection system shall be in accordance with NFPA/TAC requirements and/or attached specifications of NIT.
- Pipes(API 5L Gr. B, SMLS up to 6"NPS and welded for higher sizes) fittings(ANSI/ASME), Valves(API), flanges(ANSI/ASME), Spray nozzles and deluge valves, quartzoid bulb detectors(QBD), Detector piping, Hydrant, Monitors, Hose Boxes, Hoses shall be as per piping material specifications (PMS), and/or attached specifications of NIT.
- Cast Iron valves or any cast iron piping component like pipes, fittings, flanges, valves, fasteners, gaskets, etc. shall not be used for firefighting system or for any service.
- Spiral welded pipes shall not be used.
- Seamless pipes/fittings are acceptable in lieu of welded pipes/fittings, but welded pipes/fittings are not acceptable in lieu of seamless pipes/fittings.
- LSAW pipes are acceptable in place of ERW pipes, for same thickness.
- Double seam , 180 degree apart , is allowed for pipe sizes 36" and larger only.
- Circumferential seams (minimum 2 meter apart) is allowed for pipe sizes 36" and larger only.
- Flanges shall be in one piece material, without any joints.
- All flanged valves (except forged) shall have flanges integral with the valve body.
- Forgings are acceptable in place of castings but not vice-versa.

<div><div>पी डी आई एल PDIL</div></div>	DESIGN PHILOSOPHY-FIRE FIGHTING	PNMP/PC288/E001/SEC-5.3.4	P	<div></div>
		DOCUMENT NO.	REV	
		SHEET 10 of 15		

- l) Valves in saline water (if applicable) service shall be with non ferrous trims and all wetted parts other than trims shall be epoxy coated.
- m) Generic material of valves body, required as per process/service conditions but not specifically mentioned, shall not be lower in chemical composition than the connecting pipe material.
- n) PN equivalent rating for Class150# valves shall be minimum PN16.

#### 5.1 Hydrant Valve shall be BIS approved (IS-5290) with following detail:

Inlet	: 3"-ANSI 150 # RF
Outlet	: 63mm
Pipe Size & material	: 4" CS
Capacity	: 36 cum/hr
Type	: Oblique angle type as per TAC requirement
Material	: SS304

#### 5.2 Water Monitor

Nozzle bore size	: 38mm (Aqua fog /foam with arrangement of jet and spray).
End connection	: 4"- 150 # RF
Run Pipe Size	: Min. 6", CS
Capacity	: 2580 LPM
Material	: SS304
Approval	: IS-8442

#### 5.3 Water cum Foam Monitor:

Nozzle bore size	: 38mm (Non aspirating type-Aqua fog / foam with Arrangement of jet and spray)
Run Pipe Size	: Min. 6", CS
Capacity	: 750 GPM
Material	: SS304
Approval	: UL

#### 5.4 Long Range Water monitor

Capacity	: 2000/1000/750/500 GPM (as required)
Horizontal Range	: 50 m approx.
Material	: SS304
Approval	: UL

#### 5.5 Hose Reel

Fire hose reels (IS-444) shall be considered at strategic locations around block as first aid fire contingency. These shall be indoor wall mounted and outdoor floor mounted type on structure and shall have water connection from hydrant network. Each hose reel shall have 30 metre long hose with nozzle. Hose reel shall be minimum 30m long x 20mm bore.

<div> पी डी आई एल <b>PDIL</b></div>	DESIGN PHILOSOPHY-FIRE FIGHTING	PNMP/PC288/E001/SEC-5.3.4	P	<div></div>
		DOCUMENT NO.	REV	
		SHEET 11 of 15		

Hose reel shall cover all process areas in ground floor. Indoor wall mounted Hose reel shall be provided with each landing valve. Outdoor floor mounted type on structure at strategic locations @ 01 no.(minimum) for each package area.

#### 5.6 Hose Box

Hose boxes shall be made of M.S. material and painted red with dimensions 18 SWG thick M.S. sheet, size 750 mm x 600 mm x 250 mm. Each box shall contain 2 nos.x 15 m of 21/2" fire hose (IS-636 Type-B) with gun metal nozzle, coupling, universal branch pipe (IS-903), MS spanner. 1no. Hose Box with accessories shall be provided for each hydrant post and each fire brigade connection (3 Way, 4 Way with isolation gate valve).

#### 5.7 Portable Fire Extinguishers

Portable fire extinguishers (IS-2190, BIS marked / BIS approved) as per TAC shall be provided for plant & non plant buildings & areas, at strategic locations. Portable extinguishers of 9 kg (wheeled) & 50kg (wheeled) DCP (ABC type), 4.5kg (mounted), 6 kg (mounted) & 22.5kg and above (wheeled) CO2 type shall be provided. Contractor shall specify the numbers and location for Owner's review and approval.

#### 5.8 Deluge valve

Deluge valve shall have flanged body/housing & cover (Cast Steel ASTM 216 Gr. WCB), Internal Metallic parts SS304, Diaphragm Rubber/ Non metallic) UL listed, Red Painted, pneumatically actuated.

### 6.0 FIRST AID FIRE FIGHTING EQUIPMENTS

The selection of safety equipment should be such that it is correctly related to the type of fire expected in the area.

The general guideline for selection and use shall be as per TAC/IS requirements. Fire extinguishers shall be provided as per TAC/IS.

Contractor shall provide the Fire extinguishers items (BIS approved) as specified in tender.

#### 6.1 Fire extinguisher

Fire extinguishers as per TAC shall be provided for process risk and at each landing of operating platform of technological structures, for the protection of equipment as a means to cope up with fire at incipient stage. Supply of all Fire Extinguishers shall be with BIS Mark.

Powder used in DCP type fire extinguishers shall be MAP 90% ABC powder, UL listed & BIS approved.

The number should be determined based on the max. travelling distance of 15 M. At least one fire extinguisher shall be provided for every 250 m2 of hazardous operating area.

Chemicals/ Consumables used in the fire extinguisher shall UL listed.

Following Fire Extinguisher types shall be provided.

- 1) 6 Kgs., 9 Kgs. Capacity DCP Extinguishers (ABC type) shall be provided on Technological platforms/process ground floor and Control rooms.
- 2) 4.5 Kgs. Capacity Co2 Extinguishers shall be provided for buildings, sub stations & control rooms.
- 3) 22.5 Kgs Capacity Co2 Extinguisher shall be provided near transformer bay.

<div> पी डी आई एल <b>PDIL</b></div>	DESIGN PHILOSOPHY-FIRE FIGHTING	PNMP/PC288/E001/SEC-5.3.4	P	<div></div>
		DOCUMENT NO.	REV	
		SHEET 12 of 15		

4) 50 Kgs capacity DCP Extinguishers (ABC type) shall be provided at critical operating area in plant.

5) 2 Kgs, 4 Kgs capacity clean agent Extinguishers shall be provided for Control Room, Computer room, Computer console room, UPS room, Battery room, server/database rack room etc.

## 6.2 Sand Bucket

Sand buckets filled with sand along with scoops, mounted on structural support stand each with at least 3 sand buckets), shall be provided in Transformer bay, Sub Station, buildings, Technical structure, platforms, Pump house, etc.

The sand buckets shall have round bottom with bottom handle having 9 liter water capacity conforming to IS: 2546. The sand stored in bucket shall be fine and free from oil, water or rubbish. Rain protection of suitable design shall be provided for all sand buckets.

## 6.3 Safety Signages

Contractor shall provide the safety signages (in English & Hindi language) as per NBC/TAC , at strategic locations, for plant/ non plant areas buildings, technological structure, areas. Safety signages must be visible under both lighted & darkness conditions.

## 6.4 Emergency Escape Route

Escape route shall be marked with signage, exit point. Escape route shall not be obstructed in any way. No single accident should be capable of blocking both alternatives. Escape route should take shortest route to assembly point defined within plant.

In case of process structure, satisfactory access shall be provided to all parts of each floor by means of incombustible internal or external staircases.


Exact numbers, width, location, etc. of such staircases and ramps for basements shall depend on travel distance requirements given under National Building code of India.

## 7.0 SAFETY EQUIPMENTS/PERSONNEL PROTECTIVE EQUIPMENTS (PPE)

Quantity of safety equipments/PPE items shall depend on the facilities and size of plant.

Contractor shall provide the following safety items with minimum qty. specified for their scope of work:

- a) Safety helmets – 10 nos.
- b) Stretcher – 2 nos.
- c) Fibre glass First Aid Box with all necessary items/kit & anti snake serum -02 sets.
- d) Rubber hand gloves for electrical jobs– 10 pairs per type for each substation and each control room. (min. 10 pairs per type irrespective of facility requirement).
- e) Explosimeter- 02 nos.
- f) Fire Proximity suit – 02 nos.
- g) Resuscitator–02 nos.
- i) Hand operated siren - 1 no.
- j) Water jel blanket – 02 nos.
- l) Positive Pressure type self contained breathing apparatus – 02 nos. per control room & per substation. (min. 02 nos. irrespective of facility requirement).
- m) Hand held battery loaded Emergency light, each with 1 set spare battery- 02 nos.
- n) Sand Bucket & accessories - 02 sets.

<div><div>पी डी आई एल PDIL</div></div>	DESIGN PHILOSOPHY-FIRE FIGHTING	PNMP/PC288/E001/SEC-5.3.4	P	<div></div>
		DOCUMENT NO.	REV	
		SHEET 13 of 15		

## 8.0 EXECUTION, INSPECTION AND TESTING

All execution, inspection and testing for completion of fire protection system shall be carried out based on codes, standards and specifications. Contractor shall develop detail inspection and testing procedures for review by owner. Contractor shall carryout demonstration test for each installed system as per scope of work.

The Contractor shall meet all requirements for inspection and testing of the systems.

## 9.0 QUALITY ASSURANCE SYSTEM

All work/services to be performed by the Contractor under this contract shall be of specified/approved quality and Contractor shall have a quality assurance/quality control (QA/QC) system during the performance of various activities such as engineering, procurement, tendering, construction etc. Review/approval of activities by Owner/PMC shall not however dilute the responsibility of Contractor for maintaining quality.

The objective of the quality assurance scheme of the Contractor shall be to ensure the conformity of equipment, material, site construction (if any) to various standards, specifications, drawings and technical requirements that are being mutually agreed between the Contractor and Owner/PMC/TPI. Quality Assurance System should clearly indicate the organisational approach for quality control and quality assurance of the various equipment/construction activities (if any) and also provide a verifiable evidence of the Contractor having carried out all the activities laid down in the bid document and the procedure. Such conformity to quality level shall be ensured by controlling the quality level of purchased items at vendor's/sub-vendor's shop/site and shall cover from source surveillance to final inspection. The Contractor to submit a detailed inspection and testing plan for various shop/site activities for review by Owner/PMC/TPIA.


## 10.0 INSPECTION

The Contractor is required to organize a proper inspection and expediting system so as to ensure timely delivery of all the items/equipment meeting the specified quality criteria. This function has to be carried out by appropriate deployment of qualified personnel who have wide experience in their respective fields. Inspection of all items supplied under this contract shall be carried out by independent third party inspection agencies like Lloyds/ BV/ TUV/DNV. Third party inspection charges for foreign origin items shall be quoted by bidder. Third Party Inspection shall be done by owner approved third party inspection agencies.

Inspection authority means the Third Party Inspection Agencies (TPIA) approved by the Owner to carryout inspection of materials.

The inspecting authority shall have the right to select random samples for check test and reject materials, if samples furnished as above and tested as per the specifications fail to meet the requirement specified.

All the items shall be inspected and tested in the presence of one or more representatives of the purchaser during various stages of manufacturing. Material shall be considered acceptable for dispatch only after final certificate of acceptance is issued by the Inspector. Testing performed in

<div> पी डी आई एल <b>PDIL</b></div>	DESIGN PHILOSOPHY-FIRE FIGHTING	PNMP/PC288/E001/SEC-5.3.4	P	<div> बी एच ई एल <b>BHEL</b></div>
		DOCUMENT NO.	REV	
		SHEET 14 of 15		

the presence of the purchaser's representatives shall not relieve the supplier of their own responsibilities and guarantees and any other contractual obligations.

Quality Assurance plan (QAP) / Inspection Test Plan (ITP) shall be submitted by bidder for approval by Third Party Inspection Agency (TPIA).

The Contractor shall make arrangement for inspection and testing by statutory authorities, if applicable, at various stages of the work.

#### 10.1 Scope of Inspection by TPIA:

- i) Review of MTC (all batches).
- ii) Visual check for surfaces, external appearance (10% random witness).
- iii) Dimensional check (10% random witness).
- iv) Positive Material Identification (PMI) for alloy steels/austenitic steels (10% random witness).
- v) Hydrostatic test (10% random witness for pipes, fittings, valves, strainers, traps, collecting heads, draw off connection, hoses, hose reels, extinguishers, bellows, personnel protective equipments (if applicable for any item), fire fighting/protection equipments. Hydrostatic test shall be 10% random review for other items.
- vi) Any testing/demonstration required as per relevant code/standard/specification: 10% random review.
- vii) Packing: Report review.
- viii) Documentation (MTC, Inspection Release Note): 100% Review.

#### 11.0 TESTING

All testing shall be done, as per relevant specifications and/or NIT specifications.

##### 11.1 Non Destructive Testing

10% radiography of butt welds and 10% DP/ MP test of fillet welds shall be done for pipe classes in 150# & 300#.

100% radiography on butt weld joints and 100% DP/MP for fillet welds test shall be done for pipe classes in 600# & above.



Radiography procedure, areas of casting to be radiographed, and the acceptance criteria of valves shall be as per ASME B16.34.

The minimum requirement of radiography shall be as under :

Pipe Class	Size (NPS)	Qty
150	Up to 24"	5%
150	26" & above	100%
300	Up to 16"	10%
300	18" & above	100%
600 & above	All	100%



#### 12.0 DOCUMENTATION

Drawings and documents (4 hard copies, 1 electronic copy & 1 as-built copy of each drawing/document), for firefighting/fire protection system, design basis, general

<div> पी डी आई एल <b>PDIL</b></div>	DESIGN PHILOSOPHY-FIRE FIGHTING	PNMP/PC288/E001/SEC-5.3.4	P	<div></div>
		DOCUMENT NO.	REV	
		SHEET 15 of 15		

arrangement/layout drawings of fire water/ spray system/ sprinkler system/fire extinguishers/fire fighting equipments, design adequacy calculations, material specifications, material take-offs (linewise/consolidated), supplier drawings/specifications, inspection test plans, test certificates, spares list, etc. shall be submitted by the Contractor for review/approval/information of Owner/PMC/ Statutory authorities.





<div> पी डी आई एल PDIL</div>	<div>PERSONNEL PROTECTION EQUIPMENT LIST</div> <div>FIRE FIGHTING SYSTEM</div>	PNMP/PC288//E001/PPE LIST	P	<div></div>
		DOCUMENT NO.	REV	
		SHEET 1 of 3		



Bidder shall provide the following items complying specifications of tender & as mentioned below:

S.No.	Item	Specification	Quantity	Remarks
1	Cold/low temperature protective suit.	Design leak proof with material to withstand minus 45 degC for 30 minutes minimum, without crack/damage. Colour shall be cherry/brownish red/yellow suitable for use in LPG, liquid ammonia.	6 sets	
2	Fire Proximity Suit	UL listed	4 sets	
3	PVC suit		4 sets	
4	Leak Control Kit : Consisting of 1 no each of leak arresting pad, leakage control of external pipes, internal pipes, large external pipes up to 8 inch, drums / containers leakages, general purpose leakages, large hole leakages in storage tanks.		6 sets	
5	Oil Product Clean up Chemical : - Boom(5 inch dia , 3 mtr. Long) : 6 nos. - Boom(3 inch dia , 3 mtr. Long) : 6 nos. - Granular particles to absorb Oil : 20 Kg		2 sets	
6	Oil Spill Dispersant (Water Based) along with hand held spray nozzle. Dispersant : 40 litre Spray Gun with back pack		2 sets	



	<b>PERSONNEL PROTECTION EQUIPMENT LIST</b>  <b>FIRE FIGHTING SYSTEM</b>	PNMP/PC288//E001/PPE LIST	P	
		DOCUMENT NO.	REV	
		SHEET 2 of 3		


S.No.	Item	Specification	Quantity	Remarks
7	Non Sparking Tools One set consisting of : - Shoe handle brush -01 no - 9" Crate opener -01 no - 16oz Claw hammer with Fiberglass handle -01no. -Common knife 5 <sup>3</sup> / <sub>4</sub> " Blade : 1 no 10 <sup>3</sup> / <sub>4</sub> " OAL, -12" Groove joint plier, -7" Long nose pliers with cutters, -8" Combination Pliers, -Deck scraper, -1 1/2" Blade X 15"Long, -Spray booth scraper, -3" blade X 9 1/4" Long, -Std Screwdriver – 5/16" Tip, -6" Blade, - 3" Phillips Screwdriver, -12" Tin Snips, -8" Adjustable Wrench, -12" Adjustable wrench, -14" pipe Wrench (Aluminium), -12" Bung Wrench (Fits 3/4" X 2")		6 sets	
8	Self-contained Breathing Appartus Set (30 minute duration) with a spare cylinder (filled-up) & accessories	IS: 10245 (Part-2).& CCOE approved	6 sets	
9	Fire escape mask / filter type emergency respirators	IS: 8523	6 sets	
10	Flame Proof Search Light (Rechargeable safety hand held torch): Rechargeable type suitable for Explosive Environment.	PESO Certified	8 no	
11	Mega Phone Explosion Proof Portable battery operated Public Address System with 1 loud speaker with a range of 1 KM in still air and 500 M in noisy areas		4 set	.
12	Hand Siren With Stand : Approx. range of 1.6 KMS	IS:6026	1 no	
13	Electrically Operated Siren (Range - 3.0 Kms)	IS:1941	1 no	
14	Fireman Axe	Forged Axe head, Insulated Handle, IS-926	4 no	
15	Fibre Glass First Aid Box (with Medicines & other Items)		6 set	

	<b>PERSONNEL PROTECTION EQUIPMENT LIST</b>  <b>FIRE FIGHTING SYSTEM</b>	PNMP/PC288//E001/PPE LIST	P	
		DOCUMENT NO.	REV	
		SHEET 3 of 3		


S.No.	Item	Specification	Quantity	Remarks
16	Resuscitator : Manually operated for artificial respirators consisting of adult size nose, mouth, face plate, air bulb with oxygen inlet connection, non- return, non- breathing human valves and first aid charge packed in a plastic bag	UL listed	6 no	
17	Water jel blanket	UL/FM listed	6 no	
18	Folding Stretcher : Size 6 feet X 3 feet with tying belts & blanket.	Heavy duty Aluminium, vinyl coated nylon, BIS mark, Load 160kg min.	6 no	
19	Safety Helmet	IS-2925(Latest amendment) & EN-397 Certified, water proof, high impact, heat & chemical resistant, HDPE, ratchet fit, size 51-62 cm. with Inner head band LDPE, ventilated sweatband absorber, coloured "company name" logo.	60 no	
20	Safety Shoes	Leather upper with rubber /synthetic sole & steel cap, thermal resistant, skid resistant	60 pairs	
21	Safety Goggles	IS-5983, chemical & heat resistant	60 no	
22	PVC Hand Gloves	IS: 6994	60 pairs	
23	Nitrile Hand Gloves	CE/EN	60 pairs	
24	Electrical resistance, Insulating Rubber Hand Gloves		15 pairs	
25	Explosimeter	UL/FM listed & PESO approved	6 no	
26	Wind socks		6 no	
27	Sand buckets (9 Ltr. capacities) filled with sand along with scoops, rain protection and mounted on structural support stand (each with at least 3 sand buckets).	IS: 2546	6 set	
28	Red/Green flag each colours		30 no. each colours	

**Note:**

1. Above mentioned quantity are minimum.

	<b>TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM</b>	PNMP-TS-PPE	P
		DOCUMENT NO	REV
		SHEET 1 of 12	

# **TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT**

	<b>TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM</b>	PC288-PNMP-TS-PPE	P
		DOCUMENT NO.	REV
		SHEET 2 of 12	

## 1.0 Safety Helmet

Safety helmets are made of fibre glass shall be supplied and shall confirm to IS:2925 (Latest amendment) & EN-397. These shall be moulded seamless in one piece from natural reinforced fibre glass/polyester resin, which can withstand heavy impact. The helmet shall be made of material highly impact, heat & chemical resistant, high dielectric strength and shall also have better quality abrasion resistance and higher softening temperature. The shell structure of the helmet shall be designed to provide extra strength and toughness. The helmet shall have sweat band and adjustable head band and shall bear IS approval. The colour of the helmets shall be decided at the time of placement of order.

## 2.0 Safety Goggles

A device worn over the eyes & held in place by a headband used for protecting the eyes & eye sockets from flying particles & injurious radiations, chemical & heat resistant and shall conform to IS-5983.

## 3.0 Stretcher with Blanket


Stretcher (size 6 feet X 3 feet with tying belts & blanket) shall be supplied and shall conform to IS:4037. Material of the stretcher and other related accessories should be as per the IS standard of practice.

Heavy duty aluminium poles for easy handling and heavy duty, vinyl-coated nylon covers that resist stains and will not absorb body or bodily fluids

## 4.0 Fiber glass First Aid Box with Medicines

Fiber glass First Aid Box portable type with locking arrangement and compartmentalised storage facility and containing the required first aids as below:

- First aid for cuts, burns, sprains (instant relief sprays) - 1 each.
- Antiseptic lotion, liquids (Dettol / Savlon tincture iodine) - 1 bottle
- Pain relieving medicines, anti vomiting medicines etc. - 2 stripes of 10 each.
- 500 mg Paracetamol I.P - 100 tablets.
- Anti snake serum bottle - 1 No.
- Band-Aids - 20 pcs.
- 25 gms of Soda Bi-Carb. I.P. - 1 pkt.
- Wound dressing small (for fingers) - 12 pcs.
- Wound dressing medium (for hands and feet) - 6 pcs.
- Wound dressing large (for body) - 6 pcs.
- Burn dressing large (for body) - 6 pcs.
- Absorbent cotton wool 13 gms each - 6 pcs.

	<b>TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM</b>	PC288-PNMP-TS-PPE	P
		DOCUMENT NO.	REV
		SHEET 3 of 12	

- Dressing arrangements (scissors / blade etc.) - 1 set.
- Eye pad with bandage in separate pkt. - 08 pcs.
- Tourniquet cotton with belt & buckles. - 1 No.
- Polythene wash bottle 500 c.c. - 1 No.
- Book of instruction on first aid to injured - 1 No.
- Copy of First Aid Leaflet issued by DG FASLI – 1 No.

## 5.0 PVC Hand Gloves


Acid alkali proof PVC hand gloves made of superior quality PVC in yellow colour. The fingers and palm should be embossed/ ribbed for better grip. Palm size should be 9" and overall length 14". The gloves should be confirming to IS: 6994/1973(part-ii).

## 5.1 Nitrile Hand Gloves

CE Marked fully Nitrile rubber hand gloves (In pair) shall have inside soft cotton flocked lining. It shall be able to resist Acid, alkali & solvent while providing solid protection against snags, abrasion, puncture & cuts. Nitrile Rubber hand glove should meet requirement of EN-388 & EN-374. The overall length of the Gloves shall not be less than 12 Inches (from middle finger to end of the sleeve).

## 5.2 Electrical resistance, Insulating Rubber Hand Gloves in pair (one for Right Hand, one for Left Hand.)- 1100 Volts

1. Four Fingers and One Thumb
2. MAKE: CATU / Honeywell / Oberon / SICAME or equivalent
3. Maximum voltage of use A.C volts: 1000 Volts (rms)
4. Class - 0
5. Size: 9
6. Type: Gauntlet type
7. Max thickness (approx.): 1.6 mm
8. Construction: Seamless
9. Standard: IEC 60903
10. Category: RC
11. Tested by authorized Government Test houses / NABL accredited LAB and relevant test certificate / Batch certificate with hand gloves serial number to be furnished with the material.
12. Made from specially compounded latex or equivalent for complete insulation & totally shock proof.
13. Test certificate of the supplied item to be furnished along with the supply.
14. Packed in sealed plastic bag.
15. The gloves shall be marked indelibly at the back-
  - A) Size, class & category of gloves
  - B) Month and year of manufacturing
16. Following tests will be conducted under inspection of TPIA :

	<b>TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM</b>	PC288-PNMP-TS-PPE	P
		DOCUMENT NO.	REV
		SHEET 4 of 12	


- A) Leakage current Test
- B) Tensile strength and elongation at break
- C) Resistance to mechanical puncture
- D) AC Proof Test
- E) Flame retardancy Test

#### 5.2.1 Electrical resistance RUBBER INSULATING HAND GLOVES in pair (one for Right Hand, one for Left Hand.)- 36 KV (rms)


1. Four Fingers and One Thumb
2. MAKE: CATU / Honeywell / Oberon / SICAME or equivalent
3. Class - 4
4. Max. Voltage of use A.C volts: 36 KV (rms)
5. Size: 10
6. Type: Gauntlet type
7. Max thickness (Approx.): 4.2 mm
8. Construction: Seamless
9. Confirming to IEC 60903
10. Category: RC
11. Tested by authorized Government Test LAB / NABL Accredited LAB and relevant test certificate / Batch certificate with hand gloves serial number to be furnished with the material.
12. Made from specially compounded latex or equivalent for complete insulation & totally shock proof.
13. Technical catalogue and test certificate of the offered item to be furnished along with the offer.
14. Packed in sealed plastic bag.
15. The gloves shall be marked indelibly at the back-
  - A) Size, class & category of gloves
  - B) Month and year of manufacturing
16. Following tests will be conducted at ERDA
  - A) Leakage current Test
  - B) Tensile strength and elongation at break
  - C) Resistance to mechanical puncture
  - D) AC Proof Test
  - E) Flame retardancy Test

#### 6.0 Portable Explosive Meter cum Oxygen Meter (Explosimeter)

S.N	Particulars	Specification
1.	Use	Able to measure LEL (In Inert atmosphere) and oxygen in zone 0 area.
2.	Type	The metering unit shall be microprocessor based. It shall be suitable for use in open as well as confined space for one hand operation and rugged with casing of protective rubberized over-mold.
3.	Sensor	Combustible (LEL) sensor- IR type


	<b>TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM</b>	PC288-PNMP-TS-PPE	P
		DOCUMENT NO.	REV
		SHEET 5 of 12	

S.N	Particulars	Specification
		Oxygen sensor: Electro-chemical type. Sensors shall be replaceable type.
4.	Ambient Condition	0°C to 50°C & humidity: up to 90% RH(non-condensing). (Locations e.g Leh/ Ladakh etc. with extreme weather conditions may decide ambient conditions as per site requirement)
5.	Housing	Minimum IP65 or Better. IP rating should also be tested & certified by accredited agencies like FM/UL/CENELEC/BASSEFA/ATEX/CIMFR/IEC etc.
6.	Area Of Use	The detector shall be intrinsically safe for use in hazardous area classification conforming to Class I, Division I, Group A, B, C & D or Zone - 0, Group-IIA, IIB & IIC, having certified for use by accredited agencies like FM/UL/CENELEC/BASSEFA/ ATEX/CIMFR/IEC etc. and PESO approval at the time of supply of material.
7.	Range	Combustible Gases: 0-100% LEL O <sub>2</sub> : 0 – 25% by Vol. (Min.)
8.	Sampling Pump	Each instrument shall be fitted with motorized pump with audio and visual low flow alarm.
9.	Remote Sampling Accessories	Minimum 10 feet long sampling hose and sampling probe equipped with quick connect device shall be supplied along with instrument with suitable filter.
10.	Alarm	Minimum 85 Decibel audible alarm at 30 cm & bright red LED flashing visible alarm with vibration. Two levels of alarms for each gas sensed and low battery as minimum. Set points shall be adjustable over entire range.
11.	Battery	Rechargeable Battery (NiMH / Li-ion) shall be suitable for minimum 8 hrs. duration (with pump). Charger operable with 230V+ 5%, 50 Hz, AC supply shall be supplied with each instrument.
12.	Size & Weight	Weight shall not exceed 1Kg. (Including Battery & Sampling pump).
13.	Calibration	Frequency Shall be as per OEM recommendation or once in six month whichever is earlier. Calibration shall be easily performed using instrument's pushbuttons no other special tools will be required. Instrument should show calibration due date. Minimum 4 No calibrations within warranty period to be carried out by OEM or its authorized representative.
14.	Accessories	The instrument shall be supplied with necessary calibration cup/adaptor and calibration tubing to facilitate calibration locally.
15.	Display	Self-illuminating back-light digital display.

	<b>TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM</b>	PC288-PNMP-TS-PPE	P
		DOCUMENT NO.	REV
		SHEET 6 of 12	

S.N	Particulars	Specification
16.	Fast Response	Maximum 30 Sec. to reach to 90% of measured value The above response time shall be with 10 feet long sampling hose.
17.	Hands Free Operation	The unit shall also have a suitable arrangement for hands free operation.
18.	Rf Protection	Shall be compliant with EMC directive against EMI/RF interferences.
19.	Accuracy	+/- 2% of measured value
20.	Maximum Resolution	Combustible gas: 1.0% LEL O <sub>2</sub> : 0.1 % by Vol
21.	Performance Guarantee	Minimum 2 years including sensors. The vendor shall guarantee the design, material, workmanship and the performance of the unit for a period of 24 months from the date of supply. Any defect, faulty workmanship or operational defects found during this period shall be rectified by the vendor without any extra cost of Owner/ PMC. Suitable instrument like BG etc shall be furnished by the vendor in line with tender conditions against performance guarantee.
22.	Documentation	Vendor shall be OEM or its authorized supplier having valid authorization from OEM. All other details shall be as per ANSI/ISA 12.03.01(Combustible gases) and ANSI/ISA 92.0.01 to 92.06.01 or equivalent IEC standards.
23.	Inspection, Testing And Performance Parameter	Owner/ PMC reserve its right to get material tested at a lab of repute or vendor to submit third party inspection certificate along with all accessories by Owner/ PMC approved third party inspection agency as per the requirement of Technical Specification. In the event of non-conformity with specifications, Owner/ PMC shall be at liberty to take action as deemed appropriate at its sole discretion. Prior to dispatch of the material from vendor's / manufacture's place the following inspection and tests shall be carried at the vendor place to complete satisfaction of Owner/ PMC representative or his authorized third-party agency without any extra cost to Owner/ PMC for: <ul style="list-style-type: none"> <li>Visual inspection of Explosi &amp; Oxygen Meter (Explosimeter) to ensure no apparent damage or deficiency.</li> <li>Examination of documents / certificates / test reports/</li> </ul>



	<b>TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM</b>	PC288-PNMP-TS-PPE	P
		DOCUMENT NO.	REV
		SHEET 7 of 12	

S.N	Particulars	Specification
		instructions/ Guidelines. <ul style="list-style-type: none"> <li>All consumable required for inspection and testing work shall be arranged by vendor at his own cost.</li> <li>Vendor shall arrange all facilities to carry out inspection and testing.</li> </ul> Details of field demonstration: Owner/ PMC at its discretion may ask the vendor for field demonstration/ Training for end users at a location specified by Owner/ PMC.
24.	Packing	Material should be packed in OEM packing.
25.	Damage Of Material	Any damage and / or manufacturing defects to the supplied material will not be accepted.

**NOTE:**


- The default measurement of LEL shall be for Methane. The detector is calibrated to Methane.
- During supply, vendor shall submit operational & maintenance manual, warranty certificate and TPI report along with each instrument.
- Vendor shall supply calibration certificate by OEM for all the sensors. The calibration certificate should contain identification numbers of the sensors & instruments supplied by the OEM.
- Vendor shall clearly indicate the point-wise acceptance/deviation against the above specification in the offer.
- Vendor shall arrange to rectify the defects within two weeks from reporting of the defect at site/owner's premises specified by the owner without any extra cost to owner during warranty period.
- Vendor shall submit the declaration on the cross-sensitivity of sensors with other gasses of concern.
- Owner/ PMC authorized Inspection Agency shall inspect the material before dispatch of the material for quality assurance, testing & performance evaluation as per technical specification.

**7.0 Aluminised Fire Proximity Suit.**

**7.1 General**

The suit shall be made up of aluminised glass fabric. It shall be stitched with fire retardant Kevlar yarn or equivalent threads. The material used for the suit, shall not chemically react with water and shall not show any tendency to absorb oil, grease, petrol etc.

The suit shall include hood, coat, pants, boots, mitts and pouch suitable for accommodating BA set. Shoes shall be of standard size with proper insulation and leather lining with non-skid type sole. Metal zip fasteners shall be provided for easy donning and removal of the suit.

	<b>TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM</b>	PC288-PNMP-TS-PPE	P
		DOCUMENT NO.	REV
		SHEET 8 of 12	

No discomfort shall be experienced while climbing a ladder, in running while carrying a pressurised hose pipe or first aid box. The suit shall get dried easily. The complete set with maintenance manual shall be packed in a strong case / box.

- 7.2 Shelf life : Minimum 10 years.
- 7.3 Donning time : 1.5 minutes.
- 7.4 Protection Level : Outer shell fabric shall withstand a radiant temperature of 2000 deg.F approx.
- 7.5 Size : Regular size suitable for a fireman of height 5'6" to 6'2" approx.
- 7.6 Certification : The fabric of the fire proximity suit shall confirm to the any one of the following standards / specifications  
European Standard (EN)  
Listed by Underwriters  
Laboratories UL 214.

## 8.0 Resuscitator


The Resuscitator should be as per WHO specifications or UL listed. The resuscitator shall be an intermittent positive pressure respirator type for artificial respiration with a human non-return, non- rebreathing valve. The resuscitator shall be of bag type, manually operated and shall be packed in a transparent bag along with a first aid chart displaying its operation. The resuscitator shall be suitable to be used by an adult person.

## 9.0 Electrically Operated Siren (Range - 3 Kms)

The general requirements, 3 phase electric motor, siren, heads, starter for on/off operations, without warbling relay, acoustic power shall comply with IS:1941 (Part I)/1976. The Siren shall be approx. range of 3 KMS. It shall be suitable anywhere in the country. Siren shall be horizontal complete with mounting. The electric motor shall be totally enclosed with greased sealed ball bearing and shall conform to IS:325.

## 10.0 Hand Operated Siren (Range - 1.6 Kms)

The shape, components, material, design and construction shall comply with IS:6026-1970. It shall have portable stand as per IS:6026. The Siren shall be approx. range of 1.6 KMS.

	<b>TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM</b>	PC288-PNMP-TS-PPE	P
		DOCUMENT NO.	REV
		SHEET 9 of 12	


#### 11.0 Low Temperature Gas Protective Suit Suitable for Handling LPG, Liquid ammonia, Propane and Other Toxic Hazardous Gases.

1.	MATERIAL OF CONSTRUCTION	:	Polyamide fabric coated with viton / silicon
2.	SEAMS	:	Sewn with chemical resistance special thread to ensure leak proof design.
3.	SEALANT	:	Shall be used for the suit for achieving chemical resistance.
4.	GLOVES	:	Shall be made up of the same material used for the suit, and they shall be covered with neoprene as an extra protection. Gloves shall be fixed with the wrist.
5.	COLOUR	:	Cherry / Brownish Red / Yellow
6.	LOW TEMPERATURE WITHSTANDING CAPABILITY	:	The suit shall be able to withstand a low temperature of minus 45 deg. centigrade without any physical damages whatsoever
7.	APPROVAL	:	<p>The Vendor shall enclose latest Test Certificates duly approved by DIFR / GIRDA, clearly indicating the followings:</p> <ul style="list-style-type: none"> <li>- That the gloves can withstand a temperature of minus 45 deg C for a period of 30 minutes.</li> <li>- No cracking, blistering was noticed on the suit after the low temperature test.</li> </ul>

#### 12.0 Water Jel Blanket

Water jel blanket (Hydro jel blanket) to be used in case of fire burns shall be supplied the minimum size should be 2.5mX1.5m. It should have necessary approval from any of these agencies (UL of USA, FM of USA, LPCB of UK, and VDS of Germany). Blanket shall be woven out of new wool, impregnated with sterile water based gel. Blanket shall be capable to protect the user from heat, smoke and to provide to the burn victim. The water gel blanket shall bear approvals of IS/DGMS/DIFR or equivalent.

The wool carried is capable of absorbing upto 13 times its own weight. The Water Jel Blanket shall be packed in good quality poly-jar / canister. Water Jel Blanket shall be having 5 years usable life.

	<b>TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM</b>	PC288-PNMP-TS-PPE	P
		DOCUMENT NO.	REV
		SHEET 10 of 12	

### 13.0 Fire escape mask / filter type emergency respirators

Emergency respirator is a self rescue hood, ideal for escape from room and buildings contaminated with toxic fumes and gases created by fire or accidental pollution. It should be as per IS: 8523.

### 14.0 Self Contained Breathing Apparatus (45 Minutes)

Self-contained breathing apparatus (SCBA) suitable for fire fighting, rescue operation in toxic and oxygen deficient atmospheres. The equipment consists of compressed air cylinder, full face wide vision mask (with inner mask), pressure reducer, pressure gauge, low pressure warning whistle, exhalation valve, speech diaphragm, comfortable shoulder harness and light weight back plate, straps, buckles and easy to wear.

The Cylinder shall be capable to operate for 30 minutes. The Cylinder and Valve shall have CCOE approval. BA Set shall be confirming to IS: 10245 (Part-2). One number of spare cylinder shall also be supplied

### 15.0 PVC suit

It shall be used in handling acid and alkali. Chemical protection clothing can be manufactured from a special grade heavy duty high visibility yellow PVC. The material shall have excellent chemical resistance, high tensile, tear & elongation strength, abrasion, ozone as well as heat resistance. The clothing seam shall be welded by high frequency electrical heating.

### 16.0 Red and Green Flag


Red and green flag suitable for the fire drill operation shall be supplied. Handle should be made of aluminium. The flag should have minimum of 0.5m x0.30m dimensions.

### 17.0 Fireman Axe

Forged Axe head, Insulated Handle, IS-926.

### 18.0 Flame Proof Search Light (Rechargeable safety hand held torch)

S.N	Particulars	Specification
1.	Description	Rechargeable Hand-Held Torch
2.	Power	Rechargeable without removing batteries & Charging in Safe area.
3.	Battery Run Hours	Not less than 3 hours after complete one cycle charge. (To be certified by OEM)
4.	Lumens	Not less than 130 lmn. When measured at a distance of 1-2 Metres for major light (Lumens of the torch to be certified by OEM and NABL/ Govt. accredited Lab.)
5.	Clip/Strap	Strap/ clip
6.	Weight with	Max. 400 Grms.

	<b>TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM</b>	PC288-PNMP-TS-PPE	P
		DOCUMENT NO.	REV
		SHEET 11 of 12	


S.N	Particulars	Specification
	battery & fittings.	
7.	Certification	Intrinsically safe for use in hazardous area classification conforming to Zone '0' of Gas Group IIC hazardous area Certified by PESO.
8.	IP	Ingress Protection- Min. IP65 or better (To be certified by OEM along with relevant test certificate)
9.	Housing/ Body	Housing body should be made of material of Anti-static, high impact properties
10.	Lens	Polycarbonate
11.	DROP Test	2 Meter to be certified by OEM and NABL accredited Lab./ Govt. approved Lab.
12.	Battery with Compatible Charger	Rechargeable, Li-ion / NiMH. Charger operable with 230V $\pm$ 5%, 50 Hz $\pm$ 3% AC supply and compatible charger shall be supplied with each torch.
13.	Light Source	LED only
14.	Marking	As a minimum the product shall have following markings <ul style="list-style-type: none"> <li>Marking towards intrinsically safety of the product.</li> <li>Name of the Manufacturer</li> </ul>
15.	Warranty	Minimum one year including battery and battery charger. The vendor shall guarantee the design, material, workmanship and the performance of the unit for a period of 12 months from the date of acceptance at site..
16.	Certification	<ul style="list-style-type: none"> <li>A copy of relevant approval including PESO and other documentation along with the offer.</li> <li>During supply, vendor shall submit operational &amp; maintenance manual, warranty certificate along with each instrument.</li> </ul>
17.	Packing	Material should be packed in OEM packing
18.	Damage of Material	Any damage and / or manufacturing defects to the supplied material will not be accepted.

## 19. WINDSOCKS

LED Illuminated Windsock with heavy duty stainless steel SS-304 Stand.

Made of Stainless Steel SS-304, 360-degree rotating system to rotate the sock to wind.

- LED light of 20 watt of above suitable for outdoor installation, Cable of size 2C, 1 Sq./mm copper of 10 mtr with LED light.
- Wind Sock made of parachute polyester double lining 2-layer Combination of fluorescent colour red & white or Fluorescent Orange & Lime green with 25 mm wide reflective tape four rows for night reflection of windsock.

	<b>TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM</b>	PC288-PNMP-TS-PPE	P
		DOCUMENT NO.	REV
		SHEET 12 of 12	

- iii) The LED illuminated wind socks frame shall be made of heavy duty SS-304 rod and SS-304 strips with Extended Spokes cage two feet long as per design shown in the photos.
- iv) The frame shall be fixed on rotatable pipe stand 32mm height 5 Feet long with pedestal flange.
- v) Windsock Size: Dia 2 feet × 6 Feet Long made of parachute polyester double lining 2-layer fluorescent colour red & white Combination or Fluorescent Orange & Lime green Combination with 25 mm reflective tape four rows for night reflection.
- vi) Windsock shall be fixed with the frame along with red coloured industrial type weather proof Led lights of 20 watt and above 1 Sq./mm cable fitted with light of 10mtr per with each set.
- vii) The two bearing to be used must be maintenance free and weather proof

## 20.0 Sand Drum with Scoop

Metal drum and sand scoops with handle of large size manufactured from best quality mild steel duly red colour epoxy painted.

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		Document No.	Rev	
		Sheet 1 of 77		

## SECTION:- 5.4

### DESIGN PHILOSOPHY- ELECTRICAL

**PLANT : SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT.**

**PROJECT : Setting up of High Ash coal-to-Ammonium Nitrate Plant in Mahanadi coalfields Limited (MCL)**

1	15.05.24	15.05.24	Client's IInd comments incorporated	BK	RKV	RKV
0	22.03.24	22.03.24	Client's comments incorporated	BK	RKV	RKV
P	26.02.24	26.02.24	Issued for Client's comments	BK	RKV	RKV
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD










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		Document No.	Rev	
		Sheet 4 of 77		

<u>Electrical Sketches</u>	<u>Description</u>
PC288-PDS:E 113	Foundation Details of 11/0.433kV Transformers
PC288-PDS:E 114	Foundation Details of 11/3.45kV Transformers
PC288-PDS:E 115	Typical Details of Transformer Room Door
PC288-PDS:E 116	Sump Pit for Transformer Oil
PC288-PDS:E 119	Typical Foundation Arrangement for Panels in Sub-Station
PC288-PDS:E 120	Typical Foundation Details for HT/LT Circuit Breaker Panels
PC288-PDS:E 207	Details of Bracket Arm for Street Lighting Pole
PC288-PDS:E 208	Installation Arrangement Area Lighting Fixtures
PC288-PDS:E 210	Junction Box for Street Lighting Pole
PC288-PDS:E 213	Typical Street Lighting Pole
PC288-PDS:E 464	Schematic Diagram Panic Light
PC288-PDS:E 510	Details of Concrete Cable Trench
PC288-PDS:E 511	Cable Rack Arrangement in Trenches
PC288-PDS:E 516	Typical Arrangement of Cables buried in slit
PC288-PDS:E 530	Pre-Fabricated Cable Tray Straight Run
PC288-PDS:E 531	Pre-Fabricated Cable Tray Horizontal Tee
PC288-PDS:E 532	Pre-Fabricated Cable Tray Horizontal Cross
PC288-PDS:E 533	Pre-Fabricated Cable Tray 900 Horizontal Bends
PC288-PDS:E 534	Pre-Fabricated Cable Tray 900 Vertical Bend Bending Rad. 1000 mm
PC288-PDS:E 535	Pre-Fabricated Cable Tray 900 Vertical Bend Bending Radius 600 mm
PC288-PDS:E 536	Pre-Fabricated Cable Tray Coupling Arrangement
PC288-PDS:E 537	Pre-Fabricated Cable Tray Fixing Arrangement
PC288-PDS:E 538	Pre-Fabricated Cable Tray Reducing Coupler Plate
PC288-PDS:E 601	General Notes on Earthing and Lightning Protection
PC288-PDS:E 602	Earthing Conductor Details
PC288-PDS:E 603	Arrangement of Connections of Earth Conductors
PC288-PDS:E 604	Typical Details of Connection in Earth Pit
PC288-PDS:E 605	Earth Pit Details
PC288-PDS:E 606	Typical Arrangement of Earthing for Motor and Start Stop Push Button
PC288-PDS:E 611	GI/Al Accessories for Earth Electrode
PC288-PDS:E 613	Earthing of storage tank & vessel
PC288-PDS:E 615	GI Earth Bus
PC288-PDS:E 617	Typical Arrangement for Neutral and Equipment Earthing

<div><div> पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <u><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></u> <b>DESIGN PHILOSOPHY – ELECTRICAL</b></div>	PC-288/E/Sec-5.4	1	<div><div> Coal India</div><div> बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 5 of 77		

## 1.0 SCOPE




The scope includes work/service for the complete design, engineering, manufacture, testing at works, Third Party Inspection, supply of all electrical equipment, dispatch, storage, handling, erection, testing at site and commissioning of complete electrical system required for 'Syn gas purification Unit For Coal To Ammonium Nitrate Plant'.

- 1.1 Although every item of supply and/ or installation might not have been described, the LSTK Contractor shall supply anything and everything to complete the project.
- 1.2 This specification shall be read in conjunction with all drawing and documents attached and other relevant reference as specified therein.
- 1.3 The scope of work/ services of LSTK Contractor shall comprise complete electrics of the Syn gas purification Unit For Coal To Ammonium Nitrate Plant. The scope of work/ services shall broadly comprise but not limited to the following :
  - 1.3.1 **Design** & detailed engineering, Coordination, General Services etc.
    - a. Basic as well as detailed engineering.
    - b. Preparation of drawings/ document/ to suit Project implementation schedule. Preparation of drawings/ documents/ calculations/ formats/ test reports/ test certificates; Erection, Testing & Commission Manuals/ Operations & maintenance Manuals/ Reports/ QAP etc for approval/ Review/ reference/ record and/ or for any other requirement; submission to Owner/ Consultant in requisite sets, getting approval from Owner/ Consultant, making approved copies available to manufacturers, inspectors, erection & commissioning engineers, supervisors, owner/ Consultant etc as required in requisite sets well before those are actually required by them to fulfil their obligations.
    - c. Design, manufacture, testing of equipment/ cables/ cable trays/ earthing and other erection materials etc at manufacturer's works, submission of documents with manufacturer's test reports/ type test reports to Owner/ Consultant prior to inspection call.
    - d. Quality Assurance at each stage of manufacture including procurement of raw materials/ bought out items and arranging inspections by Owner/ Consultant/ Third Party.
    - e. Obtaining dispatch clearance from Owner in writing.
    - f. Packing, loading, forwarding, delivery at site/ store, loading/ unloading, storage as per manufacturer's recommendation; shifting from stores and handling in store as well as at site for erection.
    - g. Arrangement of testing/ checking instruments/ kits/ sets/ apparatus with valid calibration certificates issued by duly accredited laboratories/ institutions, to carry out tests stipulated in specification and documents referred therein/ other applicable standards.
    - h. Deputing electrical contractors, supervisors, electricians, cable jointers etc. on full time basis. for carrying out electrical work.
    - i. Installations of equipment/ cables/ materials.
    - j. Conducting pre-energisation tests to ensure that installation is fit to be energized.
    - k. Erection shall not be considered complete unless pre-energisation tests are carried out, results are tabulated & submitted to owner/ consultant and results are found satisfactory.
    - l. Conducting functional/ pre-commissioning checks/ Cold trial runs; no-load & load tests,
    - m. Commissioning the installation.
    - n. Conducting Performance Guarantee tests and taking corrective steps (inclusive of replacement of equipment/ materials if required) till results are satisfactory/ acceptable.
    - o. Conducting Pre-Acceptance Tests/ checks and tabulating the results/ observations



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		Document No.	Rev	
		Sheet 7 of 77		

- d. 11kV, 3.3kV, 415V Motors and other special application/ voltage motors as required.
- e. All Cables viz
  - Power Cables (11kV, 3.3kV and 1.1kV)
  - Control Cables,
  - Earthing Cable
  - Signal cables,
  - Optical fibre cables
  - Data Cables
  - Communication cables
  - Special application cables
- f. Erection/ installation & all sundry materials for installation, testing & commissioning of equipment/ panels/ fittings/ cables (including jointing & termination of cables) comprising (but not limited to) following:
  - Foundations,
  - Brackets, support structures, erection materials & accessories, as required
  - Cable trays, racks, pipes, ducts, cable channels etc as required.
  - Testing checking kits/ instruments
- g. Illumination system - AC Normal, AC Emergency and Evacuation Lighting (on 110V DC)
- h. Area Lighting
- i. Aviation lighting, as required.
- j. Neutral Earthing Resistor, NER.
- k. Below grade earthing systems to be added in the scope along with connectivity at two points from existing facility.
- l. Earthing of equipment & structures.
- m. Protection against lightning.
- n. 110V DC Batteries, Battery Charger and DC Distribution Boards.
- o. 240V AC UPS Panels with batteries & UPS & UPS Power Distribution Boards.
- p. Complete Electrics for Air Conditioning and Ventilation systems.
- q. Complete Electrics for Chemical Dosing System-
- r. Complete Electrics for fire fighting system,
- s. Complete Electrics for EOT Crane, Hoists,
- t. Fire Detection & Alarm System for Plant and Interface & Seamless Integration same with Centralised Fire Detection & Alarm System.
- u. Pressurisation system shall be wet type.
  - a. The ventilation equipment shall be designed to effect the required number of air changes per hour and supply fresh air(minimum 15 no air change/hour)
  - b. Two numbers (1+1) of blowers shall be provided and each rated for 100%. The discharge of each blower shall be connected to a common duct and an isolation valve shall be provided on discharge side of each blower.
  - c. A positive pressure of 5 mm of water gauge shall be maintained within the area to be

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		Document No.	Rev	
		Sheet 8 of 77		

**Ventilated,**

**d. Refer our specification for ventilation (ES :8205) attached**




- e. Cable trench/Cable tray with supporting structure.
- f. Substation along with Transformer Rooms.
- g. The scope shall also include the erection, testing, commissioning of above equipments.  
The contractor shall clear the site after commissioning of the equipments / system and obtain the Site Clearance Certificate from Owner's Engineer-in-charge.
- h. Any and all other Materials, Equipment and Services so as to make a totally integrated and functional system together with all accessories and associated equipment, ensuring safety, maintainability and reliability in compliance with all applicable codes, standards, guidelines, statutory regulations and safety requirements in force.
- i. Any other equipment, not specified, but required for safe, proper, trouble free and efficient operation of the system
- j. LSTK Contractor shall consider any other requirement which is not covered in this NIT, but required for successful operation of the plant.
- k. Spares & consumables for complete Contractor shall electrics as follows:
  - Commissioning Spares (as per Clause No. 17.0 of Design Philosophy-Electrical) and Spares for 2 Years operation (Mandatory) for all equipments (as per Section 10: Spare Parts) shall be supplied by the Contractor as part of LSTK contract.
- l. provide recommended spares (other than mandatory spare) for all the equipment (item-wise) with recommended quantity.
  - Spares and consumables required and first oil fills including short fall during erection, testing, cold trials, commissioning, performance evaluation tests, guarantee tests etc and till handing over of installation shall be supplied by the Contractor as part of LSTK contract.
- m. Tools & Tackles.
- n. Testing Equipments/ instruments
- o. Arranging services of major equipment suppliers during installation and commissioning.
- p. Training of Owner's Personnel for Operation & Maintenance of the Plant.
- q. Any and all other items/ facilities/ services not specifically mentioned but essential/ required for completeness of the systems/ equipments/ facilities.

- 1.4 Normal power supply shall be tapped from 2 Nos. 11KV feeders and emergency power supply from 1 no.11KV feeder at Owner's substation for . Further, down stream distribution shall be in LSTK Contractor's scope.

Bidder shall indicate the details of Normal Loads and Emergency Loads in the bid. This design philosophy contains specifications of the major equipments to indicate the basic requirement and serve as a guideline. However, it shall be the responsibility of the contractor to offer a complete quality electrical system of superior quality, even if the specifications of certain items are not given.. The items for which technical specifications are not indicated herein shall be of IS/IEC standard and specifications of these shall be subject to owner's approval in case of order.

- 1.5 The bidder shall offer the best and proven most suitable type of energy efficient equipments manufactured by well known reputed manufacturers having proven performance track record of minimum 2 years , as per vendor list appended in this bid package. However for the sake of standardization of the electrical equipment and material used for the electrical installation, the



<div><div> पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <u><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></u>  <b>DESIGN PHILOSOPHY – ELECTRICAL</b></div>	PC-288/E/Sec-5.4	1	<div><div> कोयला भारत</div><div> बी एच ई एल</div></div>
		Document No.	Rev	
		Sheet 9 of 77		

LSTK Contractor shall supply all items of a particular type or make for whole plant of the same manufacturing company for ease of maintenance and less spares inventory.

- 1.6 1 No. 415 V Feeder (400 A) at Existing Substation shall be made available by Owner for Construction Power. Tapping of Construction Power (on chargeable basis) from this feeder (including supply & erection of all required materials like structural supports for cable tray, cable trays, power cables, control cables, protection & metering, cable termination etc. as well as underground cabling work) and further distribution shall be in LSTK Contractor's scope.

In construction Power, LSTK Contractor shall ensure that the minimum power factor of 0.9 shall be maintained at their end by providing suitable power factor improvement devices.

LSTK contractor shall have to distribute construction power with adequately rated distribution and sub distribution boards/feeder pillars, power supply cables and other associated materials for feeding loads to carry out construction and fabrication activities at his own cost.

Bidder shall indicate details of construction power in the bid with month-wise breakup for the entire duration of project.

However during non availability of construction power, LSTK contractor shall have to arrange emergency power, if required, through DG set at their own cost.

- 1.7 Contractor shall provide adequate area lighting at site of construction, fabrication yards, storage yard and office etc. by means of suitable lighting fixture, lighting masts, flood lighting poles etc. which are to be supplied and maintained by the contractor as per safety aspect.

- 1.8 Load Flow, Motor starting study, Transient stability, Short ckt. Study, Relay Co-ordination, Relay Settings( for each switch board ) with existing system etc.of the entire electrical installation of Syn gas Purification unit for coal to ammonium nitrate plant 'shall be conducted by the LSTK Contractor using latest software preferably ETAP at appropriate stage of design-engineering.

All the Electrical equipments shall be designed and selected according to the Short Circuit Study Report.




In case equipment is ordered before studies are completed and revision of rating or design is required as a result of Electrical System Study then inclusion of such revisions shall be in LSTK Contractor's scope without any cost and time implication.

Contractor to share editable E tap file with all libraries.

- 1.9 LSTK Contractor has to provide the required multifunctional dual channel transducers, Digital Multi-function Meters, latest version numerical/Communicable type protective relays with non-volatile memory, comprehensive unit providing protection, metering, control & communication with communication port & interlinked with Online Energy/Load Management System and required microprocessor based devices if any in panels , communicable door mounted Motor Protection Relays in all motor feeders of PMCC & MCC, proper communication facility in supplied UPS, Battery Chargers, VFD, Soft starter , MOV and other critical equipment for proper communication with ECMS and DCS & ESD system. The interface of electrical equipments with ECMS and DCS,ESD system shall be through IEC 61850 communication protocol for Numerical relays and IEC 61850/Modbus for Multifunction Digital Meters and MODBUS TCIP/IP for battery Charger, UPS, VFD, Motor Protection Relay (MPR) etc. , Ethernet communication module shall also be used. 100% redundancy shall be provided for communication i.e. the relay should have minimum 2 Nos. IEC-61850 communication port in addition to Front Port.

All connection of numerical relays to Ethernet / Network Switch and looping of MFMs to Network / Ethernet Switches inside the switchboards and Network / Ethernet Switches, as required, for interfacing shall be in LSTK Contractor's scope.

All communication cables and all hardwiring cables (for DI, DO,AI, AO etc. ) from Switchboards Ethernet/Network Switches to respective Substation ECMS cabinets, DCS, ESD I/O Racks shall be in LSTK Contractor's scope.

<div><div> पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <u><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></u>  <b>DESIGN PHILOSOPHY – ELECTRICAL</b></div>	PC-288/E/Sec-5.4	1	<div><div> Coal India</div><div> बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 10 of 77		

**Data concentrator panel shall also to be included.**

- 1.9.1 **All cables**(FO/Multipair control/any other cable),termination, all accessories etc. from Ethernet switches to LMS/ECMS, DCS, ESD I/O rack shall be in LSTK bidder's scope.
- 1.9.2 **LSTK Contractor** shall provide separate room for local ECMS , DCS, ESD equipments in substations. Provision of future expansion of Data Concentrator Panels etc. shall also be considered while designing separate room.
- 1.10 The scope shall also include obtaining all required statutory approvals from all statutory bodies. Contractor shall carry out all modifications/alterations required by statutory bodies.  
All approvals for permanent installations shall be obtained in the name of Owner. Approval for equipment & installation for Construction Power shall be in LSTK Contractor's name.
- 1.11 In case of any discrepancies between Design Philosophy – Electrical and Technical Specification of equipment/item/work in respect of description of equipment/ item/work, the details indicated in the Design Philosophy – Electrical shall prevail.
- 1.12 Final location of equipments as well as route of cable trays shall be finalised during detailed engineering.
- 1.13 All electrical works associated with the followings but not limited to, shall be considered
  - a) Air conditioning and Ventilation systems
  - b) Fire fighting system,
  - c) Fire protection system
  - d) Cranes, Hoist, elevators
  - e) Pollution control and monitoring equipment
  - f) All auxiliary building & associated electrical building/rooms.
- 1.14 Following Interface & Integrations are envisage presently of LSTK Contractor ;
  - Control & Protection for outgoing feeders of 11 kV Switchboard at Owner substation to LSTK Contractor Switchboard (Inter tripping, Cable Protection etc.)
  - Interface and Seamless Integration with Centralised Fire Detection & Alarm System.
 However, any other interface and Seamless Integration requirement or any other unforeseen which may arise during detailed engineering/ execution stage, same shall also be in the LSTK Contractor's scope without any cost and time implication.
- 1.15 All the substations shall be provided with following equipment :
  - CO<sub>2</sub> fire extinguishers (4.5 litre capacity) as per applicable NFPA.
  - DCP fire extinguishers as per applicable NFPA
  - Synthetic insulating mats on front and back side of all the switchboards. as per latest IS.
  - Framed single line diagram in Aluminum frame with glass,
  - Do's & Don't chart as per Indian Electricity Rules in Aluminium frame with glass.
  - Shock treatment chart written in English and Local language duly framed and approved by engineer-in-charge.
  - Caution boards / dangers boards written in ENGLISH & HINDI for all the voltage levels.
  - CPR (CARDIO PULMONARY RESUSCITATION) Charts.
  - High Voltage / Low Voltage danger signage (Skull & bones).
  - Exit Route / Emergency Exit Route Signage.
  - Cable Route Marker, wherever cable is in underground.
  - Sets of Sand buckets with stand (each with at least 3 sand buckets) for substations and transformer yards.
  - HT and LT hand Gloves (3 Sets each for each substation).
  - A Type FRP ladder 3 feet & 8 feet – 2 no each type for each substations.
  - First Aid Box

Other requirement or any other unforeseen which may arises during detailed engineering shall also be in LSTK Contractor's scope.





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		Document No.	Rev	
		Sheet 12 of 77		

2.1.5 While sizing the system necessary consideration shall be given to restrict the system voltage drop within permissible limits during starting of large rated motors. At the same time, the short circuit current shall be kept within limits keeping in view of the market availability of switchgears rating. For this purpose current limiting reactors/unit ratio transformers if required may be used.

2.1.6 LSTK contractor while performing design and engineering activities shall adhere to following guidelines.

- a) If any equipment is not covered in this design philosophy but required for successful operation of the project, LSTK contractor shall prepare additional specifications for equipment or bulk material taking reference of Indian/International Codes and good engineering practices prevalent in fertilizer industry and obtain owner's approval for the same.
- b) The standard drawings attached with this package define the basic system design and distribution philosophy for the package. This is for guidance purpose only. LSTK contractor shall develop detailed drawings and submit for owner's approval.
- c) LSTK contractor shall be responsible to verify the rating and consider providing equipment with adequate rating but not less than the specified rating. Compliance should be without any extra cost and time implications.
- d) LSTK contractor shall consider any other requirement which is not covered in this bid package, but required for successful operation of the plants without any extra cost and time implications.
- e) Contractor shall obtain approval from all statutory authorities such as Central Electricity Authority (CEA)/Electrical Inspectorate, Chief Controller of Explosives (CCoE), CPCB etc. for all electrical facilities including electrical switchboards & panels supplied and installed by LSTK contractor.
- f) LSTK contractor shall Liaison and in all interface coordination with contractors of other units of project at construction, erection, testing & commissioning phase for any common facility and for smooth execution.
- g) Equipment specification sheet/data sheets for all equipment shall be prepared by the LSTK Contractor based on relevant codes and Technical specifications/ Data sheets attached as reference. Data sheet shall contain all technical data and information which are essential for review and technical acceptability, detailed engineering, installation, testing, repair and maintenance, replacement etc.
- h) LSTK Contractor shall clearly specify in their purchase specifications the requirement of conducting special tests/type tests, which are envisaged for various electrical equipment which shall have no impact on cost and time.
- i) Bidder shall must visit the site and collect all relevant information required for designing of complete system before quoting. Bidder shall make themselves familiar with the work actually involved and actual site conditions. Failure to do so shall not absolve the Bidder of their responsibilities based on adverse site conditions.
- j) All the electrical equipments shall be of proven design and technology.
- k) Normal & Emergency Load details (rating of all motor, Lighting, Switch socket etc.) load shall be submitted.
- l) Load Summary shall be prepared by LSTK contractor to determine ratings of electrical equipments (transformer, switchgears, cables etc.), to evenly distribute plant loads among the various substations and switchgear, and to evaluate the need for power factor correction. All calculation shall be necessarily reviewed / approved by Owner/Consultant. The maximum normal running load and the peak load shall be calculated as follows :

**Maximum Normal Running Load = (100% of sum of all continuous load) + (40% of sum of all intermittent loads or largest intermittent load, whichever is higher).**

**Electrical System shall be designed for maximum normal running Load operation.**

All the electrical equipments shall be designed / sized considering motor input power (i.e. BkW divided by motor efficiency).

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		Document No.	Rev	
		Sheet 13 of 77		

Margin for future requirement shall be as per clause 2.1.6 m over the above.

Minimum P.F. shall be maintained as 0.95 at every voltage level.

All the electrical equipments like Transformers, Switchboards etc. shall be suitable for starting of the largest motor, while other loads are running, considering peak load condition.

- m) Electrical equipments to be designed by LSTK Contractor i.e. Transformers, Switchgears, MCCs, PCCs etc. shall have capacity for future requirements. The Margin shall be as follows :

i) For HV transformer 10% design margin on Maximum Normal Running Loads to be considered and for LV transformer 20% design margin on Maximum Normal Running Load to be considered.

ii) Switchgear: Switchgear bus bar current rating as well as breaker shall be equivalent (nearer or higher standard rating size) to full load current of upstream Transformer.

iii) Switchboards and MCCs fed from other switchboards: shall be rated for Maximum Normal Running Loads on that board plus 20% design margin.

- n) The actual fault levels shall be arrived at on the basis of incoming power source, transformers, contribution of motors, etc.
- o) Prospective touch and step voltages shall not be adverse to the stipulations of relevant publications of Bureau of Indian Standards / IEC/IEEE-80.
- p) Sizing calculations for all the electrical equipments shall be submitted for review/approval, in case of award of order. Owner/Consultant's Comments, if any on the same shall also be considered and modification in any equipment shall be done accordingly, without any time and price implication.
- q) Seismic zone as applicable shall be considered for design of all electrical equipment.

## 2.2 Load Grouping




Electrical consumers shall be classified as 'normal / non-essential, emergency / essential or vital / critical loads as per the concepts defined below:

2.2.1 'Emergency' or 'essential' loads shall be identified on the criteria that, when failing in operation or when failing if called upon, will affect the continuity of operation, the quality or the quantity of product. For such loads, reliable source shall be ensured. Such feeders shall be grouped on a separate bus section in the respective Switchboards/ MCCs / PCCs.

2.2.2 Some of the loads which can be identified as emergency / essential load but not essentially limited to following:

- Electrical loads required for continuous operation of process plants utility in case of normal supply failure.
- Electrical loads required for safe shut down of facilities in case of normal supply failure.
- Emergency/Normal lighting & communication facilities.
- Fire Detection and Alarm System.
- AC & DC UPS / Battery charging equipment.
- Control room AC equipment -Essential ventilation system for offices / Manned areas of other buildings.
- Motorised valves as per process requirement
- PA & Paging system (Load Details by Owner during detailed engineering).
- AC Emergency Lub Oil Pump
- Any other load (To be indicated by LSTK Contractor )

2.2.3 Critical' or 'vital' loads shall be identified on the criteria that, when failing in operation or when called upon, can cause an unsafe condition of the installation, jeopardize life or cause a major damage to the installation. For critical loads if any, UPS shall be provided to facilitate

<div><div> पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <u><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></u>  <b>DESIGN PHILOSOPHY – ELECTRICAL</b></div>	PC-288/E/Sec-5.4	1	<div><div> Coal India</div><div> बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 14 of 77		

uninterrupted supply. The loads on UPS are AVR / PLC / DCS / Auxiliary supply for drives etc. Critical drives if any shall be provided with DC motors. **If DC motors will be applicable then 220V DC system along with distribution boards shall also be provided.**

2.2.4 Some of the load which can be identified as critical / vital load but not essentially limited to following :

- Loads providing control and protection to plant equipment.
- Loads serving critical equipment for safety of plant, equipment and / or personnel

2.2.5 Non-essential service is a service, which is neither 'essential' nor 'vital'. Hence the non-essential load does not require any special measure such as standby feeder or standby source to safeguard the continuity of service.

### 2.3 Statutory requirement Codes and Standards

2.3.1 The design, installation, testing & commissioning shall conform to compliance of following statutory requirements :

- Indian Electricity Act
- Indian Electricity Rules
- The Indian Factories Act
- The Indian Explosives Act.
- Statutory requirement of Govt of Odisha and Govt. of India.
- Guidelines, instructions, directions issued by Pollution control Boards of state as well as central government. Guidelines, instructions, directions issued by Chief Controller of Explosives (CCoE), CPCB, CMRI, DGMS, CEA etc.
- Guidelines of Tariff Advisory Committee
- Guidelines of Insurance Companies Association.
- Any other applicable Rules/Acts/Regulations.

The design, installation, testing & commissioning shall be in accordance with established codes, good engineering practices and latest versions of following documents valid/ applicable on the date of acceptance of bid. The stipulations in these documents shall be considered as minimum requirements:

- Indian Standard Specification or equivalent IEC Standards
- Publications of IEEE
- API Standards
- National Electrical safety Code(NESC)
- Standards of Underwrites laboratory(UL)
- American Society for Testing Material (ASTM)
- American National Standards Institute (ANSI)
- Other International Standards

LSTK contractor shall be responsible for obtaining necessary statutory approvals from all the statutory bodies/authorities e.g. Electrical Inspectorate, PESO (earlier CCoE) as applicable before commissioning of electrical facilities. The CEA clearance for electrical equipment and components thereof shall be obtained by the contractor.

LSTK Contractor shall carry out all modifications / alterations required by all statutory bodies. However, necessary statutory fee shall be deposited by the Owner.

2.4 Some of the bare minimum relevant Indian Standards are as listed below. However, system/equipment design shall be in line with latest edition of all applicable standards.

IS: 325, IEC:60034	Three phase induction motors
IS: 335	New insulating oil for transformers and switchgears
IS: 722	AC electricity meters





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		Document No.	Rev	
		Sheet 16 of 77		

IS: 4759	Hot dip zinc coating on structural steel and allied products
IS: 5082	Specification for wrought Aluminum alloys bars, rods, tubes and sections for electrical purposes
IS: 5561	Electric power connectors
IS: 5578	Guide for marking of insulated conductors (1st rev)
IS: 6362	Designation of methods of cooling of rotating electrical machines
IS: 6600	Guide for loading of oil immersed transformers
IS: 6665	Code of practice for Industrial lighting
IS: 7689	Guide for control of undesirable static electricity
IS: 8084	Interconnecting Bus bars for AC voltage above 1 KV upto and including 36 KV
IS: 9676	Reference ambient temperature for electrical equipment
IS: 10028	Code of practice for selection, installation and maintenance of transformers
IS: 10322-1	Specification for Luminaries, Part-1, General requirements
IS: 11353	Guide for uniform system of marking & identification of conductor & apparatus terminals
IS: 11448	Application Guide for AC electricity meters
IS: 12360	Voltage bands for electrical installations including preferred voltage and Frequency
IS: 12459	Code of practice for fire protection of cable runs
IS: 12615	Energy efficient motors
IS: 13234	Guide for short circuit calculations
IS: 13346	General requirements for electrical apparatus for explosive gas atmosphere.
IS: 13408	Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres
IEC: 60255	Electrical Relays
IS/IEC: 60947	Low voltage switchgear and control gear
IS: 60034-5	Degree of protection provided by Integral design of rotating electrical machines
IS: 60079-0	Explosive atmospheres, Equipment General Requirements
IS: 60079-1	Explosive gas atmospheres – Part-1 Equipment protection by Flame proof enclosures “d”.
IS: 60079-7	Equipment protection by increased safety “e”
SP: 30	National Electrical Codes (NEC) - BIS Publication
IS/IEC 62271	HV Switchboard.
IEC 61439-1/2	LV switchboard (PCC/PMCC/MCC) for TOTAL TYPE TESTED (TTA). Type Test Certificates for short circuit withstand of 50kA for 1 sec. along with ACB mounted in the Switchboards shall apply.

<div><div><div><div><div><div></div><div>पी डी आई एल</div><div>PDIL</div></div></div><div><div><div></div><div>Coal India</div></div></div></div></div></div>	<div><div><div><div><div><div></div><div>SYNGAS PURIFICATION UNIT FOR</div><div>COAL TO AMMONIUM NITRATE PLANT</div><div><div><div><div><div></div><div>OWNER: Bharat Coal Gasification and Chemicals Limited</div><div></div></div></div><div><div><div><div><div></div><div>DESIGN PHILOSOPHY – ELECTRICAL</div><div></div></div></div></div></div></div></div></div></div></div></div></div>	PC-288/E/Sec-5.4	1	<div><div><div><div><div><div></div><div>Coal India</div></div></div><div><div><div></div><div>बी एच ई एल</div><div>BHEL</div></div></div></div></div></div>
		Document No.	Rev	
		Sheet 17 of 77		

IEC 61641	Switch Board with INTERNAL ARC CONTAINMENT test.
ANSI C-37:23	Metal enclosed bus
ANSI C-37:24	Effect of Solar radiation on metal enclosed bus.
IEC 60034	Rotating Electrical Machinery
IEC 61131	Programmable controllers
IEC 60871-1 /IS 13925	Shunt Capacitors for AC power Systems Specifications

Any other standard may be followed provided it is equivalent or more stringent than the standards specified above.

2.5 In case of any conflict/deviation amongst various documents the order of precedence shall be as follows:

- Statutory rules/regulation
- Design Philosophy
- Data sheets
- Technical specification/Installation Standards, etc.
- Applicable IS/IES standards

In case of contradiction / conflict among documents and statutory requirement, LSTK Contractor shall refer to Owner for clarification. However, most stringent specification shall be followed with Owner's approval. Owner decision shall be considered as final.

## 2.6 Site Conditions

The equipment shall be designed for the following site conditions:-

- Minimum ambient Temperature **As per site ambient temp.**
- Maximum ambient Temperature 46 C.deg
- Design Reference Temperature 50 C.deg
- Relative Humidity 100%
- Altitude above mean sea level Lower than 1000 Mtrs.
- Atmospheric pollution Dusty due to presence of Coal Dust and corrosive due to presence vapours of Ammonia.

Equipment/ cables selected shall be derated for (a) higher ambient temperature, (b) restriction in temperature rise (c) variation in voltage, (d) variation in frequency (e) installation conditions viz. proximity to heat sources, bunching, layering, separation from others/ laying in conduits etc. with respect to the conditions for which it was designed & manufactured. Various de-rating factors considered shall be informed with supporting documents.

Equipment to be installed in MCC rooms/ Electrical Rooms/ Control rooms shall be designed for + 50° C so that in case of failure of Air-conditioning/ ventilation facilities, the operation/ functioning of equipment is not be affected.

## 3.0 Deleted

## 4.0 SYSTEM DETAILS AND UTILIZATION VOLTAGES

4.1 The various voltage levels for in plant power distribution shall be as follows:

A. Normal Power	11KV ± 10%, 50Hz ± 5%, 3Ph, 3 W
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<div><div><div><div><div></div><div></div><div></div><div></div><div></div></div><div></div></div><div><div>पी डी आई एल</div><div>PDIL</div></div></div></div>	<div><div><div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div><div>OWNER: Bharat Coal Gasification and Chemicals Limited</div><div>DESIGN PHILOSOPHY – ELECTRICAL</div></div></div>	PC-288/E/Sec-5.4	1	<div><div><div><div></div><div></div><div></div><div></div><div></div></div><div></div></div><div><div>भारत कोयला</div><div>Coal India</div></div><div><div>बी एच ई एल</div><div>BHEL</div></div></div>
		Document No.	Rev	
		Sheet 18 of 77		

B. Emergency Power	Voltage Variation $\pm 5\%$ , 50Hz $\pm 3\%$ , 3Ph, 3 W LSTK Contractor shall indicate Emergency Power requirement.
C. Distribution Equipment	a) 11KV $\pm 10\%$ , 50 Hz $\pm 5\%$ , 3 Ph, 3 W with resistance earthed neutral b) 3.3KV $\pm 10\%$ , 50 Hz $\pm 5\%$ , 3 Ph, 3 W with resistance earthed neutral c) 415V $\pm 10\%$ , 3 Ph, 4 W/240V $\pm 10\%$ , 1 Ph, 2W, 50 Hz $\pm 5\%$ solidly grounded neutral.
Combined variation in voltage & frequency	$\pm 10\%$
Control Supply for: - 415V motors  - Switch Gear Breaker controlled feeders: a. Closing, tripping & spring charging motor b. Auxiliary power	AC 240V $\pm 10\%$ , 50 Hz $\pm 5\%$ , 1Ph (For contactor controlled motors) <b>240V AC tapped from boards only with 415/240V control transformer.</b>  DC 110V $\pm 5\%$ (For breaker controlled motors) – Battery Charger  DC 110V $\pm 5\%$ , 2 W - Battery Charger AC 240V $\pm 10\%$ , 50 Hz $\pm 5\%$ , 1Ph, 2W
- Instrumentation and Automation, DCS & Auxiliaries	AC 240 V $\pm 10\%$ , 50 Hz $\pm 3\%$ 1Ph, 2W – Instrumentation UPS located at Control Room
Voltage Ratings- - Motors including 1500 KW and above - Motors above 160 KW Below 1500 KW.  -Motors up to and including 160 KW	11 KV, 3 Ph AC  3.3 KV, 3 Ph AC  415 V, 3 Ph AC
- Space heaters - Lighting - Panic Lights - Power Sockets/Receptacle	240V, 1 Ph AC 415V/240V AC 110V DC 415V, 3 Ph AC/240V, 1 Ph AC




4.2 The actual fault levels shall be arrived at on the basis of incoming power source, transformers, contribution of motors, etc. and shall be indicated in the Bid.

All switch boards of the same voltage shall be rated for identical fault level. Minimum fault level to be considered for design and selection of equipment shall be as follows:

11 kV Switchgear – 40kA for 3 Seconds.

3.3 kV Switchgear – 40kA for 3 Seconds.



<div><div> पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>DESIGN PHILOSOPHY – ELECTRICAL</b></div>	PC-288/E/Sec-5.4	1	<div><div> Coal India</div><div> बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 19 of 77		

The fault level for 415V switchboards shall be 50kA for 1 sec.

Impedance of transformers shall be selected suitably (tap position at principal) without comprising voltage drop at receiving end.

**11kV/0.433kV Oil type(outdoor)/ dry type(Indoor) Transformer rating shall not be more than 2000kVA.**

Fault level of DC System shall be decided by the LSTK Contractor after substantiating the same by calculation.

#### 4.3 System Earthing

The neutral of 11 KV and 3.3 KV systems shall be non-effectively earthed through resistance. The earth fault current of 11 KV and 3.3 KV shall be limited to full load current of the transformer or 400 A, whichever is less. Suitable protection system to be designed to have proper sensitive Earth fault protection.

The neutral of 415V supply system shall be solidly earthed.

**The DC system shall ungrounded system.** Prospective touch voltage earthing shall comply with the requirements of relevant Indian/IEC standards.

#### 5.0 POWER SUPPLY AND DISTRIBUTION.

5.1 Power supply from 11 KV switch boards in owner's substation.

5.1.1 2 Nos. 11 kV Normal power Feeders shall be made available in owner's 11 kV Switchboard at owner's Substation and 1 no. 11KV Emergency Power feeder shall also be provided by owner's 11KV switch board. Tapping of power supply from 11 kV Switchboards(Normal & Emergency) at owner's Substation (including supply of all required material), structural supports for cable tray, cable trays, cables, cable termination at both ends etc. shall be in LSTK Contractor's scope. Further distribution to equipment at 11 KV, 3.3 KV, 415/240 V, 240 V (UPS,Inst.) AC, 110 V DC etc. through proper type and size of cables, their supply, erection, testing and commissioning etc. shall be in LSTK Contractor's scope.

LSTK Contractor shall consider 11kV/3.45kV, 11kV/0.433kV transformers for downstream distribution. The supply system shall be designed for maximum power requirement of the plant. Double radial system of power supply, each suitable for 125% of full load shall be followed for entire plants.

LSTK Contractor shall indicate details of power requirement and the Rating of 11kV Feeders in the Bid.

5.1.2 The electrical system layout and interconnections (power as well as control) shall be such that the problem in electrical system of one plant should not affect the electrical system of other plant and vice versa.

5.1.3 The insulation system of cable, 11 kV & 3.3 kV equipments shall be based on unearthed system only.




**5.1.4 The outgoing feeders shall be sized for the nominal load. Breaker rating of all the outgoing feeders of 11KV switchboards & 3.3 KV switchboards shall be same considering provision of inter-changeability. Incomer/ Bus Coupler rating shall be same as the Bus Bar rating.**

5.1.5 Primary connections of transformers shall be provided with cables of suitable size and secondary connections shall be through cables/bus duct.

5.1.6 The entry of cables in all the switchboards shall be from bottom only.

5.1.7 All switchboards shall be provided with minimum two incoming feeders and one bus tie having auto/manual changeover facility.

5.1.8 It shall be possible to have momentary paralleling of power sources at 11 kV, 3.3 kV switchboards and 415V PMCC /PCC/MCC and trip the desired circuit breakers.

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <u><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></u>  <b>DESIGN PHILOSOPHY – ELECTRICAL</b></div>	PC-288/E/Sec-5.4	1	<div> बी एच ई एल </div>
		Document No.	Rev	
		Sheet 20 of 77		

5.1.9 The normal operation of the 11 kV, 3.3 kV Switchgears, Power & Motor Control Centre (PMCC) and Motor Control Centre (MCC) shall be as under:

- i. Bus-coupler shall be provided between all the sources. Incomer and Bus-coupler breaker rating shall be same for all the switchboards. Each incoming feeder shall independently feed the loads on respective buses with full rated bus tie breaker open and the load on each bus balanced. In order to ensure maximum degree of reliability and continuity, automatic transfer from one incoming feeder to other shall be possible through auto/manual closing of bus tie breaker in case of sustained loss of power on any bus section.
- ii. The bus tie breaker shall be provided with auto/manual selection. The bus tie breaker shall be independent in manual mode. In auto selection mode, the bus tie breaker is electrically interlocked with incoming circuit breakers, so that it cannot be closed unless one of the incoming breakers is open.
- iii. When one of the incoming feeder trips, the bus tie breaker is closed automatically based on the philosophy described and the total load is transferred to other healthy incoming feeder which is capable of carrying the entire load. Sufficient switchgear capacity is to be provided. Time for changeover is suitably selected based on downstream system requirement of reacceleration of motors etc.
- iv. Auto Change Over scheme shall be provided for incomer feeders and bus coupler feeder of 11kV switchboard, 3.3kV Switchboards and 415V Switchboards. Under normal operating conditions, incomer-1 and incomer-2 breakers shall be closed and bus coupler breaker shall remain open with 'Local-Remote-Off' switch in 'Remote' position. The bus coupler breaker shall close automatically under the following conditions being fulfilled:
  - Either of the incoming breaker trips due to under voltage (70% or below).
  - Voltage on the healthy bus is more than 80% for the set period.
  - Residual voltage on the bus with no power supply comes down to 30% or below.
 Required nos. of bus PT, line PT and under voltage relays shall be provided to achieve the desired automatic changeover.
- v. Auto transfer shall take place only on sustained loss of power on either of bus sections. Auto transfer shall be blocked in case of fault on either of bus sections or no power on both incomers.
- vi. Paralleling of two incoming feeders is not foreseen. However, facility for momentary paralleling shall be provided for intentional changeover without interruption of supply with synchro check relay in Bus Coupler panel. There shall also be provision of selective tripping of one feeder out of three feeders with a Delay (two incoming feeders and one Bus Coupler).

5.1.10 PMCC & MCC shall have 2 Nos. Normal Power Incomers feeding non-critical loads. DC Battery Charger, UPS System etc. shall be fed from PMCC. PMCC shall fed breaker controlled feeders and various power feeders whereas MCC shall fed contactor controlled load and various power feeders. PMCC and MCC shall be separate.




5.1.11 Auxiliary Services Power Board (ASPB) shall be provided in the plant for supplying power to welding switch sockets, lighting load, EOT crane and other auxiliary loads.

5.1.12 Separate MCCs be provided for Air-conditioning and Ventilation systems.

5.1.13 For the use of the Owner during plant shut down period, 1 No. indoor type feeder pillar, which shall be located in a separate room other than substation building and away from hazardous area. The feeder pillar shall be fed from the 415 V switchboards (PMCC) of the nearby substation. Feeder pillar shall comprise of 1 No. 630 A 4 P MCCB incomer, 2 Nos. of 250 A TPN MCCB outgoing feeders, 2 Nos. 125 A TPN MCCB outgoing feeders and 4 Nos. 63 A TPN MCCB outgoing feeders. Other construction details shall be as per specification of sheet steel distribution board (PC288-TS-0808).

Location of feeder pillar shall be decided during detailed engineering.

## 5.2 Instrumentation Power

<div><div> पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <u><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></u>  <b>DESIGN PHILOSOPHY – ELECTRICAL</b></div>	PC-288/E/Sec-5.4	1	<div><div> Coal India</div><div> बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 21 of 77		

- 5.2.1 The power supply for instrument shall be 240V, 1Ph from UPS System.
- 5.2.2 Provision for 240V, 1 Ph power for lighting of instrument panels shall be provided from LSDB.
- 5.2.3 All instrument panels shall have two UPS incomer supply (one from different bus of UPS DBs) to avoid any type of power obstruction in case of failure of one supply.

### 5.3 Lighting Distribution

PI note separate MLDB(with transformer) with single incomer for AC normal and Emergency lighting shall be provided. Lighting Transformer rating shall be 100/50kVA, 415/433V with +/- 5% tapping on secondary side. 70% lighting shall be on normal supply fed from AC Normal MLDB and 30% AC Emergency lighting shall be on emergency supply fed from AC Emergency MLDB. MLDB shall have fault level of Min. 50 kA for 1sec.

Lights at strategic location for safe evacuation shall be provided as panic light(DC Emergency Lights on 110V DC), in case of complete shutdown.

Indoor and Outdoor lights shall be fed from Separate Lighting Sub Distribution board (or Lighting Panel). Outdoor lights shall be fed from Lighting Sub Distribution board having Photocell / digital clock Timer through contactor.

There shall be provision to Switch ON & OFF Outdoor Type feeders from ECMS in Remote Mode.

- 5.3.1 Manual by-pass circuit for outdoor lighting shall be wired up to a switch located in Electrical control room / shift office, so that outdoor lighting can be switched ON or OFF manually to bypass the automatic switching.

- 5.3.2 All outdoor lighting fixtures and outside lighting of Sub-Stations, Offices, Control Rooms etc., shall receive power from Separate Lighting Sub Distribution board (or Lighting Panel) having Photocell and Timer through contactor.

- 5.3.3 Demographical Electronic Timer and Contactor shall be provided for Outdoor Bus Section.
- 5.3.4 Main Lighting Distribution Board shall feed Lighting Sub Distribution board having 63A 4 Pole MCB and ELCB as incomer, 16Amp DP RCBO as outgoing. The outgoing RCBO shall have rating of 300 /100 mA. Six, Nine or Twelve way Lighting Sub Distribution board shall be used having 30 % as spare outgoing RCBO feeder.
- 5.3.5 Welding outlets shall be fed from ASPB having 3 phase supply for welding connection. All welding outlets shall be provided with CBCT ELCB of 100 mA.

### 5.4 DC Power

- 5.4.1 110 V DC system shall be provided for control of circuit breaker feeders and panic lighting. It shall be obtained from Ni-Cd batteries.
- 5.4.2 The battery shall be provided with SCR controlled automatic rectifier-cum battery chargers and shall consist of Main Float cum Load charger, Standby Float cum Load charger and Boost Charger and 2 Nos. Battery Bank each of 60% capacity (of 5 hours backup at 100% capacity) with isolation facility for ease of operation & maintenance.
- 5.4.3 Each rectifier-cum - battery charger shall have independent power supply to be fed from the emergency/normal source.
- 5.4.4 110V DCDB shall have 2 sources with auto changeover facility in case of failure of 1 source.
- 5.4.5 DC Battery Charger, AC UPS and HVAC for control room shall be fed from emergency switchboard.
- 5.4.6 Battery end cell voltage shall 1.1V. Aging factor shall considered 125% and Design margin of 20%.
- 5.4.7 For Temperature derating factor shall be based upon Minimum Ambient Temperature shall be decided during detailed engineering.










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		Document No.	Rev	
		Sheet 24 of 77		

- 6.27 Fixed type glass ventilators on all sides shall be provided near the ceiling height for natural lighting.
- 6.28 Arrangement shall be provided for lifting heavy equipment to be brought into the sub-station.
- 6.29 Sufficient nos. of entrances in line with National Building Code (min. 2) shall be provided for each floor.
- All doors of sub-station shall be air-tight fire proof steel doors except doors of control rooms/ PLC rooms which may have anodised aluminium frame with toughened glass panel. All doors shall open towards exit.
  - Windows shall have anodised aluminium frame and provided with toughened glass.
  - In case height is more than 10 meters, elevators (of capacity for 10 persons) shall be provided. Elevator shall be suitable for the area of installation.
  - 1000 mm wide insulating mat as per latest IS standard of appropriate voltage grade shall be provided in front as well as rear of each panel.
- 6.30 The Sub-stations shall also have an emergency door opening outwards as per latest edition of National Building Code.
- 6.31 The sub-station shall house all the electrical power, control and monitoring equipment except those required for operation in the field. The equipment shall broadly include the following: -
- Transformers located in separate Bay/Room.
  - High Voltage Switch Boards
  - Power Control Centres
  - Power & Motor control centres
  - Emergency Power & Motor control centres
  - Motor Control Centres
  - Auxiliary Service Panel Boards
  - Lighting Transformer (Indoor / Outdoor as per requirement)
  - Main Light Distribution Board
  - Lighting Distribution Boards
  - Lighting Sub-Distribution Boards
  - Battery Sets
  - Rectifier-Cum-Battery Charger
  - Cell Booster
  - DC Distribution Boards
  - Rectifier-inverter Sets
  - 240 V AC UPS System alongwith UPS distribution board.
  - Neutral Earthling Resistors (Indoor / Outdoor as per requirement)
  - Input / Output Panels
  - VFD System
  - PA System (Space only)
  - HVAC System
  - Any other equipment required
- 6.32 All static devices such as Rectifier-Cum-Battery Chargers, Variable Speed Drive Panels, Soft Starter etc., shall be housed in a separate room. Heat load for panel to be taken by panel manufacturer.
- 6.33 Separation walls between transformers in all substations and safe inter transformer distances for switchyard transformers shall be provided.
- 6.34 Transformers shall be located in bays adjacent to the sub-station building. All bays shall have oil drained floor, surfaced with gravel or other suitable material.

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		Document No.	Rev	
		Sheet 25 of 77		

- 6.35 In order to prevent leaking oil from reaching and polluting the water bearing stratum, transformers shall have the following provisions, depending on the oil capacity of the transformer.

Oil Capacity up to 2,000 litres:

Transformers installed adjacent to sub-station shall be provided with oil soak pit with a layer of pebbles of about 40 mm granulation.

Oil Capacity exceeding 2,000 litres:

Transformers installed adjacent to sub-station shall be provided with oil collection pit and sump pit as per Drg. No. PC288-PDS:E 114 for draining away of any oil, which may escape or leak from the tanks, to a waste oil tank.

- 6.36 A clear space of at least 1.5 meter shall be maintained all around the transformers after installation of HVWS System.

High Velocity Water Spray (HVWS) System shall be provided for transformers fire protection having oil capacity more than 2000 Liters.

- 6.37 Separate common oil pits are required for Transformers.

The volume of common oil pit will be 125% of the volume of oil of the transformer, which contains the largest volume of oil in transformers.

The oil pit will be closed type of water-proof concrete construction.

The oil pit will be connected to individual pit under each transformer and drain line of each transformer will be at least 150 mm dia pipe with a minimum slope of 1:96 as per TAC Regulation.

Transformer fire/drainage of oil will be considered for only one transformer at a time.

Level of pit will be so selected that there would not be accumulation of oil/water/oil-water mixture in the pit under each transformer.

Pit shall be provided with 2 x 100% sump pump for common oil sump. 1 No. Portable sump pump shall also be provided.

Oil Pit under Transformer and its Cooler Bank: Gravel filled open oil pit will be provided under each transformer and its cooler bank. The pit shall be such that it can take oil/water surge of 20% of the volume of the transformer oil. Level of pit shall be such that there will not be accumulation of oil/water in the pit. The gravel size will be 60 mm. Each pit will be connected to the drain line leading to new common oil pit.

- 6.38 In all substations/MCC rooms, space for future extension of switchboards shall be provided. One panel extension space on each side (for each bus section) shall be provided for all HV Switchboards, PCCs. One panel extension space on each side (for each bus section) or two panel extension space on one side (in exceptional cases) shall be provided for all PMCCs, MCCs and ASPBs.

The HV switch boards and power control centres shall have sufficient number of spare feeders to the extent of 20% or 1 No., whichever is higher for each type & rating.




For other boards (PMCCs, MCCs, MLDBs, ASPBs, DCDBs etc.) sufficient number of spare feeders to the extent of 20% or 1 No., whichever is higher, for each type & rating shall be provided.

- 6.39 Fire protection for substations shall be provided to comply with requirements of relevant BIS (Bureau of Indian Standards) and other Indian/ International standards, as applicable. In case Indian standards are not available for any equipment, standards issued by IEC/ BS/ VDE/ IEEE/ NEMA/NFPA or equivalent agency shall be applicable.

In case of contradiction / conflict, most stringent specification shall be followed.





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		Document No.	Rev	
		Sheet 27 of 77		

- 7.8 Special protection if required for any feeder such as differential, restricted earth fault, directional distance power relays etc. shall also be through numerical relay having serial port for monitoring.
- 7.9 In general all protection shall be through microprocessor based numerical relay. However high speed tripping relay shall be separate.
- 7.10 All Auto-changeover logic to be built in Numerical Relay. Numerical Relays shall have sufficient I/O to cater the same and there should be minimum 10 % spare I/O for future use. External I/O Card/ Module are not acceptable.
- 7.11 All Process Stop and other important Parameters shall be routed through Numerical relays for recording and Time-stamping. Hardware Annunciator is not required. Common Audio Visual Alarm for each Bus section of Switchboard shall be provided through Numerical relays.
- 7.12 Bare minimum protection for power distribution system shall be as indicated below. However, LSTK contractor shall provide any other necessary protection required for complete protection of system:.

Protection devices for power distribution system shall be as indicated below (Figure inside bracket refers to note below) (YES – Applicable)

Sl. No.	Relay Description	Relay No.	HV Tr. Fdr. Sec Wdg. Volt=> 3.3 KV	HV Tr. Fdr. Sec Wdg. Volt< 3.3 KV	HV /LV Motor Fdr., HV Breaker controlled contactor controlled	O/G Bkr. HV Plant Fdr.	O/G Bkr. MV PMCC	I/C HV	I/C MV PMCC
1.	IDMTL Over-Current Relay	51	YES	YES	-----	YES	YES	YES (2)	YES
2.	IDMTL Earth-Fault Relay	51N	YES (4)	YES	-----	YES	YES	YES (2)	YES
3.	Standby / Backup Earth Fault Relay (earthed neutral)	51G (10)	YES (22)	YES (22)	-----	-----	-----	-----	-----
4.	Motor Protection Relay with (50, 50N, 46, 49, 50L/R, 95)	99	-----	-----	YES	-----	YES	-----	-----
5.	Instantaneous Restricted Earth Fault Relay (Earthed side)	64R (10)	-----	-----	-----	-----	-----	YES (22)	YES
6.	Instantaneous Over current Relay	50	YES	YES	-----	-----	-----	-----	-----
7.	Instantaneous Earth Fault Relay	50N	YES (5)	YES	-----	-----	-----	-----	-----
8.	Differential Protection Relay	87	YES (6)	-----	YES (7)	YES	-----	YES	-----
9.	High speed tripping relay	86 (18)	YES	YES	YES	YES	YES	YES	YES
10.	Trip Circuit Supervision Relay	95	YES	YES	YES	YES	YES	YES	YES
11.	Transformer Auxiliary Relay	63	YES	YES	-----	-----	-----	-----	-----
12.	Under Voltage Relay with timer	27 / 2	-----	-----	YES	-----	-----	YES (16)	YES (16)
13.	Check Synchronisation Relay	25	-----	-----	-----	-----	-----	YES (8)	YES (8)
14.									

#### Notes for Relay Protection Philosophy

- All the numerical relays shall be of communicable type and connected to ECMS on IEC 61850 (Ethernet based) communication protocol with time stamping and time synchronization.



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		Document No.	Rev	
		Sheet 29 of 77		

24. Accuracy class of the current transformers shall be
  - Class PS for differential and special requirements.
  - Class 0.5 / 0.2 S for metering purpose.
  - Class 5P20 for protection purpose
 All the CTs shall have rated burden of minimum 15 VA and secondary rated current of 1 A.
25. Accuracy class of the potential / voltage transformers shall be
  - Class 5P for protection purpose.
  - Class 0.5 / 0.2 S for metering purpose.
 All the PTs shall have secondary voltage 110 V or 110 V / sqrt.3 and rated burden of minimum 50 VA per phase for both metering and protection core.
26. All the incoming, outgoing and tie breaker feeders of any HV & MV Switchboard shall be provided with numerical relays only with communication facility as protection devices. Releases shall not be acceptable in any case.
27. Numerical relays in all HV motor feeders shall be suitable for RTD / BTD inputs.
28. Each bus section shall be provided with separate under voltage relays.
29. Multifunction meter shall be provided to keep a record of power consumption and supervision of all concerned parameters like current, voltage, power, frequency, power factor etc. as specified. All the metering instruments shall be flush mounted.
30. Separate Communicable Digital Multifunctional meters shall be provided in all feeders with Numerical Relays for communication with ECMS system.
31. Motors shall also be provided with Unbalanced (-Ve) Sequence Protection Relay (46), as required.
32. Numerical under voltage relays (27) with time delay relay including VT fuse failure relay shall be provided for Bus VTs.
33. All Motor feeders of PMCC & MCC (irrespective of Rating) shall have door mounted communicable (Modbus / Profibus) type Motor Protection relay (MPR) with display.
34. No Meters, transducers or measuring equipments to be installed in the Protection CT circuit.
35. Cable Differential relays for both the end to be supplied by Downstream user contractor i.e. LSTK Contractor. Cable Differential relay will be of Fiber Optic Cable based communication only.
36. All required Alarms and Trips shall be incorporated in the Numerical relays. Sufficient LED shall be available in the Relays.
37. Trip Circuit Supervision relay shall be part of Numerical relay.
38. CBCT and Earth fault relay should be for HT Motor and transformer feeder only. For LT motor feeder this will not be required.
39. Capacitor Feeder : 59, 27,50, 51, 50N, 51N, 60, CBFP etc.
40. Main HV (33KV/11KV/ 3.3KV) Incoming Panel in each substation shall be provided with line differential protection between sending end and receiving end.
41. All accessories and connecting equipment required for FO cable connection shall be provided in switch board.
42. Ethernet Switch in cubicle of both bus shall be provided and all relays shall be connected to Ethernet Switch.

- 7.13 Metering instruments shall be provided to keep record of power consumption and supervision of all concerned parameters like current, voltage, power (Active, Apparent and Reactive), frequency, power factor, Energy (Active & Reactive) etc. All the instruments shall be flush mounted. All meters shall be digital multifunctional meters with communication port for Load management at remote location. Additionally digital type ammeter, voltmeter and Hour Meter shall be provided separately for various feeders as indicated below :

The metering devices in HV and MV switchboards shall be as below:

- Type of metering: Analogue/As part of the Numerical relay  
(Figure inside bracket refers to note below) (YES - Applicable)

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		Document No.	Rev	
		Sheet 30 of 77		

Sl. No.	Feeder type	A	V	Hz	PF	MW	MWH	HM	MVAR	MVAH	MVA
1.	HV Incomer	YES	YES	YES	YES	YES	YES	----	YES	YES	YES (1)
2.	HV Bus Tie	YES	----	----	----	----	----	----	----	----	----
3.	HV Transformer	YES	----	----	----	YES	YES	----	----	----	----
4.	HV Bus PT	----	YES	----	----	----	----	----	----	----	----
5.	HV Plant Feeder	YES	----	----	----	----	YES	----	----	----	----
6.	HV Motor	YES	----	----	----	----	YES (kWh)	YES	----	----	----
7.	HV Capacitor	YES	YES	----	----	----	----	----	YES	----	----
8.	PMCC Incomer	YES	YES	----	YES	----	YES (kWh)	----	----	----	----
9.	PMCC Bus Tie	YES	----	----	----	----	----	----	----	----	----
10.	PMCC Bus PT	----	YES	----	----	----	----	----	----	----	----
11.	ACB Outgoing (Non Motor)	YES	----	----	----	----	YES (kWh)	----	----	----	----
12.	MV Motor (>55 KW)	YES	----	----	----	----	----	----	----	----	----
13.	MCC / ASB Incomer	YES	YES	----	----	----	----	----	----	----	----
14.	MCCB O/G (250A and above)	YES	----	----	----	----	YES (kWh)	----	----	----	----
15.	MLDB Incomer	YES	YES	----	----	----	YES (kWh)	----	----	----	----




#### Notes for Metering:-

1. MVA meter in external power supply incomers shall include maximum demand indication also.
2. Separate analogue type voltmeters with voltmeter selector switch and analogue type ammeters with ammeter selector switch shall be provided for incomers of all switchboards.
3. Ammeter (size 48mm x 48mm) shall be provided in space heater circuit of breaker fed HV & MV motors.
4. Apart from metering which shall be part of the numerical relays, Communicable digital multi-function meters of Accuracy Class 0.5 / 0.2( for Incomers only with suitable Metering CT shall be provided in all the breaker feeders of HV & MV Switchboard i.e. in incomers, bus coupler, outgoing plant feeders, transformer feeders, motor feeders, capacitor bank feeders, etc.
5. Multi function meters with serial communication over RS-485 or fiber optic cable, preferably with IEC protocol shall be provided in all the breaker feeders.
6. Power factor meter shall be provided for synchronous motors in addition to the metering provided for induction motors.
7. For current feedback to DCS/PLC and VFD feeders motor current transducers shall be provided and mounted in switchgear panel.
8. CT operated Ammeter for all motor feeders above 5.5 KW, all MOV and LOPs shall be provided at both LCS and feeder end of switchboard.
9. All ammeters for LV motors shall be connected through CT. Only HV motors shall have 3 ammeters or ammeter selector switch or Voltmeter and Voltmeter Selector Switch.
10. Hour run meter shall be provided in all breaker controlled motor feeder.

## 8.0 CONTROL AND MONITORING

The following provision shall be made for control and monitoring of following electrical equipments.

### 8.1 Transformers

<div><div> पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <u><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></u>  <b>DESIGN PHILOSOPHY – ELECTRICAL</b></div>	PC-288/E/Sec-5.4	1	<div><div> Coal India</div><div> बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 31 of 77		

- TNC switch in primary & secondary side of switchgear.
- Emergency trip from secondary side for tripping primary side of transformer.
- VCB with all required protection to be considered in all the 11kV & 3.3kV switchboards. .
- Lockable 'OFF' push button in transformer room to trip sending end switchgear.
- Indication lamp for 'ON' 'OFF' 'Auto-trip', 'Non-trip' and 'Trip Circuit Healthy', 'Ready to Close', 'Ready for Service', 'Test', 'Service', 'Space Heater ON'.
- Ammeter and voltmeter on both primary and secondary side.
- Load break switch with Earthing Switch on transformer primary side (only where primary side circuit breaker is not located in the same sub-station).

## 8.2 Motors Controlled Through Circuit Breakers

- TNC switch, L/R Switch with Ammeter on LCS
- Current monitoring at DCS/PLC through Dual Channel Current Transducer with Display facility installed at switchgear end, where required from process point of view.
- Indication Lamps in switchgear for 'ON', 'OFF', 'Auto-trip' and 'Trip Circuit Healthy', 'Ready to Start', 'Ready for Service', 'Test', 'Service', 'Space Heater ON', 'Space Heater ON for Motors'
- Emergency trip in switchgear.
- Winding and bearing temperatures of motors shall be available at DCS in control room.
- Process interlock in CCR, where required.
- Control and Feedback for Motor Start & Stop command, Trip Indication, ON Indication, OFF Indication, Local / Remote Indication and Ready to Start Indication in remote (DCS/PLC etc.)
- Motors controlled through Circuit breakers should also be provided with ammeter, KVAh, KWH and running hour counter. Theses shall be incorporated in Numerical relay Or Multi-function Meter.

## 8.3 Medium Voltage Motors Controlled Through Contactors

- Start & Stop Push Button (Mushroom Stay Put Type) with Ammeter, Local/Remote switch on LCS.
- Current monitoring in DCS, where required from process point of view.
- Emergency Trip in PMCC/MCC.
- Process interlock in CCR, where required shall be wired through separate auxiliary relay.
- Indication lamp for 'ON', 'OFF', 'Ready to Start' and 'Fault' in switchgear.
- Control and Feedback for Motor Start & Stop command, Trip Indication, ON Indication, OFF Indication, Local / Remote Indication and Ready to Start Indication in remote (DCS/PLC etc.)
- Motor space heater & Panel board space heater shall be provided with Ammeter & LED in Switchgear.
- All Motor feeders of PMCC & MCC (irrespective of Rating) shall have door mounted communicable (Modbus / Profibus) type Motor Protection relay (MPR) with Earth fault protection and display.

## 9.0 EQUIPMENT SPECIFICATION

### 9.1 General Features

- 9.1.1 The equipment shall be suitable for tropical climate conditions and corrosive and saline atmosphere.



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All electrical equipment accessories and wiring shall have fungus protection involving special treatment of insulation and metal against fungus, insects and corrosion.

Fine mesh screen of corrosion resistant material, preferably SS shall be furnish on all ventilating openings to prevent entry of insects.

- 9.1.2 The equipment to be installed in indoor plant area shall be enclosed in dust, damp and vermin proof enclosure equivalent to IP 54 as per relevant Indian Standards/IEC.
- 9.1.3 The equipment including motors to be installed in outdoor plant area shall have IP 55 enclosure.
- 9.1.4 4 mm FRP (fire retardant and UV stabilized) canopies shall be provided for all outdoor equipments like motors, starters, LCS, SDBs, sw. sockets etc.
- 9.1.5 All the water plants being highly corrosive - Cable tray ,LCS, Junction boxes, Lighting JB and Lighting poles in plant area shall be strictly of FRP with SS fasteners only to avoid corrosion
- 9.1.6 The switch boards, to be installed inside the building shall have enclosure IP 4X for HV switchgear, for LV switchgear degree of protection shall be IP 52 up to 1600A rating and IP-4X above 1600A rating. Equipment requiring ventilation opening such as battery charger/UPS etc. located in air conditioning room may have IP 43 enclosure however, opening for the ventilation shall be covered with fine wire mesh.
- 9.1.7 Creepage distance shall be 31mm/kV (for highest system voltage) for all equipment.
- 9.1.8 All the electrical equipment shall be provided with rolled aluminium/stainless steel heavy duty double compression type cable glands and crimping lugs for the cable terminations
- 9.1.9 The outside surface of all equipment shall be painted after suitable pre-treatment by the application of two coats of anti-rust and corrosion resisting epoxy based paints.
- 9.1.10 All similar equipment ( viz. HV Switchboard, LV Switchboard – PCC, PMCC, MCC, EPMCC, ASB, LDB, DCDB, Transformers, Numerical relays, UPS, Battery Chargers, Motors, etc.) supplied against a package should be of single Make only – for ease of O&M and spare management.




## 9.2 Power Transformers

- 9.2.1 The transformers shall be double wound, copper conductor, and Dyn11 type. Transformers shall rated for 11/3.45 kV, 11/0.433 kV , 3.3./0.433 kV, as required. Transformer with 3.45 KV Secondary winding shall be considered for the substation only, where 3.3 KV switchboard is to be installed for feeding 3.3 KV motors.
- 9.2.2 The rating of power transformers shall be selected on the basis of load and future load growth. For future load growth the following provision shall be made:-

**For HV transformer 10% design margin on continuous loads to be considered and for LV transformer 20% design margin on continuous loads to be considered..**

- 9.2.3 The rating of power transformers shall be selected keeping following into considerations:

- |                         |  |
|-------------------------|--|
| (a) Duty                | : Continuous   |
| (b)                     | Outdoor type : ONAN/ONAF (ONAN rating shall have 25% spare capacity above continuous peak load. ONAF rating shall be minimum 15% above ONAN rating). |
| (c) Indoor type         | : Dry Type<br>Epoxy cast resin/ resin encapsulated type  |
| (d) Maximum loading     | : 80% when one of the transformers is out of service   |
| (e) Peak efficiency at  | : 35% - 40% of load  |
| (f) Class of Insulation | : B or better for oil filled   |

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		Document No.	Rev	
		Sheet 33 of 77		

: F or better for dry type

9.2.4 Maximum temperature rise over ambient of 50 Degree Celsius shall be limited to:

(a) Outdoor transformers:

Top oil (measured by thermometer) : 50 ° C

Winding (measured by resistance) : 55 ° C

(b) Indoor transformers:

Winding (by resistance method) : 90 ° C or lower as permissible for class  
of insulation offered

9.2.5 Special consideration shall be given in specifying the percentage impedance of the transformers to suit the switchgear short-circuit capacity available..

9.2.6 Transformers generally up to 10 MVA shall have ONAN cooling, while ratings above 10 MVA shall be ONAN/ONAF cooled. Bare minimum protection devices for transformer have been as indicated below; however LSTK contractor shall provide any other necessary protection relays required for complete protection of system.

Primary Side.

IDMTL Over Current, IDMTL Earth Fault, High Set Over Current, Instantaneous Earth Fault, Standby Earth Fault, Restricted Earth Fault , Differential (for sizes of 5 MVA and above), \*Buchholz Alarm and Trip, \*Winding Temperature Alarm, \* Trip, \*Oil Temperature Alarm, \*Oil Level Alarm & Trip, \*Trip for Winding Temperature and Oil Temperature. All protection except REF shall be provided on secondary side, if the primary side circuit breaker is located in other sub-station. REF protection shall trip the primary Inter-tripping of primary and secondary circuit breaker of transformer shall be provided for all faults through lockout relays.

CT for Restricted Earth Fault protection shall be provided inside the transformer.

9.2.7 High Velocity Water Spray (HVWS) System shall be provided for transformers fire protection having oil capacity more than 2000 Liters and rating upto 20MVA.

9.2.8 Following Push buttons shall be provided for transformers :

- Lockable 'OFF' push button in transformer room to trip the breakers on primary side.
- Push button shall be provided on breaker on secondary side for permission to close breaker on primary side
- Emergency trip PB on breaker on secondary side for tripping breaker on primary side of transformer.




9.2.9 The instruments such as OTI/WTI, Buchholz relay and MOG shall have Magnetic Reed Switches. The mercury switch contacts are not acceptable.

9.2.10 For all transformers, conservators shall be provided with Magnetic Oil Gauge (MOG) having 1NO contact activated on Low oil level. For transformers above 2000KVA , Air cell shall be provided in the conservator.

**9.2.11 Power transformer and other oil filled transformer shall be kept in open. Only dry type transformer shall have roof slab/room**

9.2.12 Routine test on all transformers and heat run test on one transformer of each rating shall be performed in presence of Owner/Consultant.

9.2.13 All Routine, Heat Run Tests shall be performed in compliance with B.S.171, IEC publication No.60076, IS 2026 (parts I to V), CBIP and IS: 2026 (Part III) including SFRA Test before dispatch from Manufacturer's works and at erection site during commissioning or latest editions or any other authoritative standard. Certificates for Type Tests on similar type Transformers shall be submitted.

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		Document No.	Rev	
		Sheet 34 of 77		

9.2.14 All Power transformers above 5 MVA shall have facility for Remote display (in ECMS) of Oil Temperature, Winding temperature, Conservator Oil Level and moisture ppm of Oil through 4-20 mA signal / Modbus communication.

9.2.15 Transformers shall be Energy Efficiency Level 2.

9.2.16 For all other specification refer PC288-TS-0803.

### 9.3 Neutral Earthing Resistor (NER)

9.3.1 The NER shall be provided to earth the neutral of 11 kV and 3.3 kV systems. Neutral of 415V supply system shall be solidly earthed.

9.3.2 Neutral earthing resistor shall be outdoor type made of AISI 304/406 punched stainless steel grid element. The earth fault current of 11 kV & 3.3 kV shall be limited to full load current of transformer or 400 A, whichever is less.

9.3.3 All NER not requiring operation shall be provided with isolator.

9.3.4 For all other specification refer PC288-TS-0804.

### 9.4 Switchboards

#### 9.4.1 General

9.4.1.1. There shall be three positions for Breaker/Contactor trolley: - Service, Test and Isolate. In service position, the power connections shall be made; but in test and isolate mode, the power connection of bus bars shall be automatically removed.

ACB feeder for PCC, PMCC & MCC shall be single front for ease of operation & maintenance. Non-ACB feeders for motors or power may be double front type.

Breaker duty cycle shall be O-0.3sec-CO-3min-CO.

Separate CT shall be provided for differential/REF protection.

LV circuit breaker shall be 4 Pole type except for outgoing motor feeders which shall be 3 Pole type.

9.4.1.2. Suitable shutter arrangement shall be provided to protect the person from accidental contact with live bus in trolley chamber.

9.4.1.3. Ethernet switch with 10% spare ports on each bus of each switch board & all internal wiring up to Ethernet switch shall be provided in each switch board.

9.4.1.4. It shall be compatible with connection to Plant LMS/ECMS system.

9.4.1.1. The degree of protection shall be IP 4X for HV switchboards and IP 52 for LV Switchboard up to 1600A rating and IP-4X for LV switchboards above 1600A rating.

9.4.1.2. All HV, MV & LV Switchboards shall be LOTO compliance.

9.4.1.3. 11 kV & 3.3 kV Switchboard shall conforms to IS/IEC 62271-200, IAC-A FLR-50KA/40KA 1 Sec, PM, LSC 2B which means that the switchgear panels shall be four side internal arc tested, shall have metal partitions and shall confirm to loss of service continuity. LV switchboard shall conform to IEC 60947. All 3 compartments (Busbars, Circuit breaker & Cable compartment) shall be tested for Internal arc for the said rating.

9.4.1.4. The observation window on the CB compartment door shall be made of special toughened/laminated glass substantiated in type test reports as proving it arc proof. Observation window shall be of same material and construction as the type tested design/construction as specified in IEC.




9.4.1.5. Each cubicle shall be equipped with anti-condensation heater controlled by thermostat.

9.4.1.6. Each HV compartment should have individual exhaust channel / pressure relief flaps to let out over-pressurized hot gases at the top of the switchboard in case of an internal fault.







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		Document No.	Rev	
		Sheet 37 of 77		

- 9.4.1.37. GPS system and associated hardware & software shall be provided for synchronisation of clocks of numerical relay and metering LA & ECMS
- 9.4.1.38. All meters shall be digital multifunctional meters with backlight LCD display and communication port. Additionally digital type ammeter, voltmeter and Hour Meter shall be provided separately for various feeders as indicated above.
- 9.4.1.39. All the motor / capacitor feeders controlled through vacuum circuit breakers shall be provided with surge arrestors. Lightning Arrestor (LA) shall be provided on each bus of 11KV Switchboard.
- 9.4.1.40. A continuous ground bus shall be provided at the bottom of the switchgear and in cable connection side for grounding the switchgear, breaker trolley as well as to ground the cable glands.
- 9.4.1.41. Control supply bus and space heater supply bus-bars (Copper) of adequate rating shall be provided throughout the length of switchboards with as many sections as sections in power bus-bars.
- 9.4.1.42. Control supply shall be tapped from control bus in each cubicle/ panel itself through DP MCB of suitable rating.
- 9.4.1.43. The minimum thickness of sheet steel used in HV and LV switchgear including charger, UPS, ASPB etc. shall be as under:-
- a) Base Channel minimum 2.0 mm
  - b) Load Bearing Members minimum 2.0 mm
  - c) Doors and covers minimum 1.6 mm
- 9.4.1.44. A bottom channel of not less than 75 mm shall be provided.
- 9.4.1.45. The maximum height of the switchboard and other control panels shall be limited to 2400 MM. Maximum height of component requiring operation shall be limited to 1800MM.
- 9.4.1.46. The switchboards shall have adequate short-circuit ratings and be suitably sized for the load and spare capacity foreseen. The short time rating of bus bar shall be 3 seconds for HV switch boards and 1 second for other boards.
- 9.4.1.47. The HV switch boards and power control centres shall normally have four spare circuit breaker panel (size shall be as per largest outgoing feeder breaker), two on each side of bus-section.
- 9.4.1.48. For other boards (PMCCs, MCCs, MLDBs, ASPBs, DCDBs etc.) sufficient number of spare feeders to the extent of min. 20% for each type & rating shall be provided.
- 9.4.1.49. The 415V switch boards shall have PVC insulated bus bar system suitable for rated voltage. At joints of these bus bars removable shrouds shall be provided.
- 9.4.1.50. All HV & LV Switchgear, UPS, Battery Charger etc. shall have Ethernet/Network Switches and other communication equipments.
- 9.4.1.51. For interfacing with DCS system, separate marshalling panels (with 20% spare terminals) shall be provided on each bus section in all HV & MV switchboards in the same panel line-up. The marshalling panels shall be of full height same as that of switchboards. The horizontal bus bar chamber at the top shall be continuous through this marshalling panel also, for future extension of the MV switchboard. All critical control signals for DCS interface shall be hardwired between substations and DCS. Other non-critical data of Electrical system will be sent to DCS with redundant communication facility between DCS and ECMS.

Hardwired signals (with minimum requirement specified below) from various Motor feeders of a bus section for DCS interface shall be wired and terminated in the marshalling cabinet:

- DCS Start permissive

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		Document No.	Rev	
		Sheet 38 of 77		

- Process Start command (Auto)
- Remote Start command (Manual)
- Process Stop command
- Process Trip command (for breaker controlled motor feeder)
- Breaker/Contactor 'ON' indication
- Breaker/Contactor 'OFF' indication
- Ready to Start indication
- Electrical Fault Trip indication

9.4.1.52. Following monitoring signals, as a minimum, shall be taken from substation to DCS interface, through redundant MODBUS SERIAL LINK communication from ECMS system.

- Load Data viz. KW, PF, A, etc.
- L/R indication
- Process Trip indication
- Electrical Fault Trip indication
- Trip Details

9.4.1.53. Auto changeover scheme shall be provided for incomers and bus couplers on all 11 KV switch boards, 3.3 KV switch boards and PMCCs/PCCs/ MCCs. Under normal operating conditions, incomer-1 and incomer-2 breakers would be closed and bus coupler breaker would remain open with 'auto-manual' switch in 'auto' position. The bus coupler switch would close automatically under the following condition being fulfilled:-

- i. Either of the incoming breaker trips due to under voltage (70% or below).
- ii. Voltage on the healthy bus is more than 80% for the set period.
- iii. Residual voltage on the bus with no power supply comes down to 30%.
- iv. Auto change over shall be locked on loss of power on both the incomers.

Auto changeover shall also be provided on switchboards catering to emergency loads.

9.4.1.54. Paralleling of two incoming feeders is not foreseen. However, facility for momentary paralleling shall be provided for intentional changeover without interruption of supply.

9.4.1.55. Every enclosure door that provides access to live parts operating at 240 V AC and above shall be mechanically interlocked with a circuit interrupting device on the supply side such that when the door is open, the equipment is de energised.

9.4.1.56. Separate redundant AC and DC control supply shall be provided for each Switchboard.

9.4.1.57. Control supply for motor feeders having MCCB in PMCC/MCC/ASPB etc. and VFD panels etc. shall be feed from 240V UPS (Electrical) and motor controlled with breaker shall have 110 V DC control supply irrespective of its being HV or LV.




9.4.1.58. For motors with auto-starting provision, trip of a running motor shall start standby motor automatically.

9.4.1.59. All the HV/LV switchgear shall be fed through two separate transformers, each transformer having capability to take care of 100% load of the associated switchgear and shall have the facility of auto changeover in case of failure of one transformer as well as option of manual changeover for maintenance purpose.

9.4.1.60. Max. 3 runs of 400 sq.mm power HV cable shall be terminated in single panel. For more than 3 runs of cable complete dummy/adaptor panel shall be provided.

9.4.1.61. The CB ON and OFF lamp shall be provided at rear and front side of 11kV/3.3kV switchboards.

9.4.1.62. All breakers service ON/OFF contact multiplier contactors shall be mechanically latched type and independent of control supply. Loss of supply and restoring the supply shall not affect the status of the relay/ contactor.

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		Document No.	Rev	
		Sheet 39 of 77		

- 9.4.1.63. All breakers shall be electrically operable and mechanical operation from the breaker shall be possible locally. Manual breakers are not acceptable.
- 9.4.1.64. Separate Ammeter shall be provided for panel and motor feeder Space heater circuit for each panel.
- 9.4.1.65. The terminal strips used shall be of stud and nut type and control wiring shall be done with ring tong lugs only.
- 9.4.1.66. Dual channel output with display type current transducer for all HV and LV switchboard feeder shall be provided requiring Ammeter at control panel.

**9.4.1.67. CBCT and Earth fault relay should be for HT Motor and transformer feeder only. For LT motor feeder this will not be required.**




- 9.4.1.68. All external hardware shall be of stainless steel only.
- 9.4.1.69. The control compartment and power compartment shall be separate.
- 9.4.1.70. Following Set of accessories as detailed below shall be provided for each 11kV/3.3 kV Switchboard :

a) Breaker handling trolley – 2 Nos.

Following Set of accessories as listed below shall be provided for each 415 V Switchboard :

- a) Breaker lifting and handling trolley : Minimum 2 nos.
- b) Test cabinet with coupling cables for testing the breaker in draw out position : Minimum 1 No.
- c) Racking in/out handle for breakers : Minimum 4 nos.
- d) Racking in/out handle for draw out MCC modules : Minimum 2 for each MCC
- 9.4.1.71. Alarm relays with reverse flag shall be provided to annunciate failure of main incoming A.C. and D.C. power supplies and annunciation D.C. supply in each panel. Lamp indications shall be provided individually for main D.C. supply-1 fail, main D.C. supply-2 fail, and panel annunciation D.C. supply fail. A common A.C. electric bell shall be provided to give an audible alarm in case of failure of D.C. supply-1/D.C. supply-2/annunciation D.C. supply in any panel. A common push-button shall also be provided for cancellation of lamp indications and audible alarm.
- 9.4.1.72. Gland plate for single core cables shall be non-magnetic.
- 9.4.1.73. For all other specifications, refer PC288-TS-0805, PC288-TS-0806, PC288-TS- 0808 and PC288-TS-0809.
- 9.4.1.74. Separate panel shall be considered for incomer Line PT & Bus PT (11 kV & 3.3 kV Switchboards) and PT shall be draw out type. 4 pole MCB shall be provided on LV side of Bus & Line PT.
- 9.4.1.75. Inspection window shall be provided for HV termination in the switchboard for carrying out thermography, provided internal arc test certificates for this design is available with the bidder.
- 9.4.1.76. All Incomers and bus couplers shall be provided with synchronising facility. Synchrocheck relay shall be provided in each bus PT & contacts shall be multiplied and wired in each outgoing feeders of each bus section.
- 9.4.1.77. All 11kV, 3.3. kV and 415 V Switchboards shall preferably be of same make for ease of operation & maintenance.
- 9.4.1.78. Supervision of installation, testing and commissioning including testing of Relays of all switchboards shall be done through OEM only.
- 9.4.1.79. All Cable Differential Relays shall be FO Cable type only. Supply & termination of the FO cable & associated HDPE duct, as required, for feeder differential protection shall be included LSTK Contractor's scope.



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		Document No.	Rev	
		Sheet 40 of 77		

- 9.4.1.80. All Numerical Relays shall be of same Make and Model (series).
- 9.4.1.81. 11kV & 3.3kV Circuit Breaker shall have integrated earth Switch with proper Mechanical & Electrical Interlocks& Electrical Interlocks.
- 9.4.1.82. 11kV & 3.3kV Breaker rack in rack out facility should be operable only when breaker panel door is closed position.
- 9.4.1.83. LV Switchgear design shall be such that the feeder doors should not open in locked out tagged out condition.

#### 9.4.2 11 KV Switchboard

- 9.4.2.1 The 11 KV switchboard shall be indoor, metal enclosed, draw out type, equipped with VCBs, stored energy mechanism working on 110 V DC and shall feed power to the various substations through transformers and other outgoing feeders.
- 9.4.2.2 Degree of protection shall be IP4X as per IS/IEC 60529,IEC 60298. Switchgear sizes and configuration shall be rationalized to minimum spare holding.
- 9.4.2.3 A study shall be conducted by LSTK Contractor to determine the rated short circuit capacity for the selection of equipment. However, Rated short circuit breaking capacity shall be as determined by the study or 40 KA for 3 sec, whichever is higher. HV Switchboard shall be suitable for Internal Arc (AFLR) withstand current of “rated short circuit current” for 1 sec.
- 9.4.2.4 Incoming, bus coupler and outgoing feeders shall be provided with ON, OFF, Trip, Trip Circuit Healthy indications. Process trip lamp/annunciator window to be provided wherever applicable.
- 9.4.2.5 Control supply shall be 110 V DC.
- 9.4.2.6 Extra anti-condensing space heater shall be provided in Bus –Bar and Cable chamber of 11KV Switchboard.

#### 9.4.3 3.3 KV Switchboard

- 9.4.3.1 The 3.3 KV switchboard shall be indoor, metal enclosed, draw out type, equipped with Vacuum Circuit Breakers (VCBs), stored energy mechanism working on 110 V DC. for all feeders.
- 9.4.3.2 The minimum degree of protection shall be IP4X as per IS/IEC 60529,IEC 60298. Switchgear sizes and configuration shall be rationalized to minimum spare holding.
- 9.4.3.3 A study shall be conducted by LSTK Contractor to determine the rated short circuit capacity for the selection of equipment. However, rated short circuit breaking capacity shall be as determined by the study or 40 kA for 3 sec, whichever is higher. HV Switchboard shall be suitable for Internal Arc (AFLR) withstand current of “rated short circuit current” for 1 sec.
- 9.4.3.4 Incoming, bus coupler and outgoing feeders shall be provided with ON, OFF, Trip, Trip Circuit Healthy, Spring Charged indications. Process trip lamp/annunciator window to be provided wherever applicable.
- 9.4.3.5 Control supply shall be 110 V DC.
- 9.4.3.6 Extra anti-condensing space heater shall be provided in Bus –Bar and Cable chamber of 3.3KV Switchboard.

#### 9.4.4 Low Voltage Switchgears

- 9.4.4.1 415 V switchboards shall include the following:
- Power Control Centres (PCCs)
  - Power-cum-Motor Control Centres (PMCCs)
  - Motor Control Centres (MCCs)
  - Main Lighting Distribution Boards (MLDBs)




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		Document No.	Rev	
		Sheet 41 of 77		

e) Auxiliary Services Power Boards (ASPBs)

- 9.4.4.2 Low voltage switchboards shall be metal clad, arranged with self supporting units and assembled together in a row..
- 9.4.4.3 Internal physical separation / segregation of 415 V Switchboards shall be 3 B for Non-ACB feeders and 4 B for ACB feeders.
- 9.4.4.4 The switchboards shall be suitable for extension at both the ends.
- 9.4.4.5 Bus bars shall be of uniform cross section and supported on non-hygroscopic FRP insulators with adequate clearances and creepage distance to prevent flash over due to effect of dust/moisture.
- 9.4.4.6 The horizontal busbars as well as vertical droppers of LV switchboards shall have heat shrinkable insulated sleeves.
- 9.4.4.7 Sufficient bus supports shall be given to give adequate mechanical strength during short circuits.
- 9.4.4.8 A continuous ground bus shall be provided at the bottom in the PCC/PMCC/MCC for grounding the PCC/PMCC/MCC.
- 9.4.4.9 Rated short circuit breaking capacity shall be 50 KA for 1 sec.
- 9.4.4.10 The PCC, PMCC, EPMCC MCC and auxiliary services power board shall be provided with withdraw able air circuit breakers for incoming feeders and bus ties. Main lighting distribution board shall have MCCB as incomer and out going Feeders with fixed type.
- 9.4.4.11 All feeders of 415 V switchboards shall be provided with MCCB except feeder rated more than 400A, for which ACB shall be provided. All outgoing feeders shall be draw-out type in all the switchboards.
- 9.4.4.12 All ACBs shall be electrically operated- EDO type only. Manual breakers are not acceptable. Each electrically operated breaker shall be provided with antipumping (94), Breaker fail (52BF) and trip free feature, trip annunciation (30) and lockout (86) relays. Lockout relay shall be hand reset type.
- 9.4.4.13 All ACBs shall be without any internal releases. The required protections shall be wired by means of external numerical relays.
- 9.4.4.14 Motor feeders below 75 KW rating shall be contactor controlled and 75 KW & above, these shall be ACB controlled with combined motor protection relay. All other feeders of 415 V switchboards shall be provided with MCCB except feeder rated more than 400A, for which ACB shall be provided. All outgoing feeders shall be draw-out type in all the switchboards.
- 9.4.4.15 Switchboards shall be provided with thermostatically controlled anti-condensation heaters.
- 9.4.4.16 All units in the MCC shall be completely accessible and removable from front. Both power and control connections shall be stab-in type.
- 9.4.4.17 Bus bar clearances shall conform to relevant Indian Standard/IEC for equipment voltages up to and including 500 V AC.
- 9.4.4.18 The switchboards shall be compartmentalized and individual feeder modules shall be draw-out type. Fixed type modules shall not be acceptable.
- 9.4.4.19 The draw out modules shall be standardized and it shall be possible to interchange any module with a module of same size. The components to control the equipment like MCCB, starter, auxiliary relay etc. shall be wired as a unit on the individual module. Safety shutter shall be provided to prevent direct access to live parts when the chassis is removed.
- 9.4.4.20 The entire draw out construction should be designed for safe operation during placement or removal of chassis. An earthing arrangement shall be provided which will make contact first before the power contacts are made and break last. Each module shall control one motor in general.





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		Document No.	Rev	
		Sheet 43 of 77		

b) The KWH meters on incomers shall have provisions for sealing for tariff purpose, as required.

c) MCC shall conform to the following as a minimum :

- Motor starters rated for utilisation category AC3 and protection equipment with a minimum of type 2 co-ordination.
- The number of modules per tier shall not exceed 6.
- MCC incomer sizes and configurations rationalised to minimise spares holdings.

#### 9.4.5 Auxiliary Supply Power Board

The ASPB shall generally be single front, floor mounted draw out type having essential and non-essential bus. Non-essential bus shall be disconnected in case of failure of normal supply through a contactor. Substation station shall have ASPB. Additional 2 Nos.63A Feeders shall be provided for Owner's use.

#### 9.4.6 Lighting Sub Distribution Boards

The Distribution Boards shall be single front, non-draw out wall mounted type.

#### 9.4.7 UPS Distribution Boards

9.4.7.1 The UPS Distribution Boards shall be single front, floor mounted non-drawout type for supply of 240 V AC / 240 V AC UPS Distribution Boards shall have 20% spare outgoing feeders of each rating & Type (fully wired) and with all the components

#### 9.4.8 Direct Current Distribution Boards

9.4.8.1 The Direct Current Distribution Boards (DCDBs) shall be single front, floor mounted non-drawout type for supply of 110 V DC control power to switchgears and panic lighting. Each Substation station shall have separate DCDB. DCDB shall have 20% spare outgoing feeders of each rating & Type (fully wired) and with all the components

### 9.5 Motors

9.5.1 The rating of LV and HV motors shall be selected from the sizes as recommended in relevant Indian Standard/IEC.

9.5.2 All electric motors shall meet the standard IEC 60034-30-1.

9.5.3 The margin between the installed power and absorbed power shall be as recommended by the driven machine supplier but shall not be less than the following:-

Motor Rating	Margin above Driven M/C Absorbed Power
Less than 22 KW	25%
22 KW to 55 KW	15%
75 KW and above	10%

#### 9.5.4 Voltage Ratings:




Voltage rating for the motors of different ratings shall be as below:

Including & below 160 KW:	415 V, 3-phase, 50 Hz AC
Above 160 KW – below 1500 KW:	3.3 KV, 3-phase, 50 Hz AC
Including & Above 1500 KW :	11 KV, 3-phase, 50 Hz AC

All motors shall be designed for 3-Phase supply only.

9.5.5 The motors shall have maximum continuous rated duty S1 as per relevant Indian Standard/IEC. Rated duty for special duty motors wherever required e.g. cranes etc. Shall be considered as per driven equipment requirement.



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		Document No.	Rev	
		Sheet 45 of 77		

9.5.25 For all other specifications, refer PC288-TS-0810.

## 9.6 Rectifier-cum-Battery Charger

9.6.1 The Rectifier-Cum-Battery Charger shall be fully automatic using silicon controlled rectifier and shall consist of units as described below:-

- i) Main Float cum Load charger: To supply continuous load and keep the battery in healthy state.
- ii) Standby Float cum Load charger: To supply continuous load & keep the battery in healthy state in case any abnormality in Main charger.
- iii) Boost charger: To charge the battery set initially and recharge (after meeting emergency or sudden application of heavy loads.)

9.6.2 Substation shall be provided with redundant battery charger with 2x100% battery banks and connected to each Charger.

9.6.3 The battery and charger combinations shall be such as to ensure continuity of D.C. supply at load terminals without even momentary interruption.

9.6.4 AC Ammeter and AC Voltmeter on Charger Input; DC Ammeter, DC Voltmeter for charger output/ battery voltage and on demand type Battery Charge / Discharge Ammeter shall be provided.

9.6.5 Following analog signals through suitable transducer shall also be provided for hook-up in ECMS:

- Status of charging current (float & boost charging)
- Battery current
- Incoming voltage

9.6.6 Following potential free contacts shall also be provided for hook-up in ECMS

- DC under voltage
- DC overvoltage
- DC earth leakage
- AC incoming power supply failure
- AC input fuse blown-off
- Thyristor/ diode failure
- DC output fuse blown-off
- DC battery fuse blown-off
- Filter Capacitor fuse blown-off
- Load on Battery (using current direction sensing with time delay)
- Battery undervoltage/ Disconnected during discharge (using zero current sensing)
- Cubicle fan failure/ cubicle temperature high (for chargers with forced cooling).

9.6.7 For all other specifications, refer PC288-TS-0813.

## 9.7 Battery Sets.

9.7.1 These shall be Ni-Cd Battery Sets shall be rated to meet the total DC power requirement for 5 hour after complete power failure.




9.7.2 Spare capacity of 20% for future use shall be considered.

9.7.3 Battery shall be designed with minimum temperature as per site ambient temperature.

9.7.4 Load Test of all Battery to be done at site. Battery will be accepted based on load test only.

9.7.5 For all other specifications, refer PC288-TS-0814.

## 9.8 Uninterruptible Power Supply System (UPS)

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		Document No.	Rev	
		Sheet 46 of 77		

**9.8.1** 240 V AC UPS System with UPS Distribution Board shall be provided to feed 240 V AC, 50 Hz, 1Phase power supply to the instrumentation system, DCS, ECMS Equipment, Fire Detection & Alarm System etc. This UPS System along with associated Battery and UPS distribution Board shall be located at Control Room.

Block Diagram of 240 V UPS System shall be followed but with 240 V in place of 115 V

240 V AC UPS System complete with Battery, UPS Distribution Board etc. shall be separate.

UPS shall have with 20% margin for future use.

**9.8.2** The UPS System shall have IGBT type with touch screen LCD display and shall be backed up by nickel cadmium (Ni-Cd) battery rated for 1 hour at rated capacity of the UPS. Battery (100% Capacity) shall be separate for each Inverter.

**9.8.3** UPS system construction shall be such that each charger, inverter module can be made fully isolated for maintenance. No common devices/wiring shall be installed. Further there shall be no common device between main & redundant units ( e.g. master oscillators etc.) in order to ensure that the failure of the same does not cause shutdown of more than one unit.

**9.8.4** UPS system shall have facility for built in Online battery bank monitoring & testing facility for displaying/calculating expected battery bank back-up time ( during testing if battery bank does not have sufficient back up time, test shall be terminated & load shall be shifted to charger automatically).

**9.8.5** UPS shall be suitable for 100% step load.

**9.8.6** Battery Load cycle test shall be carried out by the vendor at site .

**9.8.7** The UPS rating shall be such that in any case the load on the individual UPS shall not exceed 70% (after considering 20% future margin) of the rated capacity.

**9.8.8** UPS Configuration shall be as per attached Block Diagram. The over load capacity of UPS shall be 200% for 10 cycles, 150% for 60sec & 125% for 10min.

**9.8.9** All four sections, i.e. Rectifier-I, Rectifier-II, Bypass – I and Bypass - II shall be fed through four separate feeders of emergency/ normal bus of PMCC.

**9.8.10** UPS shall be PWM based using IGBT. Each charger and SCVS shall have isolating transformer at the input.

**9.8.11** The salient features of the UPS shall be as under:

- a) High Efficiency
- b) Compatible to feed nonlinear, high crest factor loads
- c) Microprocessor based monitoring system for UPS status and fault indications
- d) High transient performance
- e) Low audible noise

**9.8.12** Each UPS shall be provided with SNMP software so that all the parameters of UPS and alarms/faults can be viewed into the remote computer. These logs/trends of load can later be printed. Web based parameter and status monitoring shall be used. It shall be hooked to ECMS and DCS System.

**9.8.13** The transfer time of UPS from inverter to bypass, in case of failure of both inverters, shall be so selected that during this transition period, instrumentation/DCS etc. which leads to tripping of plant shall not fail. Typically, it shall be as below :

- |                      |  |
|----------------------|--|
| In synchronism       | : No break transfer i.e. within 6 milliseconds (Maximum) |
| In asynchronous mode | : Within 16 milliseconds (Maximum).                      |

**9.8.14** The technical parameters of UPS shall be as under:
















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		Document No.	Rev	
		Sheet 51 of 77		

	Wire	Cable
Lighting Panel to Fixtures:	2.5 sq. mm (Cu)	3Cx 2.5 sq. mm (Cu)
Lighting Panel to JB's/ Switches:	2.5 sq. mm (Cu)	3Cx 2.5 sq. mm (Cu)
JB's/ switches to Fixtures:	2.5 sq. mm (Cu)	3Cx 2.5 sq. mm (Cu) 2.5 sq. mm (Cu)
Panel to First receptacles:	4.0 sq. mm (Cu)	3Cx 4 sq.mm (Cu)
First receptacles to looping other receptacles:	4.0 sq. mm (Cu)	3Cx4 sq.mm (Cu)
In case of only one receptacles in ckt., Panel to receptacles:	4.0 sq. mm (Cu)	3Cx4 sq.mm (Cu)
Panel/ JB's to flood light fixtures:	2 x 2.5 sq. mm (Cu)	2.5 sq. mm (Cu)

#### 9.13 Bus-Duct

- 9.13.1 The bus bars and connection shall be made of electrolytic grade copper / Aluminium. All busbars shall be insulated with Raychem sleeving.
- 9.13.2 It shall be suitably supported at regular intervals and both bus bars and supports shall be adequately sized and clamped to withstand rated short circuit current without permanent deformation.
- 9.13.3 The bus bar insulators shall be non-hygroscopic, non-inflammable material. Earth bus shall run along the full length of bus duct without any break.
- 9.13.4 Outdoor bus-duct shall be weatherproof to IP-55(W) and shall be provided with canopy, silica gel breather. Construction of outdoor Bus duct shall be such that water gets drain off easily. Extra thickness shall be provided at the corners where water accumulation is likely to happen.
- 9.13.5 Bus duct shall be supplied with bus bar flexible links for connection at both the ends and expansion joints for every 3M of bus-duct and bus duct support materials.
- 9.13.6 Openings with cover at suitable locations shall be provided on bus duct for accessing the bus bars for maintenance.
- 9.13.7 Silica-gel breather shall be provided on both indoor and outdoor portions of the busduct. (shall not be required for pressurized busduct).
- 9.13.8 Proper sealing shall be done between Outdoor & Indoor section of the Bus Duct.
- 9.13.9 For all other specifications refer, PC288-TS-0807.

#### 9.14 Electrical Control & Monitoring System.

- 9.14.1 Electrical Control & Monitoring System (ECMS) shall be provided for Supervision, control, monitoring, data acquisition, data logging & printing of status of all important electrical equipment & feeders and Load Shedding Scheme as per the recommendations of the system study report as per process requirement and in consultation with Owner/Consultant for entire fertilizer complex, by Owner(EDS LSTK Contractor).







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	from PMCC	2 to 2.5% Note-3a
d)	Cables between HV Switchboard and HV Motor (during running)	3%
e)	Cable between PMCC and motor (during running)	5%
f)	Cable between MCC (situated near PMCC) and motors	5%
g)	Cable between MCC (situated remote from PMCC) and motors	3%
h)	Cable between Auxiliary Switchboard / MLDB and Lighting Panel / Power Panel	1 to 1.5% (Note-2)
i)	Circuit between lighting panels and lighting points	4% (Note-2)
j)	DC Supply Circuit (electrical Controls)	5% and/or as per instrumentation requirement
k)	DCDB to Control Room	2% (Note-1)
l)	UPS outgoing circuit	5% (Note-1)

#### Note-1

Minimum voltage available across any instrument in the field / control room / satellite rack room shall be as per instrumentation design basis. Distribution system for instrumentation supplies shall be designed accordingly. In case of any conflict between electrical equipment specification sheet and instrumentation design basis report, the latter shall govern regarding instrumentation power supplies.

#### Note-2

In case of difficulty in achieving specified voltage drops in cables up to lighting panel, 5% drop from Auxiliary Switchboard / MLDB up to lighting points may be permitted.

#### Note-3

- Higher voltage drop may be permitted between PMCC and remote mounted MCC / ASB; if overall voltage drop up to motor (from PMCC) is limited within 5.5%.
- For large substations 1% drop may be permitted.

The maximum voltage drop at various buses during start-up of large motor and / or motor reacceleration conditions shall be within the limits stated below:-

Sl. No.	System Element	Operating Condition	Maximum Permissible Voltage Drop
a)	At the bus bars of the worst affected Switchboard	Start-up of the large HV motor with other loads on the bus or reacceleration of a group of HV motors (Simultaneous start-up or group reacceleration of HV motors is not envisaged)	10%
b)	At the bus bars of the worst affected MV Switchboard	Start-up of large MV motor with other loads on the bus,	10%

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		Document No.	Rev	
		Sheet 56 of 77		

	(PMCC / MCC)	or reacceleration of a group of MV motors.	
c)	Cables between HV Switchboard and motor	Motor start-up or reacceleration	5%
d)	Cable between MV Switchboard (PMCC / MCC) and motor	Motor start-up or reacceleration	10%

Notes:

- Soft Starter / VFD Starter shall be considered for starting large HV motors if essential / unavoidable as per system design requirement / equipment design limitation. For cases other than starting limitation, requirement of soft starter / VFD for any drive shall be confirmed by Process Department.
- Unless otherwise specified as in clause a), all HV motors and MV motors shall be suitable for Direct on Line (DOL) starting.

#### 10.1.12 MINIMUM CABLE SIZES FOR 415V MOTORS

Direct on line (D.O.L) start motors (2/4 pole motors)

MOTOR RATING	CABLE DETAILS			
	NUMBER OF RUNS	NO. OF CORES PER RUN	CONDUCTOR MATERIAL	CONDUCTOR SIZE ( MM <sup>2</sup> )
Below 3.7 KW	1	3	Cu	2.5
3.7 KW	1	3	Cu	4
5.5 KW	1	3	Cu	10
7.5 KW	1	3	Cu	10
9.3 KW	1	3	Cu	16
11 KW	1	3	Cu	16
15 KW	1	3	Cu	16
18.5KW	1	3	Al	35
22 KW	1	3	Al	35
30 KW	1	3	Al	50
37 KW	1	3	Al	70
45 KW	1	3	Al	95
55 KW	1	3	Al	120
75 KW	1	3	Al	185
90 KW	2	3	Al	95
110 KW	2	3	Al	120
125/132 KW	2	3	Al	150
160 KW	2	3	Al	185

- Minimum cables sizes as indicated above are for 2/4 poles motors fed from MCCs located near PCCs and PMCCs. Actual cable sizes shall be based on actual distance of motor from switch board.
- Cable sizes for motors not confirming to above table (e.g. for 2/4 poles motors rated up to 150kw & motors with high starting pf), extended distance, reduced voltage starting, low speed motors, VFD driven etc. shall be worked out on case to case basis.
- However cable sizing calculation shall be submitted for approval.

#### 10.1.13 Design Criteria for Cables/Bus Duct & Short Circuit Withstand Time:

- Design criteria for cables/bus duct



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		Document No.	Rev	
		Sheet 57 of 77		

Sr. No.	Design Criteria	3.3 kV / 11 kV	415 V
1.	Loads beyond 1000A rating and located near the transformer	Bus Duct / 1-core cable	Bus Duct / 1-core cable
2.	Loads located up to 200 M	Cable	Cable
3.	Loads located 200 - 1000 M	1-core cable / 3-core cable	1-core cable / 3.5-core cable
4.	Loads located beyond 1 KM	Cable	Cable
5.	Recommended limiting size of multi-core cable (sq.mm) / Single Core (sqmm)	3 Core x 400 / 1 Core x 630	3.5 Core x 300 / 1 Core x 630
6.	Insulation voltage grade	3.3 kV / 11 kV Unearthed	1100 V Earthed
6.	Type of cable insulation	XLPE	Power: XLPE Control: XLPE
7.	Power, Control & Earthing Cables	Armoured	Armoured

For breaker control motor circuits the selection of size will be made ensuring that the cable shall withstand a short circuit fault directly for 0.2 sec.

Suitable derating factors based on the site ambient conditions, method of laying and the no. of cables laid together shall also be applied.

b) Short circuit withstand time (seconds) shall be as follows for Breaker controlled feeders.

Bus duct	1 Sec.
<b>Feeders to motors and transformer</b>	<b>0.16 sec</b>
Feeders from PCC/PMCC to MCC	0.6 sec
Main 11 KV primary distribution feeders	0.7 sec
11 KV cable from transformer to switch board	1 sec
Incomer from other switchboard	0.6 sec

10.1.14 The minimum size of power cables shall be 2.5 sq. mm (Cu).

10.1.15 The control cables shall be 2.5 sq. mm (Cu). However, wiring in the panel/switch boards may be by means of 1.5 sq. mm (Cu) cables except for CT wiring which shall be 2.5 sq. mm. All the control and power wiring shall be carried by using FRLS wires only.

10.1.16 Deration factor, group laying factor etc. as per Technical Catalogue of Cable Manufacturer (of whose cables shall be supplied) shall also be considered while sizing the cables.

10.1.17 For all other specifications, refer PC288-TS-0815.

## 10.2 Cable Laying

10.2.1 The cables shall generally be laid on overhead racks. Pipe racks where available, shall be used to support the cable racks.

HV power cable shall be laid on cable tray in single layer having 1D spacing between the cables. LV power and control cable shall be laid on cable tray in touching formation in single layer.

HV Power, LV Power and Control shall be on separate trays. Instrument and electrical cable trays shall be separate.

Cables shall be clamped properly on the cable rack in such a way that position and layout of a particular cable shall not change throughout the rack so that it can be easily traced during maintenance jobs.

Walkway to be considered for access to Electrical / Instrument cables on pipe rack.

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		Document No.	Rev	
		Sheet 58 of 77		

From substations to various electrical consumers, cable shall be laid overhead. However, wherever overhead cable routing is not feasible LSTK Contractor can go for cable trench / slit (Refer PDS attached with the NIT) as per the site requirement.

Wherever, pipe rack is not available and space for overhead cable laying is possible then dedicated structure for cable shall be made for cable laying and shall be in scope of LSTK Contractor.

- 10.2.2 The cable racks shall be ladder type, pre-fabricated from suitable hot dip galvanised steel. Maximum cable tray size shall be 600mm wide. Maximum supporting span shall be 2 Mtrs. as per PDS Doc. No. PDS: E 530. Cable trays shall be designed considering 25% margin for future use.

**All cable racks must be provided with GI flat strip of size 50mm X 6mm as running earth all along the tray.**

- 10.2.3 All FO cable shall be laid through HDPE pipe with all accessories( Connecting arrangement ).
- 10.2.4 All cables shall be terminated using suitable cable lugs.
- 10.2.5 All HV terminations and joints shall be of reputed make subjected to Customer approval.
- 10.2.6 Bimetallic lugs shall be provided, as required.
- 10.2.7 In Control Room (excluding false ceiling) and Substation, lighting cable shall be laid in concealed conduit.
- 10.2.8 For all other specification of cable racks, refer PC288-TS-0816 & PDS attached.

## 11.0 ILLUMINATION SYSTEM

### 11.1 General

- 11.1.1 LED type lighting shall be provided. The average illumination levels in the various sections of the plants shall be as indicated in Annexure-I. All the plants and area lighting shall be energy efficient.
- 11.1.2 LED type lighting shall be provided for all areas. The minimum illumination levels in the various sections of the plants shall be as indicated in Annexure-I.

LED shall conform to the following types and standards:-

Product Type	Safety Standard	Performance Standard
Self ballasted LED lamps for general lighting services > 50 V	IEC 62560 Latest Edition	IEC 62612 / PAS Publicly available specification
Control gear for LED modules	IEC 61347-2-13 Latest Edition	IEC 62384 Latest Edition
LED modules for general lighting	IEC 62031 Latest Edition	IEC / PAS 62717 Latest Edition
LED luminaries	IEC 60598-1 Latest Edition	IEC / PAS 62722-2-1 Latest Edition Luminaries performance – Part 2-1: particular requirements for LED
LEDs and LED modules	IEC TS 62504 Terms and Definitions for LEDs and LED modules in general lighting.	

Maintenance factor for indoor lighting shall be considered as 0.7 and for Outdoor lighting 0.6.

The colour rendering index shall not be less than 90%.

The LED lights shall work satisfactorily at the design temperature of 50 Degree Celsius.





<div><div><div><div><div></div><div></div><div></div><div></div><div></div></div><div>पी डी आई एल</div><div>PDIL</div></div></div></div>	<div><div><div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div><div>OWNER: Bharat Coal Gasification and Chemicals Limited</div><div>DESIGN PHILOSOPHY – ELECTRICAL</div></div></div>	PC-288/E/Sec-5.4	1	<div><div><div><div><div></div><div></div><div></div><div></div><div></div></div><div>भारत कोयला</div><div>Coal India</div></div><div><div><div>बी एच ई एल</div><div>BHEL</div></div></div></div></div>
		Document No.	Rev	
		Sheet 60 of 77		

- 11.1.16 The LED module or array shall be designed in such a way that the failure of one LED shall not affect additional LED's.
- 11.1.17 Life expectancy of LED Luminaries shall be minimum of 50000 hrs with greater than 70% of rated lumen output.
- 11.1.18 Min. efficiency of LED driver: The minimum efficiency of LED driver shall be 85% for driver power output rating  $\leq 40W$  and 87% for driver power output rating  $> 40W$ .
- 11.1.19 Short circuit protection /Open load protection shall be required for LED fixtures.
- 11.1.20 Surge Protection for minimum 2kV for indoor and minimum 3kV for Outdoor LED systems shall be provided. However, if a site is prone to lightning and surges 10kV surge protection shall be required. In case of outdoor luminaries, the Surge Protection Device (SPD) should be series type with fail safe.
- 11.1.21 Color temperature of LED Luminaries: 5700K
- 11.1.22 Cover type for outdoor type fittings shall be Toughened glass or UV stabilized polycarbonate whereas, whereas, for indoor and non-weather proof items, UV stabilized Poly Carbonate can be used.
- 11.1.23 For more details, refer PDS attached.
- 11.1.24 For lighting fixtures and 16 Amp plug socket circuits, 3 core 2.5 sq. mm (Cu) cable shall be used.
- 11.1.25 Junction Boxes shall be provided with all type of Lighting Fixtures for looping. Connectors are not acceptable.

## 11.2 LED Tube Lighting Fixtures (inside Substations)

- a) High quality LED fluorescent tube twin batten type complete with 2 X 20W tube eco friendly, no UV radiation as per the specification tabulated below:

Sl. No.	Parameter	Technical Specification
1.	Degree of Protection	IP-20
2.	Lumen output per Lamp	$\geq 2000$
3.	CCT	6500K
4.	Luminous efficacy	$\geq 100$ lm/watt
5.	CRI	$>80$
6.	Guaranteed Life	$\geq 50000$ burning hours
7.	PF	$>0.95$
8.	THD	$<10\%$

## 11.3 **Street Lighting And Security Lighting**

- 11.3.1 Lighting Pole shall be fed from Street Lighting Sub Distribution Board (or Street Lighting Panel) having Photocell and Timer through contactor. Street Lighting Sub Distribution board shall have 3 PH incomer (which in turn shall be fed from Lighting Distribution Board) and 3 Phase 63A outgoing which shall be taken to the TPN Junction Box mounted on pole and looped from pole to pole.

- 11.3.2 Steel tubular poles of suitable mounting height shall be used for both street light and plant lighting (platforms/ structures/ access ways/ walk ways/ pump house/ pump bay etc.).

For Street Lighting :

11m Street Lighting Pole (PS1) for 1 Luminaire with 1.2m Bracket for Road Width upto 4m (Single Road) with mounting height (MH) from road level 9.5m approx.

11m/13m Street Lighting Pole (PS2) for 1 Luminaire with 1.2/1.8m bracket respectively for Road Width  $> 4m$  (single road) with MH 9.5m/11.5m approx. respectively.

13m Street Lighting Pole (PS4) for two Luminaire with 1.8m bracket each for Road Width  $> 7m$  (Bi Directional road) with MH 11.5m approx.






<div><div><div><div><div></div><div></div><div></div><div></div></div><div><div></div><div></div><div></div><div></div></div></div><div>पी डी आई एल</div><div>PDIL</div></div></div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div> <div>OWNER: <u>Bharat Coal Gasification and Chemicals Limited</u></div> <div>DESIGN PHILOSOPHY – ELECTRICAL</div>	PC-288/E/Sec-5.4	1	<div><div><div><div></div><div></div><div></div><div></div></div><div>Coal India</div></div><div><div>बी एच ई एल</div><div>BHEL</div></div></div>
		Document No.	Rev	
		Sheet 62 of 77		

ohm-m. Backfill shall comply the requirements and all applicable tests as per part-7 of IEC 62561.

- 12.1.7 Earthing grid/ring shall comprise of buried GI earth strips and GI pipes/electrodes.
- 12.1.8 Separate earth electrodes shall be provided for system neutral earthing. For equipment earthing, minimum two numbers of electrodes shall be provided around each plant/section. However, all these earth electrodes shall be interconnected.
- 12.1.9 Inter-connecting pits having an earth bus in an enclosed brick chamber without earth electrode shall be provided in the common underground earthing grid for convenience of taking earth conductors inside the plants.
- 12.1.10 As far as possible, the reinforcement rods inside concrete column shall be connected to the earthing grid/ring to reduce the overall earth resistance.
- 12.1.11 Individual electrical equipment shall be earthed by GI strip/GI wire/Cu/Al cable. Earth buses shall be provided in plants for earthing groups of electrical/non-electrical equipment to earthing grid/rings.
- 12.1.12 Size of earthing grid/ring and earth conductors of equipment for generating station and sub-stations shall be as per relevant standards. The fault current magnitude shall be decided based on system fault level. The time duration shall be taken as 1 second for voltage level above 66 kV and 3 seconds for voltage upto 66 kV as per IS -3043.
- 12.1.13 All equipment rated above 250 V shall have two external earth connections and those rated up to 250 V shall have one external earth connection. However, for lighting fixtures, earthing shall be done through 3rd core of the cable in safe as well as in hazardous area.
- 12.1.14 Flameproof equipment, in addition, shall have one internal earth connection. This means that 4 core cables to be used for all the flameproof equipments and 3.5 core cables to be used for all flameproof motors located at hazardous area.
- 12.1.15 All steel structures, tanks, vessels, pipes, pipe joints, valves etc. shall be earthed against static charge accumulation by 50x6 mm GI strip. The no. of earth connections shall be as follows:
- | Equipment having diameter | Hazardous area | Non hazardous area |
|---------------------------|----------------|--------------------|
| 30 M                      | 2              | 2                  |
| More than 30 M            | 3              | 2                  |
- 12.1.16 Wherever process equipments are mounted on steel structures, the structures shall be earthed instead of earthing the individual equipment.
- 12.1.17 The pipe structures shall be earthed at not more than 25M apart.
- 12.1.18 For all equipment in hazardous area, in addition to external earthing one internal earthing shall be provided.
- 12.1.19 Minimum sizes of earth conductors to be used shall be as given below.

Sl.No.	Equipment	GI conductor size	Al conductor Size
1.	HV/LV switch board, transformers, HV motors	50mm×8mm	150 sq. mm
2.	Motors rated 75 KW and above	50mm×6mm	150 sq. mm
3.	Motors rated 30 KW to less than 75 KW and vessel earthing	35mm×6mm	95 sq. mm
4.	Motors rated 5.5 KW to less than 30 KW	25mm×6mm	25 sq. mm
5.	Motors less than 5.5 KW	8 SWG	6 sq. mm
6.	All minor equipment rated 250V & above.	10 SWG	6 sq. mm

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		Document No.	Rev	
		Sheet 63 of 77		

7.	Earth Grid	75mm x 12 mm.	-
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Vendor to calculate the actual size. However, higher size of calculated one or above-mentioned size shall be provided.

All GI conductors shall meet the galvanizing requirement as per IS.

- 12.1.20 The main ground grid shall be buried in earth at a minimum depth of 1000 mm below finished grade level unless stated otherwise

## 12.2 Lightning Protection

- 12.2.1 All structure shall be protected against lightning strokes by suitable lightning protection system to be designed and installed as per IS/IEC-62305.

- 12.2.2 Bare metallic structures shall not have any air termination rods at the top. The earth connections shall be welded to the bottom of structure at 300 mm above floor level. However, tall metallic columns with insulation at top shall be provided with air termination rods. Separate earth electrodes shall be provided for each down conductor of lightning protection. However, these shall be inter-connected with the other electrodes in main grid.

### 12.2.3 Air Terminal

The vertical air terminal rods shall be installed at the roof of buildings to protect these objects from lightning strokes.

The vertical air terminal shall be made of 20 mm dia galvanized steel rod. The projected length of the rod shall be as required to protect the object (on which the rod is fixed) from lightning stroke.

The air terminal rod shall be properly fixed on the top of the building/structure to withstand very high wind pressure. In case the air terminal rod is embedded at the top of roof of building: the portion embedded inside the concrete shall not touch the reinforcement bars and shall be duly insulated from them.

All the vertical air terminal rods shall be electrically connected together by means of horizontal conductors of size 50 x 6 mm galvanized steel flats.

The shielding angle for one vertical air termination shall be 45 degrees. For more than one rod, shielding angle between the rods shall be taken as 60 degrees.

Horizontal air termination (i.e. G.S. Flat conductor) shall be so laid that no part of the rod will be more than nine (9) meters from the nearest roof conductor.

### 12.2.4 Shielding Masts

The shielding mast for lightning protection shall be installed at the top of steel columns cap plates of power house main building.

The shielding mast shall be made of galvanized steel pipe and the height of the same shall be decided considering the zones to be protected.

Each shielding mast shall be connected to grounding grid by a down conductor 50 x 6 mm. Galvanized steel flat run along the building column. In addition all power house building columns joints shall be electrically bonded.




### 12.2.5 Down Conductors

The down conductors shall be 50 x 6 mm galvanized steel flats. The connection between each down conductor and earth electrode shall be made via test link located at approximately 1500 mm above ground level.

## 13.0 CAPACITOR BANKS

- 13.1 The LSTK Contractor shall ensure that the power factor remains minimum 0.95 lag (inductive) in all the Bus of HV, MV& LV Switchboards.



<div><div> पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <u><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></u>  <b>DESIGN PHILOSOPHY – ELECTRICAL</b></div>	PC-288/E/Sec-5.4	1	<div><div> Coal India</div><div> बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 64 of 77		

Suitable capacitor bank shall be designed and installed at 415 V voltage level in the substation.

Capacitor bank at 3.3 kV or 11 kV may also be considered, if required.

The capacitor bank shall utilize the Automatic Power Factor Controllers to maintain the power factor of individual plant. Under no circumstances power factor shall become leading (capacitive) and all necessary protections to avoid this shall be used.

13.2 For all other specifications, refer PC288-TS-0822.

#### 14.0 FIRE DETECTION AND ALARM SYSTEM

14.1 LSTK Contractor shall provide the Fire Detection and Alarm System which shall be an independent system comprising of individual break glass type manual call points, automatic sensors e.g. smoke and heat detectors, main panel, repeater panel, hooter, battery, battery charger and any other hardware.

14.2 The system shall be designed to provide audio-visual indication at the main panel to be located in Control Room and repeater panels shall be provided in fire station.

14.3 The manual call points shall be provided at strategic locations with access along all exit routes and roads.

14.4 Electrical sirens shall be provided to cover entire package plant. Hooters and exit lights shall be provided at required locations in the buildings.

14.5 The fire detection system shall be interfaced with fire suppression system.

14.6 Supply, installation, testing and commissioning of above mentioned components/equipment for plant area, substation & control room shall be by the Contractor along with necessary supply and laying of required signals cables.

14.7 The required nos. of MCPs and detectors in substation & control room shall be calculated as per IS norms and contractor shall get approval from client during detailed engineering stage.

14.8 Separate Centralised Fire Alarm & Detection System of entire complex shall be provided by Owner. Fire Alarm & Detection System of this package shall be provided and hooked-up with the Centralized Fire Alarm System shall also be in LSTK Contractor's scope. All interfacing equipment as well as cabling required for hook-up shall be in LSTK Contractor's scope.

14.9 All cables (including communication cables) shall be armoured type only.

14.10 For all other specifications refer PC288-TS-0826.

#### 15.0 MOUNTING STRUCTURES

Switch sockets, cable trays, DBs etc shall be mounted / supported on suitable structure fabricated out of standard sections of mild steel, i.e. channels, angels, flats etc conforming to IS: 2066.

#### 16.0 SPARES




16.1 Commissioning Spares

The commissioning spares shall form an integral part of the scope of supply. Contractor shall be responsible for the quantification of the commissioning spares for the smooth commissioning start up of the plant/ package system. Item wise list of commissioning spares with recommended quantity shall be furnished for information. The same shall be Part of LSTK price

16.2 2 years operational spares (Mandatory)

Contractor shall supply Mandatory spares for all equipments as per Spare Parts of mentioned in NIT. The same shall be Part of LSTK Price.

16.3 Recommended Spares (Other than Mandatory spare) )

<div><div> पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <u><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></u> <b>DESIGN PHILOSOPHY – ELECTRICAL</b></div>	PC-288/E/Sec-5.4	1	<div><div> Coal India</div><div> बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 65 of 77		

Contractor shall provide recommended spares (other than mandatory spare) for all the equipment (item-wise) with recommended quantity.

16.4 All spare parts shall be identical to the parts used in the equipments.

16.5 Any other spare parts or special tools not specified, but required, shall also be provided. The same shall be part of LSTK Price.

#### 17.0 VENDORS' SERVICES

17.1 The LSTK Contractor shall consider the services of major equipment suppliers during installation, testing and commissioning in their scope as required.

17.2 The services of engineers of following equipments' (OEM) manufacturers are envisaged and required during installation, Testing and commissioning. LSTK contractor shall arrange for the same without any additional cost implication:

- AC UPS
- Variable Speed Drives
- Numerical relay
- HV & LV Switchboard
- Fire Detection & Alarm System

17.3 Site Testing, parameterization and commissioning of the Numerical relays shall be done by OEM expert only.

#### 18.0 TESTING & INSPECTION

18.1 Testing of all electrical equipments shall be done in accordance with relevant IEC/BIS codes in presence of owner's representative at manufacturer's works before despatch / at site before installation. All such tests shall be arranged by the contractor and testing charges, if any, shall be borne by the contractor.

18.2 The LSTK Contractor shall submit the certificates of type tests performed on identical equipment as evidence of the compliance of the equipment with the type tests. All Type Test Certificates shall not be older more than 5 years except GIS for which Maximum 10 years old Type test Certificates is acceptable subject to no change in Design.

18.3 The LSTK Contractor shall submit the certificates of routine and acceptance tests conducted on the purchased equipments.

18.4 All the routine/acceptance tests shall be performed at the manufacturer's works in the presence of owner's representative.

18.5 Stage Inspection of Electrical Equipment shall be considered. The owner or their representative shall be allowed to visit the manufacturing works for stage inspection during manufacturing stage.




18.6 The equipment shall be dispatched from works only after receipt of Owner written approval of the test reports.

18.7 The LSTK Contractor shall intimate the owner 4 weeks in advance of the tests and submit the detailed schedule of tests.

18.8 In addition, the equipment shall be inspected at site for final acceptance.

18.9 Certified reports of all the tests carried out at the works shall be furnished in six (6) copies for approval of the Owner.

18.10 Electrical installation work shall be subjected to inspection by owner / his authorized representative, statutory bodies like Electrical Inspector, Factory Inspector and where applicable by equipment supplier's engineer. The contractor shall carry out without extra cost to owner rectifications / modifications desired by the above authorities to make the installation conforming to I.E. Rules etc.

<div><div> पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>DESIGN PHILOSOPHY – ELECTRICAL</b></div>	PC-288/E/Sec-5.4	1	<div><div> Coal India</div><div> बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 66 of 77		

18.11 The owner may reject any portion of the work considered defective or of poor workmanship and the contractor shall make good these defects without extra cost to owner.

## 19.0 DOCUMENTATION

19.1 The LSTK Contractor shall submit the documents for electrical equipments (MS-word, MS-excel and AutoCAD) as per the drawing and documentation schedule as given in this bid package.

19.2 Sizing of Electrical system and Equipments shall be submitted during detailed engineering stage.

19.3 LSTK Contractor shall ensure that following shall be mentioned in each sheet of drawings/ documents in the order mentioned below:

- (a) Logo and Name of the client
- (b) Logo and Name of the consultant
- (c) Logo and Name of the contractor (LSTK Contractor )
- (d) Logo and Name of the Manufacturer on the drawings prepared by manufacturer, if applicable
- (e) Name of the Project for which drawings are applicable
- (f) Title of the drawing (Title shall indicate the details shown in the drawing)
- (g) Drawing/ document number with sheet number and number of total sheets in the drawing (Drawings having different title shall be assigned different drawing number)
- (h) All sheets of each drawing shall bear same title, same document number and same revision number

19.4 At the time of handing over of the installation, LSTK Contractor shall supply as built drawings taking into consideration the actual execution carried out at site.




19.5 Erection, testing/ checking (inclusive of calibration check) prior to energisation/ after energisation and commissioning Manuals shall be in bound book format and shall give step by step procedure for:

- (a) Storage, Handling and Erection
- (b) Checking/ testing after erection and before energisation.
- (c) Pre-commissioning tests/ checks and cold trials
- (d) Commissioning
- (e) Drawings relevant for erection, operation, maintenance and repair of the equipment.
- (f) List of instruments/ testing kits/ sets, measuring instruments etc. required for testing/ checking with specification, ratings, ranges etc.

19.6 Operation & Maintenance Manuals for each of the equipment/ system being shall be in bound book format and shall be supplied alongwith dispatch of equipment and inclusive of following:

- (a) Log sheets indicating daily/ hourly recordings of parameters to be noted down by customer's operating personnel.
- (b) Procedure for shut down and energisation.
- (c) Preventive maintenance schedule.
- (d) Safety procedures for safe operation of equipment and complete system.
- (e) Specification of equipment installed. Manufacturer's catalogues operation and maintenance manuals for all types of relays/components used.
- (f) Test procedures for site tests/ checks.



<div><div> पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <u><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></u>  <b>DESIGN PHILOSOPHY – ELECTRICAL</b></div>	PC-288/E/Sec-5.4	1	<div><div> Coal India</div><div> बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 67 of 77		

- (g) Spares list for each equipment/ system for 2 years operation and maintenance.
- (h) Relevant calculations and protection relay setting table for the equipment/ system being supplied by him
- (i) Instructions for Diagnostic trouble shooting / fault location charts
- (j) Tests for checking of proper functioning/ Operation.
- (k) Storage and re-conservation Manual
- (l) Safety Manual
- (m) Drawings relevant for operation, maintenance and repair of the equipment
- (n) Instructions for Maintenance and Repair
- (o) List of spare parts with ordering specifications and manufacturer's catalogues.
- (p) List of consumables with specifications, brand names and annual consumption figures.
- (q) Manufacturer's catalogues with ordering specification for all items
- (r) List of special tools and tackles
- (s) QAP, Internal Test Certificates and Inspection Certificates
- (t) Procedure for ordering spares.
- (u) All as built drawings.

19.7 Drawings/ documents to be submitted with inspection call of equipment:

- (a) Type test certificate for identical equipment
- (b) Sub-supplier's/ vendor's catalogue/technical literature
- (c) Test reports for internal inspection
- (d) Test certificates of components
- (e) Technical specification & data sheets of equipment
- (f) All drawings as applicable of category 'Approved', 'Approved with comments' and drawings 'For information/ Reference' including comments thereon



19.8 The details of equipment layout and cable routing will be designed by the LSTK Contractor during detail engineering stage and these shall be subject to approval by Owner/Consultant. Changes as required to achieve a neat layout with adequate working space all around, for better aesthetics as well as to meet statutory regulation and codes shall be done without any time and cost implication.

## 20.0 TOOLS & TACKLES

The LSTK Contractor shall supply at least one set of all special tools for each substation required for maintenance of the equipment supplied by them and price shall be included in the offer. List of tools & tackles with quantities shall be mentioned in the offer.

## 21.0 REVIEW OF DRAWINGS & DOCUMENTS BY OWNER/ CONSULTANT

21.1 The successful Bidder (herein after referred as contractor), shall submit within one month of placement of LOI; list of drawings/ documents/ Manuals that would be submitted by them. The list shall mention Serial Number, Title of the drawing/ document/ manual, Category (For Approval, For review, For Reference, etc) and tentative date of submission. The list shall be prepared taking in to account into consideration stipulations in respect of submission of drawings/ documents and scheduled date for completion.

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><u><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></u></p><p><b>DESIGN PHILOSOPHY – ELECTRICAL</b></p></div>	PC-288/E/Sec-5.4	1	<div><p>बी एच ई एल <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 68 of 77		

- 21.2 Template for name plate of drawings, documents and drawing/ document numbering system shall also be submitted by contractor and approval obtained.
- 21.3 The LSTK Contractor shall ensure that all sheets of the drawings/ documents and top sheet of manual prepared by manufacturer/ vendor/ supplier & submitted by him or by his consortium member or by manufacturer or his consultant, are checked by him/ leader of consortium and vetted by LSTK Contractor / Leader of consortium before submission with stamp ensuring correctness, completeness, suitability of document for subject work and compliance with stipulations of order
- 21.4 The responsibility for delay in approval/ review of drawings/ documents due to
- Submission of incomplete drawings/ documents not meeting the requirement of project/ stipulations of order
  - Non-compliance of comments made earlier
  - Drawings are not submitted in requisite copies;
- and consequent delay in project shall be that of contractor.
- 21.5 The contractor shall ensure that in case any model number is mentioned in the drawing, detailed technical catalogue, literature, explanatory notes to describe the model and its technical details in full are also submitted along with the drawing. Such drawings/ documents should be assigned Drawing/ Document Number, Number of sheets in the drawing, Rev number etc (Unique Identification). Reference of such drawing/ document number should be mentioned in the drawing.
- 21.6 The drawings/ documents shall be prepared in such sizes that those can be read easily. Size of font in print submitted shall not less than size 10 Arial or equivalent.
- 21.7 The drawings/ documents shall be submitted in sizes in which those are prepared. Photocopies in reduced sizes shall not be accepted.
- 21.8 The contractor shall leave space on each sheet for stamping the drawing by Owner/ consultant to avoid stamping on contents of drawing making them unreadable. Submission of drawings in A4 size shall be avoided.
- 21.9 All sheets of a drawing shall be assigned same title and drawing number. Drawings having different title shall be assigned different drawing numbers.
- 21.10 GA drawings, schematic diagrams, single line diagrams, bill of material, data sheets, characteristics curves, cable schedules and cable termination diagrams shall be assigned separate drawing numbers.
- 21.11 Revision shall be clearly marked on all subsequent issue of drawings and documents.
- 21.12 Inability to incorporate some of the comments shall be clearly stated by contractor with reasons and without delay. However, to accept or reject the non-compliance based on the reasons indicated by contractor shall be discretion of Owner/ their consultant.
- 21.13 In case alterations are considered necessary by the contractor in the drawings already approved, such drawings shall be resubmitted for approval again stating the considerations necessitating changes/ alterations. In case, alterations/ changes proposed by contractor are approved by the consultant/ Owner; all other drawings and data affected by such alterations/ changes shall be duly revised and re-submitted for the approval as stated above.
- 21.14 Contractor shall depute their concerned engineers (with the engineers of suppliers, if required) shall visit consultant after submissions of drawings for discussion, modification of drawings and approval so that project is not delayed for want of approval of drawings.
- 21.15 It will be the responsibility of contractor to submit the drawings and obtain approval to meet the project schedule. Delay in approval of drawings due to following shall be the responsibility of contractor:

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- a. non-submission of drawings/ documents/ well before those are actually required and/ or
- b. delay in incorporation of comments and/ or
- c. non-incorporation of comments by contractor and/ or
- d. submission of drawings without checking and ensuring requirement stipulated in contract/ order

21.16 Contractor shall note that any approval and/ or clearance accorded by Owner or consultant for manufacture and/ or to proceed further given during discussions or recorded in the minutes of the meetings shall be valid only after the drawings showing relevant details are submitted by contractor and clearance/ approval is accorded by Owner/ Consultant by stamping and signing on the relevant drawings.

21.17 Approval of drawings by Owner / his consultant shall not relieve the contractor of his contractual obligations and responsibility for engineering, design, workmanship, materials and performance of the equipment

21.18 Contractor shall furnish, if requested, additional drawings, calculations, information to the Owner/ Consultant to enable him to examine/ study the drawings submitted.

21.19 Contractor shall note that work shall be carried out exactly as indicated in the approved drawings and no alterations shall be made without the written approval of the Owner/ Consultant.

## 22.0 TRAINING

22.1 Training shall be imparted to owner's personnel at manufacturer's works as under:

- a) AC UPS: Two engineers for one week .
- b) Variable Speed Drive: Two engineers for one week.
- c) Numerical relay: Two engineers for one week
- d) HV & LV Switchboard : Two engineers for one week
- e) Fire Detection & Alarm System : Two engineers for one week

## 23.0 VENDOR LIST

23.1 Make of all electrical equipment shall be as per Vendor List attached with this NIT.

23.2 Any other vendor shall be subject to Owner/Consultant's approval.

23.3 Any other item for which vendors are not mentioned in NIT, LSTK Contractor shall furnish list of proven suppliers with PTR subject to Owner's/ Consultant's approval during detailed engineering. Document(PTR) shall be in English language only.

## 24.0 INSTALLATION, TESTING AND COMMISSIONING

24.1 The LSTK Contractor shall undertake installation of all electrical equipment in accordance with latest code of practices, in conformity with recommendation of the respective equipment manufacturers, drawings approved by the owner or owner's representative, direction of engineer-in-charge, statutory regulations and to the entire satisfaction of the owner.

24.2 The LSTK Contractor shall arrange all the necessary erection tools and tackles, testing and measuring instruments and shall supply the required erection materials including structural steel.

24.3 LSTK Contractor shall furnish field inspection and test data sheets for all equipments for owner's approval.

24.4 The LSTK Contractor shall obtain the necessary certificate of compliance/completion certificate with test results from statutory authorities as required. All necessary drawings and test certificates as required by them shall be furnished by the vendor.

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		Document No.	Rev	
		Sheet 70 of 77		

24.5 The erection work shall be supervised by competent supervisors holding relevant supervisory license from the Government.

#### 24.6 Installation of Equipment

- a. The equipment shall be installed in switchgear rooms, MCC rooms, control rooms and at shop floors.
- b. The scope of work of LSTK Contractor under installation shall be inclusive of but not limited to the following:
- c. Physical inspection and handling
- d. Assembly and interconnection of shipping sections, if any, as per manufacturer's instructions. Supply of materials, fabrication and installation of supporting frames/ brackets for proper support of equipment/ panels/ devices/ cable trays etc..
- e. Installation on foundation/ supports/ brackets.
- f. Alignment, levelling and clamping/ welding/ fixing/ grouting with supports/ foundation bolts as required.
- g. Mounting loose supplies and connection of wiring.
- h. Conducting pre-energisation tests/ checks to ensure that installation is carried out as per manufacturer's instructions/ direction of supervising engineer and is healthy/ fit for energisation.




#### 24.7 Cable Installation

##### 25.7.1 General

- (a) All Cables to be laid in overhead cable tray only. Cable Tray for HV, LV and Control cable should be separate. Underground cable to be avoided, Cables to be laid on racks in underground concrete cable trenches inside the plant only where overhead structure is not possible. Cables may be laid in ground (slit with HDPE conduit) where number of cables to be laid are less and do not justify use of concrete cable trenches.
- (b) All the cable tray structures shall be painted with two coats of primer and two coats of final paint after necessary surface preparation.
- (c) Cable OD 40 MM and above shall be clamped individually.
- (d) Cables shall be clamped only after the cables are neatly arranged, dressed tailored and kept in position. Support of cables on edges of cable trays/ structural steelwork shall be avoided.
- (e) Power cables shall be laid in one layer only. Control and other cables may, however, be laid in two layers. More than two layers shall not be permitted.
- (f) All the cable tray network shall be earthed by a continuous earth strip.

25.7.2 Cable laying in Trench/ on Racks/ Trays/ Cleated on Wall/ Structure. For proper support, access and neatness of appearance of installation; cables shall be laid on racks or cable trays or cleated on wall and/ or structure taking following into consideration:

- (a) Cable racks/ trays shall be 250 mm apart.
- (b) Ladder type cable trays shall be used for laying power cables.
- (c) Perforated type cable trays shall be used for laying control, signal, and communication etc. cables.
- (d) Coaxial cables for data transfer from/ to microprocessor based equipments shall be laid in HDPE conduits with pull boxes fixed to cable supporting racks.

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		Document No.	Rev	
		Sheet 71 of 77		

- (e) Top tray shall be used/ left vacant for communication, signalling and fire alarm cables.
- (f) Cables shall be laid in separate trays according to voltage and noise classification. Fire proof partition shall be provided between HV and LV cables.
- (g) Power, control and lighting cables shall be laid in separate cable trays.
- (h) Large size cables shall be clamped individually. Small size cables may be bunched together provided that in any bunch all cables have sheath of same material.
- (i) Cables in trays shall be clamped at not more than every 1500 mm for horizontal run and 800 mm for vertical run and near bends.
- (j) Cable racks/ trays shall be planned in such a way so that at least 20 % or one rack/ tray (whichever is more) can be added in future and at least 20 % free space shall be left in each cable tray for cable laying in future..
- (k) Support to cable trays shall be provided at intervals as required for proper support but at interval not more than 1000 mm.
- (l) Support to trays shall also be provided at each joint of tray irrespective of it's distance from adjacent support.
- (m) GI trays shall be fixed using nuts and bolts as welding will not be permitted.




#### 25.7.3 Cable laying in conduits

- (a) Cables shall be laid in GI conduits while laying on or crossing floors/ wall/ railway lines/ roads.
- (b) While laying on floor or wall or crossing roads conduits shall be embedded in concrete/wall.
- (c) When laid on floor the top cover shall be minimum 10 mm.
- (d) At rail/ road crossings, the conduits shall be laid not less than 1 meter below top surface of the road.
- (e) Mechanical protection by G.I. Pipe shall be provided to all cables up to 1200 mm from ground/ floor level.
- (f) Minimum diameter of G.I. pipes used for laying/ protection of cables shall be 1.6 times the cable diameter.
- (g) Only one cable shall be laid in one conduit.
- (h) Conduit shall be sealed after cable laying.
- (i) Standard bends or fabricated bends shall not be used. wherever required, conduits shall be bent using bending machine. Bending radius shall not be less than 10 times the diameter of conduit.
- (j) Jointing of the conduits shall be done using sockets which may be welded from top to avoid ingress of water.
- (k) Ends of conduits shall be made smooth to avoid damage to cables.

#### 25.7.4 Cable Jointing

- (a) Joints in cable length less than standard drum length shall not be allowed.
- (b) Joints, if unavoidable, shall be made at most suitable places.
- (c) Joints shall not be made at passageways or under rail/ road crossings and in hazardous area.
- (d) Joints shall be segregated by not less than 2 meters so as to reduce the possibility of one joint failure affecting the other.



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		Document No.	Rev	
		Sheet 72 of 77		

- (e) Individual cores in cables shall always be joined number to number or colour to colour of the insulation over the conductors.
- (f) Continuity and current carrying capacity for earth conductor and/ or armour shall be provided.
- (g) Cable jointing shall be done by joiners who possess certificate of competency for carrying out particular joint.
- (h) Minimum 2 meters cable loops shall be kept near each joint.

#### 25.7.5 Cable Termination

- (a) Double compression heavy type glands/ heat shrinkable termination kits and bi-metallic/ copper lugs shall be used for termination of cables.
- (b) Paint of the gland plate at the contact point of gland shall be removed for proper contact.
- (c) Cable glands/ termination kits shall be earthed.
- (d) Cables to individual cubicles shall be neatly laid out and supported.
- (e) Cables shall be clamped at a distance of 400 mm from gland/ termination.
- (f) Conductors of control cables shall be neatly arranged in compact group. The entire group shall be placed and tied with nylon straps.
- (g) Spare cores shall be terminated with sufficient length to permit future connection to the terminal block associated with control cables.

#### 25.7.6 Identification




- (a) Cable tags shall be made of non- corrodible material, preferably SS.
- (b) Voltage, cable number etc shall be engraved on each tag.
- (c) Cable tags shall be tied to each cable at
  - (i) All termination (outside as well inside panel/ box.)
  - (ii) All bends.
  - (iii) All points before and after which their route cannot be easily identified.
  - (iv) Entry and exit from conduits.
  - (v) All joints.
  - (vi) Every 15 meter for straight run.

### 25.0 TESTING OF INSTALLATION AFTER ERECTION

25.1 The LSTK Contractor shall carryout tests/ checks after erection of equipment/ cables to check, ensure and demonstrate the conformity of equipment supplied and installation done with the specification and statutory requirement.




25.2 Prior to starting the test, the LSTK Contractor shall satisfy himself and ensure that

- a. The installation is strictly in accordance with the specification, drawings and statutory requirement.
- b. Any automatic controls that might vitiate the tests have been relaxed.
- c. All instruments to be used for testing are suitable for the purpose and have been calibrated by a recognised laboratory within the last 12 months and copy of the calibration certificates have been submitted to the Owner/ Consultant.

<div><div> पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <u><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></u>  <b>DESIGN PHILOSOPHY – ELECTRICAL</b></div>	PC-288/E/Sec-5.4	1	<div><div> Coal India</div><div> बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 73 of 77		

- d. The testing, commissioning, operation and maintenance manuals are available to the testing engineer and Owner/ Consultant.
- e. Formats for recording test results have been finalised with the Owner/ Consultant and copies have been distributed to all concerned.

- 25.3 The skilled manpower to test all the equipment, cables, earthing etc deputed by LSTK Contractor is well aware of and prepared to perform checks/ tests.
- 25.4 The tests shall be witnessed by the representatives of Owner/ Consultant.
- 25.5 The LSTK Contractor shall compile and tabulate all the test results in agreed formats and submit to Owner/ Consultant for approval prior to acceptance of installation.
- 25.6 Testing and checking shall be carried out to demonstrate and record prior to completion, that supply and installation meets the requirement/ performances specified. The installation shall be tested in presence of Owner/ Consultant.
- 25.7 The LSTK Contractor shall give at least 24 hours notice to Owner/ Consultant to enable them to witness the test.
- 25.8 The LSTK Contractor shall submit to Owner/ Consultant test record sheets on daily basis.
- 25.9 Equipment or any part of the installation shall be energised only after all pre-energisation tests are completed and test results are approved by Owner/ Consultant.
- 25.10 Failure to submit test results as tests are completed may render the LSTK Contractor for carrying repeat tests.
- 25.11 The LSTK Contractor shall supply six (6) bound and indexed copies of all tests in agreed formats prior to preliminary acceptance and handing over of the equipment/ installation, duly signed by representatives of the Owner/ Consultant who have witnessed the tests.
- 25.12 It will be the responsibility of the LSTK Contractor to supply/ arrange at his own cost all necessary testing equipment and measuring equipment required for conducting the tests as per applicable standards.
- 25.13 Should any of the tests reveal any discrepancy or non-conformity, the same shall be attended to and retested before proceeding with any other tests.
- 25.14 All tests shall be conducted in accordance with this specification, standard specifications of Bureau of Indian Standards, recommendations of IEC and IE Rules.
- 25.15 Tests checks to done at site shall be inclusive of but not limited to the following:
- a. Physical Check & Verification : All Equipment/Cables etc
  - b. Tightness of connections : All Equipment/Cables etc
  - c. Checking for cleanliness : All Equipment/Cables etc
  - d. Size & No. of Earth connection : All Equipment/Cables etc
  - e. Erection, alignment, mounting height and clearances : All Equipment/Cables etc
  - f. Insulation Resistance test : All Equipment/Cables etc
  - g. Earth continuity test : All Equipment/Cables etc
  - h. Earth Resistance test : All Equipment/Cables etc
  - i. Earth loop impedance test : All Equipment/Cables etc
  - j. No load & rated load current : All Motors/ Loads
  - k. No load & rated load P.F. : All Motors/ Loads




<div><div> पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <u><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></u> <b>DESIGN PHILOSOPHY – ELECTRICAL</b></div>	PC-288/E/Sec-5.4	1	<div><div> Coal India</div><div> बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 74 of 77		

l.	No load & rated load Power	:	All Motors/ Loads
m.	Functional checks	:	All Equipment & Controls
n.	Primary injection test	:	All switchgear
o.	Secondary injection test		All protective relays/ devices
p.	Ratio and polarity test		CTs
q.	Power frequency HV test		Power & Control circuit
r.	Phase sequence checks		/C & bus couplers
s.	Winding resistance test		Motors & Transformers
t.	Direction of rotation		All motors
u.	Free running for 2 Hrs		All motors
v.	Under voltage tests		All U/V Devices
w.	Calibration Checks		All instruments
x.	Load and Performance tests		UPS, PLC, & Variable Frequency equipment, Battery Bank
y.	Checking of Voltage, current		UPS, PLC, & Variable Frequency equipment
z.	Checking of specific gravity and acid level		Battery
aa.	Illumination levels		All areas

25.16 It is anticipated that following equipment will be necessary to perform testing of the installation. The LSTK Contractor shall, therefore, arrange these as well as any other equipment for testing of the installation.

- a. HV Testing Set
- b. Primary Injection Set
- c. Secondary Injection Set
- d. IR Testers
- e. Earth Continuity testers
- f. Soil resistivity Testers
- g. Earth resistance Testers
- h. Phase to earth loop impedance testers
- i. Mili volt drop testers
- j. Micro-ohm meter
- k. Phase sequence testers
- l. Clip-on ammeters
- m. Voltmeters
- n. Power factor meter
- o. Frequency meter
- p. 3 Ph 4 wire unbalance load kWh meter
- q. Cable fault location equipment
- r. Digital multi-meter suitable for testing IC voltage and current levels



<div><div> पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>DESIGN PHILOSOPHY – ELECTRICAL</b></div>	PC-288/E/Sec-5.4	1	<div><div> Coal India</div><div> बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 75 of 77		

- s. Analogue Multi-meters
- t. Portable multi-range precision ammeters, voltmeters complete with CTs, PTs for AC/ DC circuits.
- u. Protection relay test plugs
- v. Portable earthing equipment
- w. Dual beam oscilloscope with storage facility.
- x. UV recorder
- y. Illumination level meter
- z. Thermometers
- aa. Power Analyser / Portable Power Meter
- bb. Rpm meter
- cc. Noise meter

25.17 At least following tests shall be specifically conducted before commissioning in presence of owner's representative. All the test results shall be recorded and submitted to the owner.

- a) Insulation Test
- b) Continuity Test
- c) High Voltage Test
- d) Simulation Test
- e) Earth Resistance Test

## 26.0 QUALITY ASSURANCE

- 26.1 All equipment, components, materials proposed to be supplied by LSTK Contractor shall be procured, manufactured, erected, commissioned and tested as per a comprehensive Quality Assurance Programme (QAP) to be approved by the Owner/ Consultant.
- 26.2 The Successful Bidder shall submit within 1 Month of from order; Quality Assurance Plan (QAP) for all the equipment/ panels/ cables/ motors/ devices etc. under their scope of supply.
- 26.3 All routine and acceptance tests shall be carried out as per relevant IS / IEC/ Other Standards during inspection at manufacturer's works in presence of Owner or his representative.
- 26.4 The LSTK Contractor shall submit type test certificates for similar equipment supplied by him elsewhere. In case type test certificates (not more than 5 years old and conducted at duly accredited laboratory) for similar equipment is not available, the type test shall be conducted in presence of Owner or his representative without any financial implications to Owner.
- 26.5 The inspection procedure shall be finalized and approved by Owner and/ or their consultant/ authorized representative.
- 26.6 Inspection will be carried out as per drawings and quality assurance plan approved by the Owner/ Consultant. Inspection shall be carried out either at manufacturer's shop/ works or any other place where facilities for conducting tests/ checks are available.
- 26.7 Owner reserves the right to witness any of the tests and verify the documents of the LSTK Contractor, his supplier/ vendor/ manufacturer.
- 26.8 Manufacture test certificate for bought out components shall be submitted during inspection.
- 26.9 No equipment or part items shall be dispatched without final acceptance certificate and dispatch instructions in writing issued by Owner and/or their authorized representatives.
- 26.10 The LSTK Contractor shall carry out an inspection and testing programme during manufacture in his works and/ or that of his vendor's works to ensure accuracy/ correctness/

<div><div><div><div><div></div><div></div><div></div><div></div><div></div></div><div></div><div></div><div></div><div></div></div><div>पी डी आई एल</div><div>PDIL</div></div></div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div> <div>OWNER: Bharat Coal Gasification and Chemicals Limited</div> <div>DESIGN PHILOSOPHY – ELECTRICAL</div>	PC-288/E/Sec-5.4	1	<div><div><div><div></div><div></div><div></div><div></div><div></div></div><div></div><div></div><div></div><div></div></div><div>कोयला भारत</div><div>Coal India</div></div> <div><div><div><div></div><div></div><div></div><div></div><div></div></div><div></div><div></div><div></div><div></div></div><div>बी एच ई एल</div><div>BHEL</div></div>
		Document No.	Rev	
		Sheet 76 of 77		




completeness of components, compliance with drawings, conformance to functional and / or performance requirements, identify and acceptability of all materials, parts and equipment. The LSTK Contractor shall also carry out all tests/ inspections required to establish that the items/ equipment conform to requirements of the specification and the relevant codes/ standards specified in the specification in addition to carrying out tests as per the approved Quality Plan.

- 26.11 Quality audit/ surveillance/ approval of the results of the tests and inspection, approval of drawings will not, however, prejudice the right of the Owner to reject the equipment at any subsequent stage if it does not comply with the specification or does not give complete satisfaction in service and shall in no way limit the liabilities and responsibilities of the LSTK Contractor of ensuring complete conformance of the materials/ equipment supplied to relevant specification, standard, data sheets, drawings etc.
- 26.12 The owner or their representative shall be allowed to visit the manufacturing works for stage inspection during manufacturing stage.
- 26.13 The LSTK Contractor shall intimate the owner 4 weeks in advance of the tests and submit the detailed schedule of tests.
- 26.14 LSTK Contractor s shall supply reports of type tests, acceptance tests, all requisite factory tests and site tests in bound volumes.
- 26.15 All the equipment shall be tested at site to know their condition and to prove suitability for energisation and required performance.

## **27.0 COORDINATION WITH OTHER CONTRACTORS**

- 27.1 LSTK Contractor shall coordinate with Owner's other Contractors and shall freely exchange all technical information required for this purpose.
- 27.2 All civil works connected with electrical installation shall be under the LSTK Contractor's scope.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - UPS SYSTEM	PC288-TS-0802	0	 कोयला इंडिया  बी एच ई एल
		Document No.	Rev	
		Sheet 1 of 11		

# **TECHNICAL SPECIFICATION** **UNINTERRUPTED POWER SUPPLY**

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - UPS SYSTEM</div>	PC288-TS-0802	0	<div> बी एच ई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 2 of 11		

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	AMBIENT CONDITIONS & ELECTRICAL SYSTEM CHARACTERISTICS
4.0	DESIGN AND OPERATIONAL REQUIREMENTS
5.0	CONSTRUCTIONAL DETAILS
6.0	COMPONENT DETAILS
7.0	OPTIONAL ITEMS
8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	DRAWINGS AND DOCUMENTS
11.0	SPARES
12.0	PACKING
13.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR UNINTERRUPTED POWER SUPPLY
ANNEXURE - II	METERING INDICATIONS AND ALARM SCHEDULE

## **1.0 SCOPE**

- 1.1 The specification covers the design, manufacture, testing at works and despatch in well packed condition of Uninterrupted Power Supply System required to supply AC power for non linear loads (i.e. instrumentation loads).
- 1.2 This standard shall be read in conjunction with block diagram & UPS distribution diagram.
- 1.3 The scope shall include the following:
- i) Full wave controlled rectifier
  - ii) Inverter
  - iii) Static switches
  - iv) Storage battery
  - v) Static voltage stabilizer for bypass supply
  - vi) Manual bypass switches
  - vii) Isolation / output transformer to achieve desired output voltage
  - viii) UPS Distribution Boards
  - ix) Interconnecting cabling between various units of UPS
  - x) All other items required, but not specified for safe and reliable operation of UPS system.

## **2.0 STANDARDS TO BE FOLLOWED**

- 2.1 The equipment shall conform to the latest issue of the following and relevant Indian Standard specifications Equipment complying with equivalent IEC standards shall also be acceptable.
- IS-13314 - Solid state inverters run from storage batteries
  - IS-11260 - Stabilized power supplies AC output
  - IEC-146 - Solid state inverters
- 2.2 The equipment shall also conform to the provision of Indian Electricity Rules, Indian Supply Act and any other statutory regulations in force from time to time.

## **3.0 AMBIENT CONDITIONS & ELECTRICAL SYSTEM CHARACTERISTICS**

These shall be as specified in the enclosed Design Philosophy - Electrical.

## **4.0 DESIGN AND OPERATIONAL REQUIREMENTS**

- 4.1 The UPS unit and its associated equipments shall be suitable for operating at the specified rating continuously with the specified voltage and frequency variations under the ambient conditions without exceeding the temperature rise limits specified in relevant standards and without any detrimental effect on any part.
- 4.2 The UPS system shall be based on latest generation of IGBT based, pulse width modulated (PWM) design with proven performance. The basic scheme required for UPS system shall be as indicated in Block diagram in this specification.
- 4.3 The UPS shall have Redundant Scheme with Bypass. Under normal operating conditions, both inverter units should run in parallel sharing 50% load in synchronism with by-pass power and supply uninterrupted A.C. power to load. On failure of one of these inverters, the faulty inverter should get automatically disconnected from the load and healthy inverter should supply 100% load in synchronism with by pass supply. In

- the event of second inverter also developing a fault, a no-break load transfer to standby power supply should take place through static switch.
- 4.4 Output frequency of the inverters must remain synchronised to one another which in turn shall be synchronised to the standby power supply frequency provided the latter does not vary by more than +3% to -5%. It should be possible to change the setting of frequency range of synchronism between above limits by frequency selector switch. Outside these limits inverter should desynchronise with the bypass and run at its own frequency. When running at its own frequency, frequency variation shall be maintained less than  $\pm 1.0\%$ . Resynchronisation with bypass power supply must take place automatically with some time delay when frequency comes back to +3% to -5% range. Change-over from inverter to bypass or bypass to inverter shall also be possible in desynchronised mode of operation. Change-over time in both synchronised and desynchronised mode operation shall be indicated.
- 4.5 The UPS unit shall be suitable for 0.7 lagging to unity power factor. The overall power factor may be taken as 0.8 lagging.
- 4.6 The maximum waveform distortion of the output voltage shall not exceed 5% r.m.s. for linear loads and 10% r.m.s. for non-linear loads. The UPS unit shall be suitable for operation for non-linear loads having crest factor of 3.
- 4.7 The inverter steady state output voltage and frequency (free running) variation shall not exceed  $\pm 1\%$  for specified input power supply condition and no-load to full load condition.
- 4.8 Voltage dip / rise on sudden application / throw of 100% load or on changeover from inverter to bypass or vice versa shall not exceed 15% and shall be recovered within 100 m. sec. to rated voltage.
- 4.9 UPS shall be designed for overload of 125% for 10 min. and 150% for 10 sec. after which drooping characteristic shall come into operation.
- 4.10 On failure of the main supply, inverter unit shall continue to supply rated load from the battery bank for two hours duration.
- 4.11 Charger shall simultaneously supply entire power necessary for inverter and to keep the battery of required capacity in fully charged condition. Provision for automatic charging in both float and boost shall be made.
- 4.12 Battery shall be Nickel-Cadmium or Lead Acid Plate tubular positive plate or VRLA type. The battery capacity shall be decided considering load power factor as 0.8, derating factor for ageing 0.8 and derating for minimum ambient temperature as applicable.
- 4.13 The ventilation fans, if provided shall be fully redundant and connected to the output from the inverter and an audio-visual alarm shall be provided on its failure. It shall be possible to operate inverter for about half an hour even after the failure of the fan without temperature rise inside the inverter cubicle exceeding the safe operating temperature limits.
- 4.14 In case of inverter failure due to any reason or overload, affected unit shall be isolated and changeover to other inverter or to bypass shall take place automatically.
- 4.15 Noise level at a distance of 1m from UPS panels shall not exceed 60 dB.
- 4.16 UPS system shall be provided with necessary control, protection, metering, indication, alarm & annunciation for reliable and safe operation of the system. The suggestive list is indicated in Annexure-II.



**SYNGAS PURIFICATION UNIT FOR  
COAL TO AMMONIUM NITRATE PLANT  
TECHNICAL SPECIFICATION - UPS SYSTEM**

PC288-TS-0802

0

Document No.

Rev

Sheet 5 of 11



- 4.17 All semi-conducting devices shall be protected by fast acting semi-conducting fuses. These fuses shall be co-ordinated with load side HRC fuses.
- 4.18 The battery may be taken out of service for maintenance during which period it shall be possible for the inverter to continue operation taking power from the rectifier. The input filter of the inverter shall be suitably designed to take care of this operational requirement.
- 4.19 It shall be possible to vary the output voltage step lessly within  $\pm 5\%$  of the specified output voltage. This adjustment shall be possible to be made when UPS is in operation.
- 4.20 UPS system shall be suitable for both floating output and earthing of one leg in case of single phase system / star-point in case of three phase system.
- 4.21 The UPS system shall have very high system of reliability having minimum MTBF of 50,000 hrs. Vendor shall furnish the value of MTBF, MTTR & availability factor.

## **5.0 CONSTRUCTIONAL DETAILS**

- 5.1 The equipment shall preferably be supplied in enclosed, dust & vermin proof, floor mounted, sheet steel enclosure. In case, it is necessary to provide opening for ventilation, this should be closed by fine mesh. Minimum degree of protection for enclosure shall be IP-43 as per IS/IEC-60947.
- 5.2 Enclosure shall be fabricated with cold rolled sheet annealed steel of minimum thickness 2.0 mm.
- 5.3 The door hinges shall be concealed type. The doors and the removable covers shall be provided with non-deteriorating neoprene gaskets without any discontinuities. Gaskets shall be held in position in groove in shaped sheet steel work or these shall be of U type.
- 5.4 All external hardware shall be cadmium plated steel. Hardware for fixing the removable parts shall be provided with retaining devices.
- 5.5 Panels shall be liberally designed. All components shall be so mounted that they are easily accessible for inspection and maintenance.
- 5.6 UPS unit shall preferably have separate panels for each rectifier inverter units, bypass supply, distribution boards etc. Various panels of UPS except distribution boards shall be mounted side-by-side & bolted together to form compact assembly.
- 5.7 Distribution boards shall be of fixed type single front execution in fully compartmentalised design and divided into distinct panels each comprising of bus-bar chambers, individual feeder modules and vertical cable alley.
- 5.8 Mounting height of components requiring operation and observations shall not be lower than 300 mm and higher than 1800 mm.
- 5.9 All the live parts which are accessible after opening the front cover / back cover shall be properly insulated or provided with insulating barrier to prevent accidental contact. Bus bars of distribution boards shall be PVC sleeved.
- 5.10 Nameplate consisting of black Perspex with white engraving shall be provided for each panel and for each equipment mounted on the front of the panel. Suitable label identification for each component mounted inside the panel shall also be provided.
- 5.11 All the wirings shall be properly laid and ferruled at both ends. PVC channels may be used for wiring. For control wiring, minimum 1.5 sq. mm copper conductor shall be used.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - UPS SYSTEM	PC288-TS-0802	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 6 of 11		

- 5.12 The power connections shall be made by PVC insulated flexible copper cables or taped copper / aluminium strip.
- 5.13 All power & control cables shall enter from the bottom.
- 5.14 Removable bolted aluminium gland plate, heavy duty compression type rolled aluminium cable glands, crimping type aluminium cable lugs for Al. cables and copper cable lugs for Cu. cables, pressure clamp / bolted type terminals etc. shall be provided for each incoming and outgoing cable.
- 5.15 Terminal blocks shall be grouped according to circuit functions and suitably numbered. 20% extra terminals shall be provided in the terminal block.
- 5.16 A suitably sized earth bus shall be provided at the bottom of panel with provision for earth connection at both ends to purchaser's earth grid.
- 5.17 All panels shall be of same height so as to form a bank which shall give good aesthetic appearance.

## 6.0 COMPONENT DETAILS

- 6.1 All components shall conform to relevant IS / IEC standards and shall be of reputed make. Makes of all components shall be subject to owner's / consultant's approval.

### 6.2 Thyristors, diodes and transistors

The thyristors, diodes and transistors shall have adequate safety margins to withstand specified operating conditions. A factor of safety of minimum 4 shall be taken against voltage surges.

### 6.3 PCBs

All electronic control & monitoring printed circuit cards shall preferably be modular plug in type. Monitoring points shall be provided in each of the PCB, PCBs shall be firmly clamped in position so that vibration or long usage does not result in loose contacts. Failure of each PCB shall be indicated by visual alarm and indication. The visual fault diagnostic shall preferably indicate fault into various sections of the card.

### 6.4 Transformers and Chokes

All transformers and chokes shall be of dry type and air cooled. This shall be class 'H' insulated, vacuum impregnated. Class B insulated cast resin transformers and chokes shall be also acceptable.

### 6.5 Electrolytic Capacitors

These shall be polarised aluminium type I, suitable for long life and category I, as per IS-4317 or equivalent IEC. The capacitor shall preferably be self healing type. These shall be so located in inverter panels that the operating temperature does not exceed 65°C maximum.

### 6.6 Instruments

Ammeters & voltmeters shall be moving coil type of class 1.5 accuracy as per IS-1248. These shall be flush mounting type of minimum size of 96 mm x 96 mm and shall have taut band scale of 240°. Frequency meter shall be of reed type having range of 45 Hz to 55 Hz.

### 6.7 Static Switches

Static switches shall be naturally commutated type with parallel inverse connected thyristors. These shall be rated for continuous duty for 100% load. Short time rated static switches are not acceptable.

### 6.8 Voltage Stabilizer

Voltage stabilizer shall be static type and shall satisfy the following requirements:

- i) Maximum output voltage variation under steady state condition shall be  $\pm 3\%$ .
- ii) Maximum harmonic distortion shall be less than 5%.
- iii) The output voltage shall be restored within  $\pm 2\%$  of nominal value in less than 2 secs.

#### 6.9 **Battery**

Battery along with accessories shall conform to Engineering Standard ES-0814.

#### 6.10 **Indication Lamps**

All indication lamps shall be of LED type suitable for the specified control voltage, having minimum illumination of 40 milli candela. The colour of the LEDs shall be as follows:

ON	:	Red
OFF	:	Green
FAULT	:	Yellow

#### 6.11 **Moulded Case Circuit Breakers**

For isolating devices of various equipment, moulded case circuit breakers shall be used. These shall be provided with overload and short circuit protective devices and shall conform to IS 2516.

### 7.0 **OPTIONAL ITEMS**

These shall supplied as per requirement.

#### 7.1.1 **Monitoring System** Microprocessor based monitoring system for UPS to supervise the UPS operation and to print out the following data at a preset time automatically by using its own printer shall be provided.


- i) Output voltage of UPS (Common)
- ii) Output current of UPS (Common)
- iii) Input DC voltage of each inverter
- iv) Input voltage of each rectifier (Ph to Ph)
- v) Input current of each rectifier
- vi) Output current of each inverter
- vii) Output voltage of each inverter
- viii) Room temperature
- ix) Input frequency of each inverter
- x) Output frequency of each inverter

#### 7.1.2 In addition to print out once in a preset time, above data shall also be automatically printed for the following conditions:

- i) Power source change over from mains to battery and vice-versa.
- ii) Change over of load from UPS to bypass supply and vice versa.
- iii) On failure of UPS
- iv) On failure of either inverter
- v) Also facility for on demand print out of above data shall be provided.

#### 7.1.3 On failure of UPS, the printer shall print out the waveform of the following:

- i) Output voltage of UPS

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - UPS SYSTEM	PC288-TS-0802	0	 श्री एच डी एल 
		Document No.	Rev	
		Sheet 8 of 11		

- ii) Output current of UPS
- iii) Output voltage of each UPS
- iv) Output current of each UPS

## 7.2 **Insulation monitoring & automatic earth fault finding system**

Insulation monitoring and automatic earth fault finding system shall be provided to detect earth fault in unearthed system. The system shall preferably be of the type which injects a low frequency alternating voltage between the earth and the network which is used for determining the insulation resistance and to detect and locate earth faults. There shall be fixed detectors located in incoming feeders of main distribution boards and portable detector for location of fault within a feeder. The fixed detector shall be connected to a central unit which can display a faulty feeder.

## 7.3 Potential free contact shall be brought to outgoing terminal for remote monitoring system for the following:

- i) UPS-1 fault
- ii) UPS-2 fault
- iii) Load on inverter
- iv) Load on bypass

## 8.0 **PAINTING**

### 8.1 The enclosure after suitable pre-treatment shall be painted with two coats of anti-rust paint followed by two coats of anticorrosive paint.

### 8.2 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

### 8.3 Unless otherwise specified, the finishing shade shall be light grey shade no.631 as per IS: 5.

### 8.4 Electrostatic powder paint shall be preferred.

## 9.0 **TESTS AND INSPECTION**

### 9.1 The UPS units shall be subjected to tests as per relevant standards. The tests shall include, but not limited to the following:-

- i) Rectifier & inverter soft starting
- ii) Regulation test
- iii) Heat run test for 8 hours
- iv) Overload test
- v) Test for changeover time in synchronised and desynchronised mode.
- vi) Test for dynamic response and transient performance
- vii) Sequence & transfer test
- viii) Noise level measurement
- ix) Test to check the selectivity of protective devices
- x) Alarm test (simulation of various fault conditions)
- xi) Measurement of harmonic distortion
- xii) Ventilation test (operation without fan)

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - UPS SYSTEM	PC288-TS-0802	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 9 of 11		

xiii) Insulation test

xiv) Current division in parallel UPS

9.2 All the above tests shall be carried out in presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and site inspection.

9.3 These inspections, shall, however, not absolve the vendor from his responsibility for making good any defects which may be noticed subsequently.

## 10.0 DRAWINGS AND DOCUMENTS

10.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

10.2 All drawings and documents shall have the following description written boldly.

- Name of client
- Name of consultant
- Enquiry / order number with plant / project name
- Equipment Code no. & Description

## 11.0 SPARES

11.1 Commissioning Spares: Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval.

11.2 Spares for 2 Years operation (Mandatory), as specified shall be supplied.

11.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.

11.4 All spare parts shall be identical to the parts used in the equipment

## 12.0 PACKING


12.1 The board shall be properly packed before despatch to avoid damage during transport, storage and handling.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

12.3 A sign to indicate the upright position of the panels to be placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.

## 13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - UPS SYSTEM	PC288-TS-0802	0	 श्री अर्घ्य डी एल 
		Document No.	Rev	
		Sheet 10 of 11		

### ANNEXURE - I


#### DOCUMENTATION FOR UNINTERRUPTED POWER SUPPLY

Sl. No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification sheet	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	Block Diagram	N	Y	Y
4.	General Arrangement drawings and foundation plan	N	Y	Y
5.	Calculation for battery sizing	N	N	N
6.	Feeder Details for Distribution Boards	N	Y	Y
7.	Descriptive literature and catalogues	N	N	Y
8.	Bill of materials	N	Y	Y
9.	Schematic & Wiring Diagram	N	Y	Y
10.	Installation, operation & maintenance manual	N	N	Y
11.	Spare parts list with identification	N	N	Y
12.	Test Certificates	N	N	Y
13.	Guarantee certificates	N	N	Y

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N – No

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - UPS SYSTEM	PC288-TS-0802	0	 श्री अमृत कर्म Coal India	 बी एच ई एल BHEL
		Document No.	Rev		
		Sheet 11 of 11			

## ANNEXURE – II

### METERING INDICATIONS AND ALARM SCHEDULE

#### A. METERING

1. Incoming Voltmeter with selector switches for each incomer
2. Ammeter with selector switches for each incomer
3. Ammeter & Voltmeter at each inverter output and bypass output.
4. Frequency meter & power factor meter at one common point of output
5. Ammeter & Voltmeter at incoming of each UPS distribution boards
6. Ammeter at each rectifier output
7. Battery charge / discharge meter

#### B. LED INDICATION

1. A.C. Mains 'ON'
2. Rectifier output 'ON'
3. Load on inverter
4. Load on bypass
5. Inverter synchronised to mains
6. Battery on float
7. Battery on boost
8. Fault (one lamp for all types of fault)

#### C. AUDIO-VISUAL ALARM (with Accept, Reset & Test facilities)

1. Mains failure
2. Rectifier failure
3. Inverter output over voltage
4. Inverter output under voltage
5. Inverter fuse failure
6. Rectifier fuse failure
7. Fan failure
8. Inverter temperature high
9. Static switch failure
10. Bypass input failure
11. Inverter desynchronised

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – POWER TRANSFORMER	PC288-TS-0803	0	 बो एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 1 of 24		

# **TECHNICAL SPECIFICATION** **POWER TRANSFORMERS**

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – POWER TRANSFORMER	PC288-TS-0803	0	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 2 of 24		

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	GENERAL DESIGN FEATURES
6.0	CONSTRUCTIONAL FEATURES
7.0	FITTINGS
8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	DRAWINGS AND DOCUMENTS
11.0	SPARES
12.0	PACKING
13.0	DEVIATIONS
ANNEXURE - I	LIST OF FITTINGS
ANNEXURE - II	DOCUMENTATION FOR TRANSFORMERS



<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – POWER TRANSFORMER</div>	PC288-TS-0803	0	<div> बो एच आई एल </div>
		Document No.	Rev	
		Sheet 3 of 24		

## 1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, manufacture, testing at works and despatch in well-packed condition of Power Transformers.
- 1.2 This standard shall be applicable for 3 phase, core type, separate winding power transformers of rating 315 KVA and above.
- 1.3 This standard shall be read in conjunction with the relevant part of Design Philosophy – Electrical.

## 2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of IS 2026, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.
- 2.2 The design and operational features of the equipment offered shall comply with the provisions of the latest issue of the Indian Electricity Rules and other relevant Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.
- 2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

## 3.0 SERVICE CONDITIONS

### 3.1 Ambient Conditions

These shall be as indicated in Design Philosophy – Electrical.

### 3.2 System Details

These shall be as indicated in Design Philosophy – Electrical.

## 4.0 OPERATING REQUIREMENTS

- 4.1 The transformer shall be suitable for operating at the rated capacity continuously at any of the taps, under the ambient conditions and with the voltage and frequency variations without exceeding the permissible temperature rise and without any detrimental effect on any part.
- 4.2 The transformer shall also be capable of delivering rated current at a voltage equal to 105 % of the rated voltage.
- 4.3 The maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be such that under 10 per cent continuous over voltage condition it does not exceed 1.9 Tesla at any tap position.
- 4.4 The transformer shall be capable of allowing at least three consecutive starts of the largest Squirrel Cage Induction Motor, while delivering 85% of its rated power without any harmful effect on its insulation. It shall be possible to repeat the starting cycle once in eight hours.
- 4.5 The transformer shall be designed to be loaded as per IS 6600.
- 4.6 The transformer shall be so designed as to operate in parallel satisfactorily with similar transformers.

## 5.0 GENERAL DESIGN FEATURES

- 5.1 Transformers shall be built under strict quality assurance procedures to comply with IEC 60076 and or IEC 60726 and shall have a guaranteed life time of 30 years.
- 5.2 Transformers shall be suitable for continuous operation at full load for at least 30,000 hours without maintenance requiring the transformer to be de-energized
- 5.3 The design of the transformers shall be in accordance with the latest practice.
- 5.4 **Rated Voltage, Frequency and Phase Connection**  
These shall be as indicated in Design Philosophy – Electrical.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – POWER TRANSFORMER	PC288-TS-0803	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 4 of 24		

- 5.5 The transformer shall be so designed that it is capable of operation at 125% rated voltage for a period of one minute and 140% rated voltage for a period of five seconds due to sudden load throw off.
- 5.6 Transformer shall be capable of withstanding thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any winding.
- 5.7 Transformers shall withstand, without injurious heating, combined voltage and frequency fluctuations which produce the following over fluxing conditions:
- 110% for continuous operation
  - 125% for 1 - minute
  - 140% for 5 – seconds

#### 5.8 Tap Changing Gear

- 5.8.1 Each transformer shall be provided with on-load/ off-circuit tap changing equipment on the high voltage winding with taps. It shall be mounted on one side, in an easily accessible position.
- 5.8.2 The range of tap changer shall be as indicated and arranged in steps of 2.5%.
- 5.8.3 The off-circuit tap changing shall be affected by an externally operated handle capable of being padlocked in any position and provided with tap position indicator and mechanical stops at the extreme positions.
- 5.8.4 For transformer specified with on-load tap changer, tap changing gear shall be complete with tap position indicator, limit switch, lock and key and necessary control panel. Provision shall be made for auto-manual operation. The manual operation shall be possible both from the panel as well as from field. In case the tap changer is located in a separate housing, the housing shall be connected with the conservator for oil connection. A separate buchholz relay shall be provided in such a case. Emergency mechanical manual device shall also be provided. A minimum of 2 lakh trouble-free operations shall be guaranteed.

#### 5.9 On-Load Tap-Changing Mechanism (O.L.T.C.)

- 5.9.1 For transformer specified with on-load tap changer, high speed tap changing gear shall be complete with tap position indicator, limit switch, lock and key and necessary control panel. Provision shall be made for auto-manual operation. In case the tap changer is located in a separate housing, the housing shall be connected with the conservator for oil connection. A separate buchholz relay shall be provided in such a case. Emergency mechanical manual device shall also be provided. A minimum of 2 lakh trouble-free operations shall be guaranteed. The OLTC gear shall have diverter resistance and the current diverting contacts shall be housed in a separate oil chamber segregated from the main tank of the transformer.
- 5.9.2 Transformer shall be provided with an on-load tap changing mechanism, as required. This shall be designed suitable for remote control operation from switch boards in the control room in addition to being capable of local manual as well as local electrical operation.
- 5.9.3 It shall not be possible to use the electric drive when manual gear is in use and it shall be possible to use only one electrical control at a time. Operation of the local or remote control switches shall cause one tap movement only until the control switch is returned to the off position for the next operation.
- 5.9.4 The local electrical control switches shall be mounted in the outdoor cubicle.
- 5.9.5 The equipment shall be so arranged as to ensure that when a tap change operation has been commenced it shall be completed independently of the operation of the control relays and switches. If a failure of the auxiliary supply during a tap change or any other contingency result in that movement not being completed, adequate means shall be provided to safeguard the transformer and its auxiliary equipment from damage. Supervisory indication shall be provided to indicate "The change incomplete" foul.

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – POWER TRANSFORMER</div>	<div>PC288-TS-0803</div>	<div>0</div>	<div> श्री एम डी एल <b>BHEL</b></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 5 of 24</div>		

- 5.9.6 Limit switches may be connected in the control circuit of the operation motor provided that a mechanical de-clutching mechanism is incorporated. Otherwise it shall be directly connected to the operating motor circuit and mechanical stop provided.
- 5.9.7 Thermal devices or other means shall be provided to protect the motor and control circuits. All relays switches, fuses etc. shall be mounted in the marshalling box and shall be clearly marked to indicate their purpose.
- 5.9.8 The whole of the apparatus shall be of robust design and capable of giving satisfactory service without undue maintenance under the conditions to be met in service, including frequent operation.
- 5.9.9 A five-digit counter shall be fitted to the tap changing mechanism to indicate the number of operations completed by the equipment.
- 5.9.10 A permanently legible lubrication chart shall be fitted within the driving mechanism chamber.
- 5.9.11 The On-Load Tap Changer shall include the following :-
- An oil immersed tap selector and arcing switch or arc-suppressing tap selector, provided with resistor for reduction of make and break arcing voltage, overload and short circuits.
  - Motor driven mechanism.
  - Control and Protection devices.
  - Local and remote tap-changer position indicator.
  - Manual operating device.
- 5.9.12 The on-load tap changer shall be designed so that the contacts shall not interrupt arc within the main tank of the transformer. The tap selector and arcing switch or arc suppressing tap selector switch shall be located in one oil filled compartment. The compartment shall be provided with a means of releasing the gas produced by the arcing. It shall be designed so as to prevent the oil in the tap selector compartment from mixing with the oil in the transformer tank.
- 5.9.13 The oil in those compartments of the main tap-changing apparatus which do not contain contacts used for making or breaking current shall be maintained under conservator head by means of an adequate diameter pipe corresponding dia of OLTC oil surge relays connection from the highest point of the chamber connection corresponding to the dia. of OLTC oil surge relay from the highest point of the chamber to the conservator. This connection shall be controlled by a suitable valve and shall be arranged so that any gas leaving the chamber will pass into the gas and oil actuated relay.
- 5.9.14 The tap changer shall be capable of permitting parallel operation with other transformers for which necessary wiring and accessories, if any, shall be provided.
- 5.9.15 The centre of manual operating device shall be located at a height of 1500 mm from rail top so that it can be operated by a person standing at the ground level. The arrangement shall be strong and robust in construction. The transformer shall give full load output on all tap positions.
- The mechanism shall be complete with normal accessories including at least the following:-
- A mechanical tap position indicator (Rated tap voltages shall be marked on the diagram plate).
  - A mechanical operation counter.
  - Mechanical stops to prevent over cranking of the mechanism beyond extreme tap positions.
- 5.9.16 The control scheme for the tap changer shall be provided for independent control of the tap changers when the transformers are in independent service. In addition, provision shall be made to enable parallel operation control also at time so that the tap changer will be operated simultaneously when one unit is in parallel with another will not become out of step and this will eliminate circulating current.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – POWER TRANSFORMER	PC288-TS-0803	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 6 of 24		

Additional features like Master / Follower and visual indication during the operation of motor shall also be incorporated.

Control circuit shall incorporate the following:

- a) Local/remote manual electrical operation.
- b) Device to ensure a positive and full completion of tap change once it is initiated even if there is loss of power.
- c) An interlock to cut-off electrical control automatically upon recourse being taken to manual mechanical control in emergency.
- d) Electrical interlock to cut-off a counter impulse for a reverse tap change, being initiated during a progressive tap change and until the mechanism comes to rest and resets circuits for a fresh operation.
- e) All auxiliaries and devices for electrical control of OLTC gear should be housed in a weather-proof cabinet mounted on the transformer and shall include:
  - Local tap position indicator
  - 5 digit operation counter
  - Cubicle lighting
  - Thermostatically controlled space heater.
  - Miniature circuit breaker with magnetic and thermal overload devices for controlling the incoming supply to the OLTC motor.
  - Padlocking arrangement for the hinged cabinet door.
  - Removable plate with cable glands.
  - Inside tag with control scheme indelibly marked.

5.9.17 Necessary interlock, blocking independent control when the units are in parallel, shall be provided.

5.9.18 Under abnormal conditions such as may occur if the contactor controlling one tap changer sticks, the arrangement must be such as to switch off supply to the motor so that an out of step condition is limited to one tap difference between the units. Details of out of step protection provided for the taps should be furnished in the bid.

5.9.19 The contactor and associated gear for the tap change driving motors shall be housed in a local kiosk mounted adjacent to the transformer. The motors shall be suitable for operation on 230 V single phase or 3-phase 440 V, 50 cycle external power supply. The kiosk having space heater, shall be dust and vermin proof and suitable protected against corrosion or deterioration due to condensation, fungi etc.

5.9.20 Indoor cubicle (RTCC panel) shall be provided in the control room which shall contain :

- a) Indication of the transformer ratio in use on each transformer and the number designating the tap in use by means of digital type indicators.
- b) Raise and lower push Button switch and AVR Relay.
- c) Independent/Master/Follower selector switch.
- d) Remote tap position indicator with indicating lamp.
- e) Repeater dial of winding temperature indicator for remote indication with a device for indicating hottest spot winding temperature in addition to a pointer to register the highest temperature reached.
- f) An indication lamp showing tap change in progress.
- g) Necessary audible and visual alarms.
- h) Pressure relief device operation alarm.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – POWER TRANSFORMER	PC288-TS-0803	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 7 of 24		

- i) Out of step relay with two spare contacts (2 NC and 2 NO).
- j) The remote indoor cubicle in addition to the above indications shall also have the following trip and non-trip alarm windows facias with 5 spare windows suitable for 110V DC supply.
  - i. Oil Temperature alarm
  - ii. Winding Temperature alarm
  - iii. Winding temperature trip
  - iv. Buchholz alarm
  - v. Buchholz trip
  - vi. Sudden Pressure trip (Main tank)
  - vii. Surge Relay trip (OLTC Gear)
  - viii. Tap changer out of step alarm
  - ix. Low oil level alarm
  - x. Cooling fans working indication
  - xi. Oil pumps on and off indication
  - xii. Failure of group of fans alarm
  - xiii. Failure of group of oil pumps alarm
  - xiv. Failure of supply
  - xv. Oil flow alarm

Each relay for tripping function shall have two normally open and two normally closed contacts for connection.

#### 5.9.21 Remote Electrical Group Control

The OLTC control scheme offered shall have provision of remote electrical group control during the parallel operation of transformer. This is in addition to independent control of OLTC:

- i) A four position selector switch having Master, Follower, Independent and Off position shall be provided in the remote OLTC control panel for each transformer.

This shall be wired to enable operator to select operation of OLTC in Master, Follower or Independent mode.

- ii) Out of step relays with timer contacts shall also be provided to give alarm and indication in case tap position in all the transformers under group control are not in same position.

#### iii) **Master Position**

If the selector switch is in Master position, it shall be possible to control the OLTC units in the follower mode by operating the controls of the master unit. Independent operation of the units under Follower mode shall have to be prevented. However the units under independent mode will be controlled independently.

#### iv) **Follower Position**

If the selector switch is in Follower mode, control of OLTC shall be possible only from panel of the Master unit.

#### v) **Independent Position**

In this position of Selector Switch, Control of OLTC of individual unit shall only be possible

5.9.22 The OLTC shall be provided on the conservator side of the Power Transformer and not in front of H.V. Bushings.

5.9.23 OLTC shall be suitable for bi-directional power flow.



<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – POWER TRANSFORMER</div>	PC288-TS-0803	0	<div> बी एच ई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 8 of 24		

#### 5.10 Impedance Voltage

The impedance voltage of the transformer at 75°C shall be as per relevant IS / IEC. This shall be guaranteed within limits specified in relevant IS / IEC at principal tap position.

#### 5.11 Losses

The losses under the full load condition, at the rated voltage and frequency shall be indicated by the vendor at 75°C. These shall be guaranteed within the tolerable limits specified in IS: 2026 at principal tap position. The purchaser has the right to impose penalty charges or reject the transformer in case of any difference in the test and guaranteed values.

For upto 2 MVA transformer losses shall be as per energy efficiency level-3 of latest IS 1180.

#### 5.12 Temperature Rise

The temperature rise of the winding, oil and core shall not exceed the values specified in IS: 2026 when the transformer is delivering its rated output continuously under the service conditions.

#### 5.13 Insulation Level

All windings up to maximum system voltage of 72 KV shall have uniform insulation to earth. For windings having higher maximum system voltage, graded insulation is acceptable.

#### 5.14 Terminal Arrangements

The HV and LV side terminal arrangement shall be provided as required. Disconnecting link chambers shall be provided on the transformer primary side in all cases as well as on secondary side, except where the termination is through bus duct. The disconnecting chambers shall be oil filled, preferably connected with the main tank through an isolating valve and also provided with a drain valve. However for system not exceeding 11 KV, air filled disconnecting chamber may be accepted. Suitable cable end box complete with cable glands and lugs shall be provided for termination of cables. Gland plate for single core cables shall be non-magnetic.

5.15 The transformer shall be able to withstand the electro-dynamic and thermal stresses due to terminal short circuit of the secondary, assuming the primary side fed from an infinite bus. All leads and windings in cores shall be properly supported, clamped and tightened after vacuum drying to ensure the short circuit withstand capacity. The short circuit withstand duration shall be 3 Secs.

5.16 The short circuit test results for similar transformers shall be furnished.

5.17 The transformer shall be so designed as to minimise any undue noise and vibration.

The noise level shall be limited to the value specified by latest NEMA Standard / CBIP.

5.18 Due attention shall be given in the design for the suppression of harmonics.

#### 5.19 Cooling System

5.19.1 The cooling system shall be provided as required. In case the transformer is designed for two types of cooling, the output rating for each type shall be indicated in the offer. The minimum acceptable output shall be 70% of rated output when forced type of cooling system is not in operation.

5.19.2 Wherever ONAF Cooling is specified, the cooling fans shall be adequately rated and shall be suitable for auto/manual and local/remote operation. Auto operation shall be through winding temperature indicator contact..

5.19.3 Transformer shall have multiple cooling units with standby cooling units.

5.19.4 Cooling fans for each radiator bank shall be housed in fan box to prevent ingress of rain water. Each fan shall be suitably protected by galvanized wire mesh guard. It shall be possible to remove the cooling fan with motors without disturbing and dismantling the cooler structural frame work.

5.19.5 Where OFAF cooling is applicable, two numbers of centrifugal oil pumps shall be used. Measures shall be taken to prevent mal-operation of Buchholz relay or sudden pressure relay when all oil pumps are simultaneously put into service. The pumps shall be so designed that

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – POWER TRANSFORMER	PC288-TS-0803	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 9 of 24		

on failure of power supply to the pump motor, the pump impeller will not limit the natural circulation of oil.

- 5.19.6 Cooling fans and oil pump motors shall be of squirrel cage, totally enclosed whether proof type suitable for operation on 400 volts, three phase, 50 Hz power supply. All motors having ball and roller bearings and grease lubricators shall be fitted with hexagonal nipples conforming to relevant Indian Standard.
- 5.19.7 An oil flow indicator with alarm contacts shall be provided for the confirmation of the oil pump operating in a normal state. An indication shall be provided on the control panel to indicate that the pump is running.
- 5.19.8 The coolers and theirs accessories shall be hot dip galvanized or corrosive resistant painted.
- 5.19.9 The supporting arrangement for the cooler units or for radiator banks shall be in such a manner that the stresses if developed, shall not be transferred to the flanges of the butterfly valves.
- 5.19.10 The shut off valves shall be provided on the tank at each point of connection of cooler units radiators to the transformer tank. Removable blanking plates shall be provided to permit blanking off the oil connection to cooler radiators.
- 5.19.11 All valves shall be of gun metal or cast steel or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall be opened by turning counter clock-wise when facing the hand wheel.
- 5.19.12 Means shall be provided for pad locking of valves in the open and closed position.
- 5.19.13 Every valve shall be provided with indicator to show clearly the position of the valve whether open or closed.
- 5.19.14 All valves shall be provided with flanges having machined faces.
- 5.19.15 The drilling of valve flanges shall comply with the requirements of IS:3639.

## 5.20 CONTROL OF COOLER OPERATION

- 5.20.1 Each motor or group of motors shall be provided with an electrically operated contactor and with control gear of suitable design both for starting and stopping the motor manually and also automatically from the contacts on the winding temperature indicating device as specified. Additional terminal for remote manual electrical control of motors shall be provided. Overload and single phasing protection shall be provided. HRC fuses shall be provided for short circuit protection. This equipment shall be accommodated in the marshalling box. The power supply shall be adequately and properly fused.
- 5.20.2 Where small motors are connected in groups, the group protection shall be arranged so that it operates satisfactorily in the event of a fault occurring on a single motor.
- 5.20.3 Where fans and oil pumps are provided, the connection shall be arranged as to allow the motors or groups of motors to be started up and shutdown either collectively or individually.
- 5.20.4 All motor contactors and their associated apparatus shall be capable of holding in and operating satisfactorily and without over heating for a period of ten minutes if the supply voltage falls for that period, to 75% of normal value and at normal frequency. The motor contactors and associated apparatus shall be capable of normal operation with a supply voltage of 85 % of the normal value and at normal frequency.
- 5.20.5 All contacts and other parts which may require renewal, adjustment or inspection shall be readily accessible.
- 5.20.6 The control arrangements are to be so designed as to prevent the simultaneous starting of motors of total rating of more than 20 HP where such an eventually may arise, two step operation shall be preferred.
- 5.20.7 Alarm indication for failure of group of fans and oil pump shall be provided.
- 5.20.8 Alarm indication shall be provided to indicate failure of power supply.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – POWER TRANSFORMER</b>	PC288-TS-0803	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 10 of 24		

5.20.9 Provision in the cooler control circuit may be made such that tripping of transformer breaker on Differential or Sudden Pressure should lead to supply disconnection to motor of the cooler pump.

## 6.0 CONSTRUCTIONAL FEATURES

### 6.1 Core

6.1.1 The transformer core shall be of high grade, non-ageing, electrical silicon cold rolled magnetic sheet steel of low hysteresis loss and high permeability. The maximum flux density in any part of the core and yoke at rated voltage and frequency shall not exceed 1.7 Tesla. The core structure shall be securely grounded to prevent electrostatic potential. Lifting eyes and lugs shall be provided on the limbs and coils assembly. Preferably no bolt shall be used in the cores. Clamping shall be done external to the limb. Bolts passing through the yoke, if any, shall be insulated for 2 KV for transformers rated up to 33 KV and 5 KV for higher voltage ratings (rms) for 1 minute.

6.1.2 The temperature of the core shall not exceed that permitted in IS.

6.1.3 The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angles to the plane of laminations which may cause local heating. The temperature of any part of the core or its support structure in contact with oil shall not exceed 120 deg C under normal operating condition and 130 deg C under most extreme operating condition. Adequate temperature margin shall be provided to maintain longer life expectancy for this material.

6.1.4 Core and winding shall be capable of withstanding the shock during transport, installation and service. Adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

6.1.5 All steel sections used for supporting the core shall be thoroughly sand blasted after cutting, drilling and welding.

6.1.6 Each core lamination shall be insulated with a material that will not deteriorate due to pressure and hot oil.

6.1.7 The supporting frame work of the core shall be so designed as to avoid presence of pockets which would prevent complete emptying of tank through drain valve or cause trapping of air during oil filling.

6.1.8 Adequate lifting lugs will be provided to enable the core and windings to be lifted.

6.1.9 The core shall be earthed to the core clamping structure at one point only, through a removable external link suitably located and protected to facilitate testing after installation of the transformer.

6.1.10 In case core laminations are divided into sections by insulating barriers or cooling ducts parallel to the plane of the lamination, tinned copper bridging strips shall be inserted to maintain electrical continuity between sections.

6.1.11 A drawing furnishing the details of the internal earthing design shall be included in the manual

### 6.2 Tank

6.2.1 The tank shall be made of good commercial grade low carbon steel plate of adequate thickness capable of withstanding stress not less than 0.40 kg/cm<sup>2</sup>, properly welded and gusseted to ensure a rigid construction. It shall also be able to withstand normal transportation shocks without any deformation and shall be capable of withstanding following vacuum.

Highest System Voltage	MVA Rating	Vacuum in mm of Hg
Up to 72 KV	Up to 1.6	250
	Above 1.6 to 20	500
	Above 20	760



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – POWER TRANSFORMER	PC288-TS-0803	0	 कोई एच आई एल 
		Document No.	Rev	
		Sheet 11 of 24		

Above 72 KV

For all Ratings

760

- 6.2.2 For outdoor transformer, the top of the tank, the marshalling box and the headers of radiators, shall be of such a construction so as to prevent accumulation of water.
- 6.2.3 Guides shall be provided to facilitate tanking and untanking of the core with the coil assembly. The details of anchoring of core and coil assembly of the tank shall be furnished.
- 6.2.4 Radiators, where necessary, shall be provided on the tank to facilitate cooling. These shall be detachable type and shall be provided with isolating valves at ends, drain plug and air release plug. The radiators shall be fabricated out of minimum 1.25 mm thick seamless steel tubing or pressed sheet steel. For sizes up to 500 KVA, cooling tubes shall be acceptable.
- 6.2.5 Each tank shall be provided with:
- Lifting lugs suitable for lifting the equipment complete with oil.
  - A minimum of four jacking pads in accessible position to enable the transformer complete with oil to be raised or lowered using hydraulic jacks. Each jacking pad shall be designed to support with an adequate factor of safety for at least half of the total mass of the transformer filled with oil allowing in addition for maximum possible misalignment of the jacking force to the centre of the working surface.
  - Suitable haulage holes shall be provided.
- 6.2.6 The tank shall be designed in such a way that it can be mounted on the rollers.
- 6.2.7 The base of each tank shall be so designed that it shall be possible to move the complete transformer unit by skidding in any direction without injury when using plates or rails.
- 6.2.8 All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression. All gasketed joints shall be designed, manufactured and assembled to ensure long-term leak and maintenance free operation. Groove provided to accommodate round nitrile rubber cord for rectangular openings shall be milled.
- 6.2.9 The transformer shall be mounted on rollers, as per manufacturer's standard practice.
- 6.2.10 The roller mounted transformers are to be provided with flanged bi-directional wheels and axles. This set of wheels and axles shall be suitable for fixing to the under carriage of transformer to facilitate its movement on rail track. Suitable locking arrangement along with foundation bolts shall be provided for the wheels to prevent accidental movement of transformer.
- 6.2.11 The rail track gauge shall be 1676 mm.
- 6.2.12 To prevent transformer movement during earthquake, suitable clamping devices shall be provided for fixing the transformer to the foundation.
- 6.2.13 The tank cover shall be designed to prevent retention of rain water and shall not distort when lifted. The internal surface of the top cover shall be shaped to ensure efficient collection and direction of free gas to the buchholz relay.
- 6.2.14 At least one adequately sized inspection openings shall be provided in the transformers for easy access to bushings and earth connections. The inspection covers shall not weigh more than 25 kg. Handles shall be provided on the inspection cover to facilitate lifting.
- 6.2.15 The tank covers shall be fitted with pockets at the position of maximum oil temperature at maximum continuous rating for bulbs of oil and winding temperature indicators. It shall be possible to remove these bulbs without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.
- 6.2.16 Bushing turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – POWER TRANSFORMER</b>	PC288-TS-0803	0	
		Document No.	Rev	
		Sheet 12 of 24		

6.2.17 All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression. All gasketed joints shall be designed, manufactured and assembled to ensure long-term leak and maintenance free operation. Groove provided to accommodate round nitrile rubber cord for rectangular openings shall be milled.

6.2.18 The maximum temperature on any metal part shall not exceed 130 deg. Celsius.

6.2.19 Seamless pipe shall be used upto 80mm confirming to IS 1978 & IS 1979, ERW mild steels pipes as per IS 1239 (Part 1) medium shall be used for  $\geq 100$ mm and IS 3589 for 150mm. Non-magnetic Stainless-steel materials used shall conform to IS 6911 or ISO 683-13 or EN 10088-2 or AISI 304L or ASTM A240 or J4(S20430 Modified).

### 6.3 Windings

6.3.1 Each coil shall be made out of paper insulated electrolytic grade copper conductor. Similar coils shall be interchangeable. Successive coils of a winding shall be connected by accessible joints and shall be brazed and finished smooth to prevent abrasive damage to insulation. There shall be no sharp bends in the connecting leads to prevent corona discharge. Aluminium foil wound transformer will also be acceptable.

6.3.2 Immediately after winding process, it shall be vacuum dried, dimensionally pre-stabilized and oil impregnated before next process.. The insulation resistance and polarization index of the winding measured after impregnation shall be furnished in the test certificate.

6.3.3 The magnitude of impulse surges transferred from HV to the LV winding by inductive and capacitive coupling shall be limited to a value below the rated impulse strength of the LV winding. The impulse voltage test results and surge distribution on windings for similar transformer shall be furnished.

6.3.4 The manufacture shall ensure that windings are made in dust proof, Positive pressure, Desert Climate environment. Movement of windings and active part shall be done on air-castors to prevent shocks and abnormal jerks.

6.3.5 Winding clamping arrangement shall distribute the clamping forces evenly over the ends of the windings. All insulating materials and structures shall be protected from contamination and the effects of humidity during and after fabrication, and after receipt, by storing them in a separate, climate-controlled area.

### 6.4 Insulating Oil

6.4.1 The insulating oil shall be virgin high grade inhibited, conforming to IEC-60296 & all parameters specified below, while tested at supplier's premises. The contractor shall furnish test certificates from the supplier against the acceptance norms as mentioned below, prior to dispatch of oil from refinery to site. Under no circumstances, poor quality oil shall be filled into the transformer and only thereafter be brought up to the specified parameter by circulation within the transformer.

6.4.2 At manufacturer's works the quality of oil used for first filling, testing and impregnation of active parts shall meet at least parameters as mentioned in IEC . The oil test results shall form part of equipment test report.

6.4.3 Prior to filling in main tank at site and shall be tested for

1. Break Down voltage (BDV) : 70kV (min.)
2. Moisture content : 5 ppm (max.)
3. Tan-delta at 90 °C : 0.0025 (max)
4. Interfacial tension : More than 0.004 N/m

6.4.4 Prior to energisation at site oil shall be tested for following properties & acceptance norms as per below generally in line with IEC 60422:

1. Break Down voltage (BDV) : 70 kV (min.)

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – POWER TRANSFORMER</div>	PC288-TS-0803	0	<div> को ई एच डी एल </div>
		Document No.	Rev	
		Sheet 13 of 24		

2. Moisture content : 10 ppm (max.)
3. Tan-delta at 90 °C : 0.01 (max.)
4. Resistivity at 90 °C :  $6 \times 10^{12}$  ohm-cm (min.)
5. Interfacial tension : 0.035 N/m (min.)
6. \*Oxidation Stability (Test method as per IEC 61125 method C, Test duration: 500hour for inhibited oil)
  - a) Acidity: 0.3 (mg KOH /g) (max.)
  - b) Sludge: 0.05 % (max.)
  - c) Tan delta at 90 °C: 0.05 (max.)
7. \* Total PCB content : Not detectable (2 mg/kg total)

\* For Sr. No. 6 & 7 separate oil sample shall be taken and test results shall be submitted within 45 days after commissioning for approval of Consultant.

Oil sample shall be drawn before and after heat run test and shall be tested for dissolved gas analysis. Oil sampling to be done 2 hours prior to commencement of temperature rise test. For ONAN/ONAF cooled transformers, sample shall not be taken earlier than 2 hours after shutdown. The acceptance norms with reference to various gas generation rates shall be as per IEC 61181.

## 6.5 Insulation Materials

- 6.5.1 Class 'A' insulating materials specified in IS 1271 shall be used. Paper insulation shall be new and free from punctures. Wood insulation, where used, shall be well seasoned and treated.
- 6.5.2 The mineral oil shall comply with IS: 335. 10% extra oil shall be supplied along with the transformer in non-returnable drums.
- 6.5.3 For the transformers required to be filled up with inert gas for transport purpose, the required amount of oil including 10% extra shall be supplied in non-returnable drums.

## 6.6 Bushing

- 6.6.1 The bushing insulator shall be rated for the maximum system voltage and shall comply with the requirements laid down in IS. The minimum current rating shall be 400 Amps. in case of overhead line connected transformers, the bushings shall be outdoor type having creepage distances of 31mm/kV and complete with arcing horns. In case of transformers connected with bus duct or cable, the bushings shall be enclosed in the terminal box. In either case, they shall be detachable from outside of the tank. The hardware shall be of tinned copper or nickel plated brass suitable to receive the conductors. Separate neutral bushings shall be provided for earthing the neutral, as required. All bushings shall be marked with the symbols corresponding to the connection diagram indicated in the diagram plate and in accordance with IS.
- 6.6.2 Bushing rated 52 KV class and above shall be oil impregnated paper condenser bushings. Bushing rated below 52KV voltage class shall be solid porcelain or oil communicating type.

## 6.7 Conservator

- 6.7.1 Main conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture, and shall be fitted with magnetic oil level gauge with low oil level potential free contacts.
- 6.7.2 OLTC shall have conventional type conservator with prismatic oil level gauge.
- 6.7.3 Conservator tank shall have adequate capacity with highest and lowest visible-levels to meet the requirements of expansion of total cold oil volume in the transformer and cooling equipment from minimum ambient temperature to 100degC. The capacity of the conservator tank shall be such that the transformer shall be able to carry the specified overload without overflowing of oil. The Calculation shall be submitted during design review.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – POWER TRANSFORMER	PC288-TS-0803	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 14 of 24		

- 6.7.4 The conservator shall be fitted with integral lifting lugs in such a position so that it can be removed for cleaning purposes. Suitable provision shall be kept to replace air cell and cleaning of the conservator wherever applicable.
- 6.7.5 Conservator shall be positioned so as not to obstruct any electrical connection to transformer. Pipe work shall neither obstruct the removal of tap changers for maintenance or the opening of inspection or manhole covers.
- 6.7.6 Pipe work connections shall be of adequate size for their duty and as short and direct as possible. Only radiused elbows shall be used.
- 6.7.7 The feed pipe to the transformer tank shall enter the transformer cover plate at its highest point and shall be straight for a distance not less than five times its internal diameter on the transformer side of the Buchholz relay, and straight for not less than three times that diameter on the conservator side of the relay.
- 6.7.8 This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle of not less than 5 degree.
- 6.7.9 Contact of the oil with atmosphere is prohibited by using a flexible air cell of nitrile rubber reinforced with nylon cloth.
- 6.7.10 The temperature of oil is likely to rise upto 100 deg C during operation. As such air cell used shall be suitable for operating continuously at 100 deg C.
- 6.7.11 Air cell of conservator shall be able to withstand the vacuum during installation /maintenance periods. Otherwise provision shall be kept to isolate the conservator from the main tank when the latter is under vacuum by providing a vacuum sealing valve or other suitable means in the pipe connecting main tank with the conservator.
- 6.7.12 The transformer manual shall give full and clear instructions on the operation, maintenance, testing and replacement of the air cell. It shall also indicate shelf life, life expectancy in operation, the recommended replacement intervals and the supplier.
- 6.7.13 The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator.

## 6.8 Neutral Earthing Arrangement

The neutral terminals of transformer shall be brought to the ground level by a brass/tinned copper grounding bar, supported from the tank by using porcelain insulators. The end of the brass/tinned copper bar shall be brought to the bottom of the tank, at a convenient point, for making bolted connection to two (2) 75 x 6 mm galvanised steel flats connected to Owner's grounding mat.

## 7.0 FITTINGS

- 7.1 Fittings as listed in Annexure - I shall be provided. Any other fittings which may be necessary for the satisfactory operation of the transformer shall also be provided on each transformer.
- 7.2 All fittings shall conform to relevant Indian Standard Specifications.
- 7.3 Fittings such as conservator and associated pipes, explosion vent pipe etc. shall be designed to withstand vacuum as specified in Clause 6.2.1 against atmospheric pressure.
- 7.4 Fittings such as rating plate, dehydrating breather, off-circuit tapping switch, dial type thermometer etc. which need to be observed/ operated, shall be mounted at convenient heights of not more than 1.5 M from the base of the transformer and located so as to be clearly visible from the front.
- 7.5 All opening shall be provided with gasketted metallic covers for protection during transportation.
- 7.6 All valves shall be of globe/butterfly type provided with blanking plates. The valve body shall be made of either Carbon Steel with trim of 13 Cr. steel or gun metal.

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – POWER TRANSFORMER</div>	<div>PC288-TS-0803</div>	<div>0</div>	<div><div>बी एच ई एल <b>BHEL</b></div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 15 of 24</div>		

- 7.7 The rating plate, the terminal diagram and terminal marking plates shall be made of Aluminium and shall contain relevant details as per IS 2026. The Code No. of equipment shall be marked on a separate plate.
- 7.8 All terminals shall be anti loosening type and complete with connectors of required size. The earthing terminals shall have identification marks.
- 7.9 All valves in oil line shall be suitable for continuous operation with transformer oil at 115 deg C.
- 7.10 The oil sampling point for main tank shall have two identical valves to be put in series .Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.
- 7.11 A valve or other suitable means shall be provided to fix (in future) on line dissolved gas monitoring system to facilitate continuous dissolved gas analysis. The location & size of the same shall be finalised during detail engineering stage

#### 7.12 Winding Temperature Indicator

Winding temperature indicator for measuring hot spot temperature of the winding shall comprise of current transformer image coil, temperature sensing element, capillary tube jacketed with PVC sleeve, 150 mm dia. local indicating instrument with two pairs of contacts one for alarm and other for trip and maximum point indicator capable of being reset by hand without tools.

In addition to the above, the following equipment shall be provided for remote indication of winding temperature for each of the winding:

##### a) Signal transmitter for each winding

Signal transmitter shall have additional facility to transmit signal for recording winding temperature at Owner's data acquisition system, for which duplex platinum RTD with nominal resistance of 100 ohms at zero degree centigrade shall be supplied. The RTD shall be three wire ungrounded system. The calibration shall be as per SAMA (USA) standard or equivalent. The RTD may be placed in the pocket containing temperature sensing element and image coil for WTI system which will be used for both remote WTI and DAS. Necessary equipment for sending the signal to remote WTI and DAS shall be provided. In lieu, separate RTD for each of the functions shall be provided.

##### b) Remote winding temperature indicator

It shall be suitable for flush mounting on Owner's panel. This shall not be repeater dial of local WTI and will operate by signal transmitter. Any special cable required for shielding purpose, for connection between cooler control cabinet and remote WTI control circuit, shall be in the scope of Contractor. Only one RWTI with a selector switch shall be provided for all the windings (HV and LV).

#### 7.13 Oil Temperature Indicator

Oil temperature indicator for measuring top oil temperature shall comprise of 150 mm dial type thermometer, thermometer pocket and capillary tube jacketed with PVC sleeve. Thermometer shall have two pairs of contacts, one for alarm and other for trip and maximum point indicator capable of being reset by hand without tools.

In addition to the above, the following equipment shall be provided for remote indication of oil temperature:

##### a) Signal transmitter

Signal transmitter shall have additional facility to transmit signal for recording oil temperature at Owner's data acquisition system, for which duplex platinum RTD with nominal resistance of 100 ohms at zero degree centigrade shall be supplied. The RTD shall be three wire ungrounded system. The calibration shall be as per SAMA (USA) standard or equivalent. The RTD may be placed in the pocket containing temperature sensing element and image coil for OTI system which will be used for both remote OTI and DAS. Necessary equipment for sending the signal to remote OTI and DAS shall be provided. In lieu, separate RTD for each of the functions shall be provided.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – POWER TRANSFORMER	PC288-TS-0803	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 16 of 24		

b) Remote oil temperature indicator

It shall be suitable for flush mounting on Employer's/RTCC panel. This shall not be repeater dial of local OTI and will operate by signal transmitter. Any special cable required for shielding purpose, for connection between cooler control cabinet and remote OTI control circuit, shall be in the scope of Contractor. Only one ROTI with a four point selector switch shall be provided.

**7.14 Buchholz Relay**

The Buchholz relay as per IS 3637 shall be of double float type, provided with, two pairs of contacts, one for alarm and other for trip, facility for testing by injection of air by hand pump and with a cock for draining and venting of air. The relay shall be provided with shutoff valves on the conservator side as well as on the tank side.

The alarm and trip contacts of all protective devices shall be potential free and rated for 1 Amp at 110 V / 220 V D.C.

**7.15 Marshalling Box**

A marshalling box shall be provided to accommodate all auxiliary devices except those which are to be located directly on transformer or housed in a separate panel.

- i. Terminal boxes, Junction Boxes & Marshalling Panel shall have IP 55 enclosure(min.), dust, weather and vermin proof type.
- ii. The marshalling box shall be dust, weather and vermin proof type made of sheet steel of not less than 2 mm thick. The box shall be rectangular in shape having sufficient space for easy termination of cables. The terminal block shall be pressure clamp type. 10% spare terminals shall be provided.

Suitable heavy duty double compression type rolled Aluminium cable glands for all incoming and outgoing cables shall be provided.

**7.16 Current Transformers**

The current transformers shall be provided and shall comply with IS 2705. The C.T. terminals shall be accessible through a weatherproof removable cover for the purpose of testing etc. CT polarity shall be clearly marked. The C.T. for standby earth fault protection shall be 15 VA, 5P10. The C.T's for differential and restricted earth fault protection shall be of Class PS accuracy. The values of  $V_k$  and  $I_{mag}$  for these CTs shall be furnished at the order stage.

**7.17 Wiring**

All controls, indication and protective devices provided on the transformer shall be wired upto the terminal block inside the marshalling box, by means of stranded copper heat resistant PVC insulated armoured cable of 1.1 KV grade and size not less than 2.5 sq. mm. Wiring shall be properly fixed on cable tray with at least 100 mm clearance from the transformer body. Suitable identification mark shall be provided on all wires.

7.18 All bought out items shall be of reputed make to be approved by Consultant/ Owner.

**7.19 NITROGEN INJECTION FIRE PREVENTION AND EXTINGUISHING SYSTEM**

7.19.1 Nitrogen Injection Fire Prevention and Extinguishing System shall be provided for fire protection of Transformer against fire due to an arc, during internal faults and external fires is for preventing tank explosion. The system design shall also conform to TAC/ NFPA norms.

7.19.2 The system should comprise the following :-

- i. Fire Extinguishing Cubicle with base frame and containing, oil drain assembly, nitrogen cylinder, electric mechanical control unit for oil drain and nitrogen release detections necessary for monitoring system flanges on top panel for connecting pipe connections from transformer, panel lighting etc.
- ii. Control Box for monitoring system operation, automatic control and remote operation, with alarms, indication light switches, push buttons, audio signal, suitable for tripping and signaling on 110V DC supply.

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – POWER TRANSFORMER</div>	PC288-TS-0803	0	<div><p>बी एच ई एल <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 17 of 24		

- iii. Pre-stressed non-return valve (PNRV) working on transformer oil flow rate, with proximity switch for remote alarm indication and with visual position indicator.
- iv. Required number of fire detectors rated for 141<sup>0</sup>C for heat sensing, each fitted with two number cable glands.
- v. Signal box for terminating cable connections from PNRV and fire detectors.
- vi. Pressure relief valve with limit switch.

7.19.3 The following arrangements are required to be made on the transformer Tank at the time of fabrication of the tank :-

- i. Oil drain opening with pipe, flange and manual gate valve at about 120mm below the top cover. Pipe size DN125 for 100 MVA and higher ratings.
- ii. Nitrogen Injection openings with pipe size DN 25 with flange and manual gate valve on tank sides at about 100-200 mm from the bottom plate.
- iii. Flanges having 4 Nos. 18 dia. holes with pcd as 155mm and dummy pipe on the conservator pipe between buchholz relay and conservator tank manual gate valve, for fixing PNRV.
- iv. Fire detector brackets on top cover.
- v. Brackets for fixing signal box at a suitable location on top cover or tank size wall.

#### 7.19.4 ACTIVATION OF NIFPES:

Mal-functioning of fire prevention / extinguishing systems is their major shortcoming which leads to interruption in power supply. The Contractor shall ensure that the chances of malfunctioning of NIFPES are practically nil. To achieve this objective, the Contractor shall work out their scheme of activating signals which, while preventing mal-operation, should not be too rigorous to make the operation of NIFPES impracticable in case of actual need. Transformer isolation shall be the mandatory pre-requisite for activation of the system in Automatic mode or Remote mode in the control room.

In addition, at least following electrical-signals shall be provided in series for activating NIFPES.

#### 7.19.5 Auto Mode

- a) For Prevention of Fire :
  - i. Differential Relay Operation
  - ii. Buchholz Relay parallel with Pressure Relief Valve or RPRR. (Rapid Pressure Release Relay)
  - iii. Tripping of all concerned breakers is a prerequisite for initiation of system activation.
- b) For Extinguishing Fire :
  - i. Fire Detector
  - ii. Buchholz Relay paralleled with Pressure Relief Valve or RPRR.
  - iii. Tripping of all connected breakers is a prerequisite for initiation of system activation.

7.19.6 Manual Mode (Local/Remote): Tripping of all connected breakers is a pre-requisite for initiation of system activation.

7.19.7 Manual Mode (Mechanical): Tripping of all connected breakers is a pre-requisite for initiation of system activation.

#### 7.19.8 General Description of NIFPES

#### 7.19.9 Schematic of the System

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – POWER TRANSFORMER	PC288-TS-0803	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 18 of 24		

NIFPES should be a stand alone dedicated system for oil filled. It should have a fire extinguishing FE) cubicle placed on a plinth at a distance of 6-10 mtrs. from the transformer. The F.E. cubicle may be connected to the transformer oil tank (near its top) and to the oil pit from its bottom through oil pipes with gate valves. The F.E. cubicle should house a pressurized nitrogen cylinder connected to the transformer oil tank (near its bottom). Cable connections are to be provided from signal box placed on the transformer to the control box in the control room and from control box to F.E. cubicle. Fire detectors placed at the top of transformer are to be connected in parallel to the signal box. The signal box may be connected to a pre-stressed non-return valve fitted between the conservator tank and Buchholz relay. Control box is also to be connected to relay panel in control room for system activation signals.

#### 7.19.10 Operation

On receipt of all activating signals, drain of pre-determined quantity of oil commences thus removing high temp. top oil layer. Simultaneously nitrogen is injected under high pressure at a pre-fixed rate, string the oil thus bringing the temperature of top oil layer down. Nitrogen occupies the space created by oil drained out and acts as an insulating layer between the tank oil & fire on top cover. Pre-stressed non return valve blocks oil flow from conservator tank, thus isolating it & preventing aggravation of fire.

#### 7.19.11 System Components

Broadly, NIFPES shall consist of the following components. It is emphasized that all components, necessary for fast reliable & effective working of NIFPES shall be considered within the scope.

#### 7.19.12 Fire Extinguishing Cubicle

It shall be made of 3mm thick steel sheet, painted dark red from inside & outside with hinged split doors fitted with high quality tamper proof lock. It shall be complete with the base frame and the following:-

- Nitrogen gas cylinder with regulator and falling pressure electrical contact manometer
- Oil drain pipe with mechanical quick drain valve.
- Electro mechanical control equipment for oil drain and pre-determined regulated nitrogen release.
- Pressure monitoring switch for back-up protection for nitrogen release.
- Limit switches for monitoring of the system.
- Flanges on top panel for connecting oil drain and nitrogen injection pipes for transformer.
- Panel lighting (CFL Type)
- Oil drain pipe extension of suitable sizes for connecting pipes to oil pit.

#### 7.20 Control Box

Control Box for monitoring system operation, automatic control and remote operation, with following alarms indication, light switches, push buttons, audio signal, line fault detection suitable for tripping and signaling on 110V DC supply :

- System on\*
- PNRV open\*
- Oil drain valve closed\*
- Gas inlet valve closed\*
- PNRV closed^
- Fire Detector Trip^
- Buchholz Relay Trip^
- Oil drain valve open^
- Extinction in pressure^



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – POWER TRANSFORMER	PC288-TS-0803	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 19 of 24		

- Cylinder pressure low^
- Differential relay trip^
- PRV/RPRR trip^
- Transformer trip^
- System out of service
- Line fault free detector
- Line fault differential relay
- Line fault buchholz relay
- Line fault PRV
- Line fault transformer trip
- Line fault PNRV
- Auto/Manual/Off
- Extinction release on
- Extinction release off
- Lamp test
- Visual / Audio Alarm
- Visual / Audio alarm for DC supply fail

The signals marked (\*) shall be in the topmost row of control box panel. The signals marked (^) shall follow next.

#### 7.21 **Pre-stressed Non Return Valve (PNRV)**

PNRV is to be fitted in the conservator pipe line between conservator & Buchholz relay. It shall have the proximity switch for remote alarm, indication and with visual position indicator. The PNRV should be of the best quality because malfunction of PNRV shall be of serious consequence as its closing leads to stoppage of breathing of transformer.

#### 7.22 **Fire Detectors**

The system shall be complete with adequate number of fire detectors fitted on the top of oil tank, OLTC/Off ckt. Tap changer rated for 1410C for heat sensing each fitted with two no. cable glands (water proof/weather proof).

#### 7.23 **Signal Box**

It shall be fitted on the transformer for terminating cable connections from PNRV & fire detectors and for further connection to the control box.

#### 7.24 **Cables**

Fire survival cables, able to withstand 7500C, 4 core x 1.5mm sq. for connection of fire detectors in parallel shall be used. Fire retardant low smoke (FRLS) cable 12 core x 1.5mm sq. for connection between transformer signal box/marshalling box to control box and control box to fire extinguishing cubicle shall be used.

Fire retardant low smoke (FRLS) cable 4 core x 1.5mm sq. for connection between control box to DC supply source and fire extinguishing cubicle to AC supply source, signal box marshalling box to prestressed non return valve connection on transformer shall be used.

#### 7.25 **Pipes**

Pipes, complete with connections, flanges, bends, tees etc. shall be supplied alongwith the system.

#### 7.26 **Other items**

- a) Oil drain and nitrogen injection openings with gate valves on transformer tank at suitable locations
- b) Flanges with dummy piece in conservator pipe between Buchholz relay and conservator tank for fixing PNRV.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – POWER TRANSFORMER	PC288-TS-0803	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 20 of 24		

- c) Fire detector brackets on transformer top cover.
- d) Spare potential free contacts for system activating signals i.e. differential relay, buchholz relay, pressure relief valve, transformer isolation (master trip relay).
- e) Pipe connections between transformer to fire extinguishing cubicle and fire extinguishing cubicle to oil pit.
- f) Cabling on transformer top cover for fire detectors to be connected in parallel and inter cabling between signal box to control box and control box to fire extinguishing cubicle
- g) Mild steel oil tank with moisture proof coating with capacity as minimum 10% of total oil quantity of transformer, with water tight cover, to be place in the oil pit. This tank shall be provided with the manhole, air vent pipe through silica gel breather, drain valve and a spare gate valve at the top.
- h) Gate valves on oil drain pipe & nitrogen injection pipe should be able to withstand full vacuum. A non-return valve shall also be fitted on nitrogen injection pipe between transformers & gate valve.
- i) Pressure relief valve, wherever not fitted on the transformer.
- j) The F.E. cubicle shall be painted with post office red colour (Shade 538 of IS-5). All the exposed parts i.e. pipes, supports, signal box etc. shall be painted with enameled paint.

#### 7.27 Modification on the transformer

No modification on the transformer shall be allowed which affects its performance (i.e. efficiency, losses, heat dissipation ability etc.), safety, life etc. or its any other useful parameter. This requirement shall be of paramount importance and shall be followed.

However, in any case, performance of transformer should not be affected in any manner by having NIFPES system and the Contractor shall give an undertaking to this effect. All pipes should be washed/rinsed with transformer oil. If any damage is done to the transformer and/or any connected equipment during installation & commissioning full recovery therefore shall be effected from the Contractor.

It shall be solely the responsibility of Contractor/Sub-Contractor to install, carry out pre-commissioning tests & commission NIFPES at Ridge Valley indicated in this Specification, to the entire satisfaction of the Owner/Consultant..

#### 7.28 Interlocks

It shall be ensured that once the NIFPES gets activated manually or in auto mode, all the connected breakers shall not close until the system is actually put in OFF mode. Also PNRV shall get closed only if all the connected breakers are open.

#### 7.29 In general, following Fire Extinction period and other data shall be followed :

On commencement of Nitrogen Injection	:	Maximum 30 seconds
From the moment of system activation to complete cooling	:	Maximum 3 minutes
Fire detectors heat sensing temperature	:	141 <sup>0</sup> C
Heat sensing area	:	800mm radius
Pre-stressed non return valve setting for Operation	:	minimum 60 ltr. Per minute
Capacity of Nitrogen cylinder :	:	Minimum 68 litre water capacity And shall hold minimum 10 cubic Meter gas to 150 bar pressure
Power Source	:	
Control Box	:	220VDC

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – POWER TRANSFORMER	PC288-TS-0803	0	 को ई एच डी एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 21 of 24		

Fire extinguishing cubicle for 230VAC  
lighting

7.30 The following information in detail shall be provided :

- a) The maintenance and testing schedule for NIFPES.
- b) All the steps required to be undertaken for restarting the transformer and connected equipment after operation and mal-operation (if any) of the NIFPES.
- c) The process of venting nitrogen in case nitrogen pressure in the cylinder exceeds the stipulated maximum value.

## 8.0 PAINTING

- 8.1 The surface to be painted shall be shot or sand blasted to remove all dust, scale and foreign adhering matter. All traces of oil and greases should be removed by suitable treatment.
- 8.2 All steel surfaces in contact with insulating oil shall be painted with heat resistant oil insoluble insulating varnish.
- 8.3 All steel surfaces exposed to outside shall be painted with suitable anti-rust and anticorrosive paints. Epoxy paints shall be used.
- 8.4 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.
- 8.5 The paint should not fade during drying process. The paint should be able to withstand temperature up to 120 deg. C .The detailed painting procedure shall also be submitted along with the bid which shall be finalized before award of the contract.
- 8.6 Unless otherwise specified, the finishing shade shall be light grey Shade No. 631 as per IS 5.
- 8.7 1 litre of paint per transformer shall be supplied for touch up at Site.

## 9.0 TESTS AND INSPECTION

- 9.1 All transformers shall be routine tested as per IS 2026. Transformer oil shall be tested as per IS 335. Heat run test shall be carried out for one transformer of each rating.
- 9.2 Type test certificate shall be furnished.
  - a. Temperature-rise tests (IEC 60076-2)
  - b. Dielectric tests: Full-wave impulse-voltage withstand test (IEC 60076-3)
- 9.3 Additional tests, wherever specified, shall be carried out on one transformer of each rating.
- 9.4 All the above mentioned tests shall be carried out in the presence of Purchaser's representative. In addition, the transformers shall be subject to stage inspection at works and inspection at site for final acceptance.
- 9.5 These inspections shall, however, not absolve the Vendor from their responsibility for making good any defect which may be noticed subsequently.

## 10.0 DRAWINGS AND DOCUMENTS

- 10.1 The drawings and documents as per Annexure-III shall be furnished, unless otherwise specified.
- 10.2 All drawings and documents shall have the following descriptions written boldly:
  - Name of Client
  - Name of Consultant
  - Enquiry / order number with plant / project name
  - Equipment Code No. and Description
- 10.3 The transformer shall be suitably packed to avoid damage in transit and shall be properly sealed so as to completely exclude oxygen and moisture from coming in contact with oil.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – POWER TRANSFORMER	PC288-TS-0803	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 22 of 24		

Bushing shall be wrapped in straw ropes or similar material and complete transformer shall be packed in wooden crates.

- 10.4 The packing box shall contain a copy of the installation, operation and maintenance manual.
- 10.5 All loose pieces shall be separately wrapped in moisture resistant paper and marked with identification mark of the corresponding transformer.

#### 11.0 SPARES

- 11.1 Commissioning Spares: Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval.
- 11.2 Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 11.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 11.4 All spare parts shall be identical to the parts used in the equipment
- 11.5 All spare parts shall be identical to the parts used in the equipment

#### 12.0 PACKING

- 12.1 The transformer shall be suitably packed to avoid damage in transit and shall be properly sealed so as to completely exclude oxygen and moisture from coming in contact with oil. Bushing shall be wrapped in straw ropes or similar material and complete transformer shall be packed in wooden crates.
- 12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.
- 12.3 All loose pieces shall be separately wrapped in moisture resistant paper and marked with identification mark of the corresponding transformer.

#### 13.0 DEVIATIONS

Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – POWER TRANSFORMER	PC288-TS-0803	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 23 of 24		

## ANNEXURE - I LIST OF FITTINGS

- I. The fittings as given below shall be provided for all the ratings of transformers.
  1. Oil Sampling Valve.
  2. Filter valves with plug.
  3. Radiator shutoff valves on top and bottom for each unit.
  4. Buchholz relay shutoff valves.
  5. Winding temperature indicator for 1000 KVA and above.
  6. Oil temperature indicator.
  7. Oil level indicator with minimum marking.
  8. Oil conservator complete with drain plug and oil filling hole with cover.
  9. Buchholz relay with air release device and alarm and trip contacts.
  10. Silica gel breather with oil seal and connecting pipe.
  11. Explosion vent.
  12. Bi-directional rollers.
  13. Inspection holes with cover.
  14. Marshalling Box.
  15. Rating Plate.
  16. Diagram and Terminal marking plate.
  17. Lifting lugs.
  18. Jacking pad.
  19. Earthing Terminals.
  20. Air release device.
  21. Neutral bushing for earthing.
  22. Ladder with safety device for access to the top of transformer tank.
  
- II. The additional fittings as given below shall also be provided, as per requirement:
  1. Magnetic oil level gauge with low oil level alarm contact.
  2. Hauling lugs for extra high voltage transformers.
  3. Protective CTs for
    - a) Stand-by earth fault.
    - b) Restricted earth fault.
    - c) Differential protection.
  4. Bi-directional wheels if already bi-directional rollers not considered.
  5. Skids.
  6. Cooler units complete with valves, fans, pumps, oil flow indicators, supporting structure with fixing and foundation bolts etc as required and Cooler Control panel.
  7. Tap-changing gear complete with tap position indicator, operation counter etc. For OLTC gear(where specified), oil surge relay(OSL) with shut-off valve, Local control cabinet.
  8. Nitrogen Injection Fire Prevention and Extinguishing System

**ANNEXURE - II**  
**DOCUMENTATION FOR TRANSFORMERS**

Sl. No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet	N	Y	Y
2	Technical Particulars	N	Y	Y
3	Dimensional drawing for complete Transformer, Marshalling Box, disconnecting chamber, terminal chambers etc.	N	Y	Y
4.	Schematic and Wiring Diagram	N	Y	Y
5.	Terminal arrangement drawing	N	Y	Y
6.	Installation, operation and maintenance manual	N	N	Y
7.	Catalogues and test certificates for bought out accessories	N	N	Y
8.	Type test certificates of similar transformer	N	N	Y
9.	Test Certificates	N	N	Y
10.	Guarantee Certificates	N	N	Y
11.	Spare parts list with identification marks	N	N	Y

**Note:**

- 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
- 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - NEUTRAL EARTHING RESISTORS</div>	PC288-TS-0804	0	<div><div>कोयला भारत Coal India</div><div><div>बी एच ई एल <b>BHEL</b></div></div></div>
		Document No.	Rev	
		Sheet 1 of 7		



# **TECHNICAL SPECIFICATION** **NEUTRAL EARTHING RESISTOR**

 <div>पी डी आई एल <b>PDIL</b></div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div> <div>TECHNICAL SPECIFICATION - NEUTRAL EARTHING RESISTORS</div>	PC288-TS-0804	0	 <div>वी एच डी एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 2 of 7		

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	GENERAL DESIGN AND CONSTRUCTIONAL FEATURES
6.0	ACCESSORIES
7.0	PAINTING
8.0	TESTS AND INSPECTION
9.0	DRAWINGS AND DOCUMENTS
10.0	SPARES
11.0	PACKING
12.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR NEUTRAL EARTHING RESISTORS



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - NEUTRAL EARTHING RESISTORS	PC288-TS-0804	0	
		Document No.	Rev	
		Sheet 3 of 7		

## 1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, manufacture, testing at works and despatch in well packed condition of Neutral Earthing Resistor for earthing the neutral of power transformers / generators for limiting the line to ground fault current.
- 1.2 This standard shall be read in conjunction with the relevant part of Design Philosophy – Electrical.

## 2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of IS 3043, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.
- 2.2 The design and operational features of the equipment shall also comply with the provisions of latest issue of the Indian Electricity Rules and other relevant Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.
- 2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

## 3.0 SERVICE CONDITIONS

### 3.1 Ambient Conditions

These shall be as indicated in Design Philosophy – Electrical.

### 3.2 System Details

These shall be as indicated in Design Philosophy – Electrical.

## 4.0 OPERATING REQUIREMENTS

- 4.1 The neutral earthing resistor shall be suitable for carrying the rated current for duration of 30 seconds under the specified ambient conditions and voltage and frequency variations without the temperature exceeding 350°C.
- 4.2 The resistor shall be designed to carry continuously 20% of the rated short time current without any harmful effect.
- 4.3 The housing shall be sized such that temperature rise of the metal parts through which current is not required to pass, when rated current is passed for the specified period, shall not exceed 40°C.

## 5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

### 5.1 Resistors

- 5.1.1 The resistance bank shall be of heavy duty non-inductive type having high specific resistance and low temperature co-efficient.
- 5.1.2 The resistor elements shall be made of joint-less, non-corroding, sturdy and oxidation resistant AISI 304 / AISI 406 stainless steel of punched / formed construction.

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - NEUTRAL EARTHING RESISTORS</div>	PC288-TS-0804	0	<div><div>बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 4 of 7		

5.1.3 The contact between elements shall be made by individually bolting the terminals of two adjacent elements and connecting them in series, parallel or combination of both to achieve the specified resistance. The interconnecting link shall be zinc plated copper of uniform cross section throughout.

5.1.4 The resistance grid shall be properly supported so that damage due to vibration and thermal or mechanical stresses is avoided.

5.1.5 Porcelain / Epoxy insulators rated for the highest system voltage shall be used to insulate the resistor elements from the body of the housing.

5.1.6 Insulation level for resistor bank shall be as follows:

Highest system voltage	Power frequency withstand voltage	Impulse withstand Voltage
Up to 3.6 KV peak	10 KV RMS	40 KV
7.2 KV peak	20 KV RMS	60 KV

## 5.2 Metal clad housing

5.2.1 The housing shall be fabricated out of 3 mm thick sheet steel fitted on a 6 mm thick mild steel frame work. This shall be floor mounting type and rectangular in shape.

5.2.2 It shall be suitable for outdoor installation and shall have minimum degree of protection IP: 43 as per IS 2147. Ventilating louvers, if provided, shall be covered by fine wire mesh from inside and shall be such that the above degree of protection for the enclosure is not altered. Top cover of the housing shall be slopping construction to prevent accumulation of water.

5.2.3 All external hardware below 8 mm size shall be of stainless steel and those of higher size of mild steel cadmium plated or zinc passivated.

## 5.3 Isolation Arrangement

5.3.1 An isolator shall be provided on the incoming side to isolate the resistors from the main equipment.

5.3.2 The isolating switch shall be single pole knife type having a rating of 1.5 times the rated current of the resistor. The switch shall have four sets of potential free auxiliary contacts, 2 NO and 2 NC for remote indication, wired to a terminal block. An external handle, suitably insulated and lockable both in the ON and OFF positions, shall be provided for the switch. The handle shall preferably be mounted at a height of 1.5 meters from the base of the housing.

## 5.4 Current Transformers

Epoxy moulded current transformer of accuracy 5P for stand by earth fault protection and PS for restricted earth fault protection shall be provided, as per requirement. The CT connections shall be brought to separate terminal box with shorting arrangement.

## 5.5 Terminal Arrangement

5.5.1 For incoming connection, either bushing or cable box arrangement shall be provided. In case of bushing connection, the bushing shall be provided on top of the housing. In case of cable box connection, the same shall be mounted on the side of the housing.

5.5.2 For the outgoing connection, cable box arrangement is to be considered in all cases. The cable box shall be mounted on the side of the housing.

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><b>TECHNICAL SPECIFICATION - NEUTRAL EARTHING RESISTORS</b></p></div>	PC288-TS-0804	0	<div><p>बी एच ई एल <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 5 of 7		

5.5.3 Heavy duty double compression type rolled aluminium cable glands shall be provided for all the incoming and outgoing cables.

5.5.4 The equipment terminals shall be anti loosening type and complete with tinned copper cable lugs suitable for cables of specified size. For bushing connections, suitable tinned copper conductor shall be provided as per conductor size specified.

## 6.0 ACCESSORIES

6.1 The equipment shall be complete with cable glands, cable lugs, drain plug, lifting hook, name plate, foundation bolts and all other accessories required to make the equipment complete in all respects.

### 6.2 Name Plate

6.2.1 Name plate shall be of stainless steel with letters embossed on them.

6.2.2 The name plate shall contain all the required details and shall include at least the following:

- i) Make
- ii) Description of code no. of equipment
- iii) Short time rating
  - a) Current
  - b) Duration
- iv) Rated voltage
- v) Maximum temperature rise over ambient
- vi) Total resistance at ambient temp.
- vii) Materials of resistors
- viii) Degree of protection of enclosure

## 7.0 PAINTING

7.1 The enclosure, after suitable pre-treatment shall be painted with two coats of antirust paint followed by two coats of anti-corrosive paints.

7.2 Epoxy based paints shall be used.

7.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

7.4 The finishing paint shall be light grey shade no. 631 as per IS 5.

## 8.0 TESTS AND INSPECTION

8.1 Following tests shall be carried out on the neutral earthing resistors:

### 8.1.1 Routine Tests

- i) Resistance value measurement at room temperature.
- ii) Power frequency high voltage test for one minute.
- iii) Insulation resistance test.

### 8.1.2 Type test

- i) Heat run test.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - NEUTRAL EARTHING RESISTORS	PC288-TS-0804	0	
		Document No.	Rev	
		Sheet 6 of 7		

8.2 The above mentioned tests shall be carried out in the presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and inspection at site for final acceptance.

8.3 The purchaser's inspection shall, however, not absolve the vendor from his responsibility for making good any defects which may be noticed subsequently.

## 9.0 DRAWINGS AND DOCUMENTS

9.1 The drawings and documents as per Annexure-I shall be furnished unless otherwise specified.

9.2 All drawings and documents shall have following descriptions written boldly.

- Name of the client
- Name of consultant
- Enquiry / order number with plant / project name
- Equipment code no. and Description.

## 10.0 SPARES

10.1 Commissioning Spares: Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval.

10.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.

10.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.

10.4 All spare parts shall be identical to the parts used in the equipment.

## 11.0 PACKING

11.1 The neutral earthing resistor shall be properly packed to safeguard against weather conditions and handling. It shall be wrapped in polythene bag with an additional wrapping of bitumen paper to make it completely waterproof before the equipment is packed in wooden crates.

11.2 A sign to indicate the upright position of the panel for placing during transport and storage shall be clearly marked.

11.3 Packing box shall include one copy of the installation operation and maintenance manual

## 12.0 DEVIATIONS

12.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

## ANNEXURE - I

### DOCUMENTATION FOR NEUTRAL EARTHING RESISTORS


	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - NEUTRAL EARTHING RESISTORS</b>	PC288-TS-0804	0	
		Document No.	Rev	
		Sheet 7 of 7		

Sl. No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	General arrangement drawings	N	Y	Y
4.	Illustrative and descriptive catalogues	N	N	Y
5.	Installation, Operation and maintenance manual	N	N	Y
6.	Test Certificates	N	N	Y
7.	Guarantee Certificates	N	N	Y

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No



	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>SPECIFICATION - MEDIUM VOLTAGE SWITCH BOARDS</b>		<b>PC288-TS-0805</b>		0
			Document No.	Rev	
			Sheet 1 of 22		



# **TECHNICAL SPECIFICATION** **MEDIUM VOLTAGE SWITCH BOARDS**

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	DESIGN AND CONSTRUCTIONAL FEATURES
6.0	COMPONENT DETAILS
7.0	ACCESSORIES
8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	DRAWINGS AND DOCUMENTS
11.0	SPARES
12.0	PACKING
13.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR MEDIUM VOLTAGE SWITCH BOARDS

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></div> <div><b>SPECIFICATION - MEDIUM VOLTAGE SWITCH BOARDS</b></div>	<div>PC288-TS-0805</div>	<div>0</div>	<div><div>कोयला भारत</div><div><div>बी एच ई एल <b>BHEL</b></div></div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 3 of 22</div>		

## 1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well-packed condition of Medium Voltage Switchboards.
- 1.2 This standard shall be applicable for the Power Control Centres, Power cum Motor Control Centres and Motor Control Centres.
- 1.3 This standard shall be read in conjunction with relevant part of Design Philosophy – Electrical, Schematic diagrams etc.

## 2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of the equipment shall comply with the latest issue of the following Indian Standards, unless otherwise Specified. Equipment complying with equivalent IEC standards shall also be acceptable.

- |              |  |
|--------------|--|
| IS 8623      | - Specification for low voltage switchgear and control gear assemblies                         |
| IS/IEC 60947 | - Low-voltage switchgear and control gear (General Rules)                                      |
| IS 5578      | - Guide for marking of insulated conductors  |
| IS 10118     | - Code of practice for selection, installation and maintenance of switchgear and control gear  |
| IS 11353     | - Guide for uniform system of marking and identification of conductors and apparatus terminals |

Various components housed in the switchboards shall conform to the Indian Standard specifications as mentioned against the component details or IEC specifications.

- 2.2 The design and operational features of all the equipment offered shall also comply with the provisions of the latest issue of the Indian Electricity Rules and other Statutory Acts and Regulations, as applicable. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.
- 2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specification / IEC Specification, the requirement specified herein shall prevail.

## 3.0 SERVICE CONDITIONS

### 3.1 Ambient Conditions

These shall be as indicated in Design Philosophy – Electrical.

### 3.2 System Details

These shall be as indicated in Design Philosophy – Electrical.

## 4.0 OPERATING REQUIREMENTS

The Medium Voltage Switchboards shall be suitable for operating at the specified rating continuously, with the specified voltage and frequency variations under the ambient conditions, without exceeding the permissible temperature rise and without any detrimental effect on any part.



<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></div> <div><b>SPECIFICATION - MEDIUM VOLTAGE SWITCH BOARDS</b></div>	PC288-TS-0805	0	<div> श्री एम आई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 4 of 22		

## 5.0 DESIGN AND CONSTRUCTIONAL FEATURES



### 5.1 General

- 5.1.1 The switchboards shall consist of an assembly of a series of floor mounting, identical, metal clad, dead front type sheet steel panels of unitized design. The panels shall be placed side by side to form a compact assembly and shall be extensible on either side.
- 5.1.2 The complete assembly shall be dust, damp and vermin proof having minimum degree of protection equivalent to IP-52 as per IS/IEC:60947.
- 5.1.3 The frame work of the cubicles shall be of bolted/welded construction. The minimum thickness of sheet steel shall be 2 mm for load bearing members, 1.6 mm for non-load bearing members and 3 mm for base channel. The doors and covers shall be fabricated from cold rolled sheets. Suitable reinforcement, wherever necessary, shall be provided.
- 5.1.4 The door hinges shall be concealed type.
- 5.1.5 All external hardwares shall be cadmium plated. The hardwares for fixing the removable parts shall be provided with retaining devices.
- 5.1.6 The doors and the removable covers shall be provided with non-deteriorating neoprene gaskets. Gaskets without any discontinuity shall be preferred. Gaskets shall be held in position in groove, in shaped sheet steel work or these shall be of U type. Adhesive cement, if used, shall be of good quality so that the gaskets do not come off during service.
- 5.1.7 All the components shall be accessible for inspection and maintenance without the necessity for removal of the adjacent ones.
- 5.1.8 The layout of the component inside the module shall be liberal to facilitate maintenance and interconnecting wiring between the components shall not be subjected to any undue stresses at the bends.
- 5.1.9 Mounting height of components requiring operations and observation shall not be lower than 300 mm and higher than 1800 mm.
- 5.1.10 Inter panel barriers shall be provided.
- 5.1.11 All the live parts which are accessible after opening of front cover/cable alley cover/back cover shall be properly insulated or provided with insulating barrier to prevent accidental contact. Removal facility shall be provided for all such parts.
- 5.1.12 Adequate arrangement for earthing shall be provided to safeguard the operator or other personnel from electric hazards under all conditions of operation.

### 5.2 Panel Arrangement

The Switchboards shall be in fixed/draw out, single front execution, fully compartmentalised type and divided into distinct panels, each comprising of :

- i) A completely metal enclosed bus-bars compartment running horizontally the top.
- ii) Individual feeder modules.
- iii) Enclosed vertical bus-bars serving all modules, in case of multi-tier panels.
- iv) A vertical cable alley.
- v) Separate horizontal enclosure for all auxiliary power and control buses.



<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></div> <div><b>SPECIFICATION - MEDIUM VOLTAGE SWITCH BOARDS</b></div>	<div>PC288-TS-0805</div>	<div>0</div>	<div><div>कोयला इंडिया <b>BHEL</b></div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 5 of 22</div>		

### 5.3 Circuit Breaker Controlled Feeders

- 5.3.1 The panels housing circuit breaker feeders shall be in single front draw out execution. The incoming and bus coupler circuit breaker feeders shall be in single tier formation while the outgoing circuit breaker feeders may be in double tier formation.
- 5.3.2 A suitable barrier shall be provided between the circuit breaker and the associated control, protective and indication devices including instrument transformers.
- 5.3.3 All the protective relays and meters shall be flush mounted type. The relays and meters pertaining to a particular circuit breaker shall be mounted on the same panel. Where it is not possible to accommodate all the relays and meters in the same panel, one metering panel shall be provided adjacent to the circuit breaker panel exclusively for that feeder. Location of these in the adjacent panel of other feeders shall not be acceptable.
- 5.3.4 A spacious cable chamber suitable for accommodation, support and termination of required number of power cables shall be provided at the back. No bare bus-bars or live connection shall intrude into the cabling space.
- 5.3.5 The switchboard shall be provided with following inter locks and safety features:
- It shall not be possible to open the compartment door unless the breaker is drawn to isolated position.
  - The withdrawn and engagement of a circuit breaker shall not be possible unless it is in open position.
  - The operation of a circuit breaker shall not be possible unless it is in fully service, test or isolated position.
  - It shall not be possible to close the circuit breaker in service position unless all auxiliary and control circuits are connected.
  - A breaker of the lower rating shall be prevented from engaging with the stationary element of higher rating.
  - Insertion of the manual mechanism shall render the motorised mechanism in operation.
  - Circuit breaker 'ON', 'OFF' indication shall be provided at the back of each panel. Alternatively, alarm shall be provided in case panel back door is opened with breaker "ON".
  - Caution nameplate shall be provided at the back of incomer's panels where terminals are likely to remain live and isolation is possible only from remote end.
  - Automatic safety shutter, with Padlocking facility for locking in closed position, to completely cover the spouts for the bus-bars and cable connection when the breaker is withdrawn.

### 5.4 Switch/MCCB Controlled Feeders

- 5.4.1 The panels housing motor starter or other feeders shall be either fixed or draw out type in single front execution.
- 5.4.2 All components of one feeder shall be mounted on a rigid sheet steel chassis.
- 5.4.3 Each panel shall be divided into a number of modules in tier formation placed one above the other. These modules shall be closed on all sides.
- 5.4.4 The modules shall be so placed that largest one is placed at the bottom of the panel. Type modules shall be at least 300 mm from the base channel.
- 5.4.5 The number of modules shall be so decided that the cables in the cable alley are not over crowded. However the number of module in any panel shall not exceed six.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>SPECIFICATION - MEDIUM VOLTAGE SWITCH BOARDS</b>	PC288-TS-0805	0	 श्री एम आई एल 
		Document No.	Rev	
		Sheet 6 of 22		



- 5.4.6 The minimum size of module shall be 300 mm and 200 mm for starter and switch fuse feeders respectively.
- 5.4.7 The minimum clear width of cable alley shall be 250 mm.
- 5.4.8 For MCC rated above 630 Amp. The incomer and bus coupler modules shall be located in individual single panel. For MCC rated for 630 Amp. and below the incomer and bus coupler modules shall be half the panel size.
- 5.4.9 The module door shall be so interlocked that it shall not be possible to open the door with switch in closed position and close the door unless the module is fully plugged in. Defeat interlock facility shall be provided.

## 5.5 Special Features of Draw out Modules

- 5.5.1 The module shall be fully draw out type with sheet steel chassis moving freely on the guides. Chassis of the same size shall be fully interchangeable.
- 5.5.2 The module shall have the following distinct mechanical positions:
- i) Service -- In which both power and control contacts shall be made.
  - ii) Test -- In which power contacts shall be isolated but control contacts shall be made.
  - iii) Isolated -- In which both power and control contacts shall be Isolated.
- Maintenance position shall be preferred.
- 5.5.3 Each position shall be clearly marked. Padlocking facility shall be provided to padlock the chassis in any of the position.
- 5.5.4 The movement of the chassis from one position to the other shall be controlled by using an appropriate racking mechanism. Stopper shall be provided to prevent over travel of the chassis beyond the isolated position.
- 5.5.5 The guiding system shall permit smooth movement of the module and the power and control contacts shall be self-aligning type so that accurate alignment of the contacts is ensured.
- 5.5.6 No wiring shall be taken to the door. Only the actuators of the push buttons and switches, lenses for the indicating lamps and Perspex cover for meters shall be mounted on the door.
- 5.5.7 The power contacts shall be of plug-in/stab-in type made of silver plated copper, spring loaded and of adequate current carrying capacity. The contacts shall be so designed that contact pressure is maintained both under normal and short circuit conditions.
- 5.5.8 The parting contacts, both on bus-bar side and outgoing cable side, shall always be copper to copper and both sides silver plated. A bimetallic strip shall be used where two dissimilar materials are in contact.

## 5.6 Bus-Bars and Connections

- 5.6.1 The bus-bars shall be for three phase and neutral. The main bus-bars and connections shall be made of electrolytic grade copper of rectangular cross-section. Auxiliary bus-bars for control supply, space heater supply etc. shall be made of electrolytic copper.
- 5.6.2 The horizontal bus-bars shall be insulated with heat shrinkable PVC sleeves of reputed make to protect against approach to live parts. The vertical bus-bars shall be sleeved or shrouded by barriers. Removable type insulating shrouds shall be provided for all joints of horizontal bus-bars.
- 5.6.3 The bus-bars shall be amply sized to carry the rated continuous current under the specified ambient temperature without exceeding temperature limits specified in IS:

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>SPECIFICATION - MEDIUM VOLTAGE SWITCH BOARDS</b>	<b>PC288-TS-0805</b>	<b>0</b>	 श्री एम आई एल 
		Document No.	Rev	
		Sheet 7 of 22		

8084. The thermal rating of the bus-bars shall be designed to withstand the system fault current for 1 second without exceeding the limiting temperature of 200°C for bare Aluminium/Copper. Calculation for bus-bars sizing shall be furnished along with the offer.

- 5.6.4 Horizontal bus-bars shall be of the same cross-section through out. Stepped bus-bars shall not be acceptable.
- 5.6.5 The bus-bars shall be arranged and colour coded according to IS: 5578 / IS: 11353.
- 5.6.6 The bus-bar chamber shall be sufficiently spacious and shall have separate screwed covers for maintenance purpose.
- 5.6.7 The bus-bars shall be rigidly supported at equal intervals to withstand maximum short circuit stresses. The supports shall be of moulded construction with built-in anti-tracking barriers. The support materials shall be of DMC or fibreglass reinforced thermosetting plastic.
- 5.6.8 Bus-bar joints shall be between the two transporting sections only.
- 5.6.9 A minimum of two bolts shall be used in bus-bar joints. Only high tensile electric galvanized bolts, nuts and washers shall be used.
- 5.6.10 In case of Aluminium bus-bars, all joints shall be suitably treated to avoid oxidation of contact surfaces and bimetallic corrosion.

#### 5.7 **Earth Bus**



A continuous earth bus of electrolytic grade copper, running along the entire length of the lower part of the switchboard shall be provided with lugs at two ends for external connections. The minimum size of earth bus shall be suitable for carrying three phase fault current for 1 sec.

#### 5.8 **Bus Duct**

- 5.8.1 Suitable extension of bus-bars in proper phase sequence on the top, with the connecting bolts shall be provided where connection of transformer to switchboard is specified to be through bus duct.
- 5.8.2 Bus duct between two halves of a switchboard, if required, shall be supplied by the switchboard manufacturer. The bus-bars of interconnecting bust duct shall be similar to the main bus-bars of the switchboard and as specified above.
- 5.8.3 Bust duct between transformer and incoming breaker panel, if included in Vendor's scope, shall conform to ES-8062.

#### 5.9 **Clearances and Creepage Distances**

- 5.9.1 The clearances and creepage distances shall not be lower than the values specified below:
  - i) Minimum clearance between two live conductors -- 20 mm
  - ii) Minimum clearance between live parts and accidentally dangerous part -- 20 mm
  - iii) Minimum creepage distance -- 28 mm
- 5.9.2 The clearances and creepage, as specified above, shall definitely be maintained in the bus-bar system. Provision of bus-bar insulation, separators or barriers shall not be considered to reduce the clearance from the values specified above.
- 5.9.3 At the termination points in the equipment e.g. switches, contactors, thermal relays etc. It is realized that above clearances may not always be possible to be maintained. All

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></div> <div><b>SPECIFICATION - MEDIUM VOLTAGE SWITCH BOARDS</b></div>	<div>PC288-TS-0805</div>	<div>0</div>	<div><div>कोयला भारत</div><div><div>बी एच ई एल <b>BHEL</b></div></div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 8 of 22</div>		

such points, where above clearances and creepage distances are not possible to be maintained, shall be insulated or taped.

#### 5.10 **Insulation**

- 5.10.1 The insulation used shall be non-hygroscopic and may be of porcelain, epoxy resins or fibreglass moulded with plastic. It shall be of adequate electrical, mechanical and thermal strength to give trouble free service during normal operation and short circuit conditions.
- 5.10.2 The insulation shall be treated suitably to withstand the tropical conditions and atmospheric pollution.

#### 5.11 **Power Wiring**

- 5.11.1 The connections from bus-bar to individual functional unit on the modules shall be of PVC insulated flexible copper cables or taped Copper/Aluminium strip.
- 5.11.2 The power wiring size shall be decided based on rating of the switch/breaker after using a rating factor of not more than 50% over the current rating in free air.
- 5.11.3 Power wiring size selected for breaker controlled module shall also be able to withstand full short circuit current for duration of 0.25 sec.
- 5.11.4 In any case minimum size of power wiring shall not be less than 4 sq. mm copper.
- 5.11.5 The size of connection from incomer to horizontal bus-bar and from horizontal bus-bar to bus-coupler shall not be less than the size adopted for horizontal bus-bar.



#### 5.12 **Control Wiring**

- 5.12.1 The switchboard shall be completely factory wired and ready for external connections.
- 5.12.2 The wiring shall be carried out with flexible stranded PVC insulated copper conductor cables of 1100 Volt grade. The size of wires shall be as follows:
 

C.T. Circuit	-- 2.5 sq. mm
V.T. and Control Circuits	-- 1.5 sq. mm
- 5.12.3 All wiring shall be provided with dependent both ends marking as per IS: 5578. Numbered ferrules, reading from the terminals outwards, shall be provided at both ends of all wiring for easy identification. These shall be interlocking type plastic ferrules.
- 5.12.4 Control wiring circuits, fed from a supply common to a number of panels, shall be so protected that failure of a circuit in one panel does not effect the operation of the other panels.
- 5.12.5 The wiring to the equipment mounted on the doors shall be carried out with flexible multi strand copper conductor cable and so supported that on opening of the door there is no undue strain on wire leads.
- 5.12.6 The control cables shall be neatly arranged and property supported.


#### 5.13 **External Cable Termination**

- 5.13.1 All power and control cables shall enter the switchboard from the bottom. Sufficient space shall be provided for ease of connection and termination of cables.
- 5.13.2 The type, number and sizes of cables shall be as indicated in Feeder details.
- 5.13.3 Compression type cable glands along with the cable lugs as required shall be provided for termination of cables.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>SPECIFICATION - MEDIUM VOLTAGE SWITCH BOARDS</b>	<b>PC288-TS-0805</b>	<b>0</b>	 श्री एम आई एल 
		Document No.	Rev	
		Sheet 9 of 22		

- 5.13.4 The cable glands shall be of rolled Aluminium heavy duty double compression type and shall be mounted on a removable gland plate, provided at a minimum height of 75 mm from the bottom of the switchboard. Two number spare knockouts of size 20 mm shall also be provided on the gland plates for future use. Gland for termination of single core cables shall be nonmagnetic type.
- 5.13.5 For all power cables, crimped type Aluminium lugs for Aluminium cables and tinned Copper lugs for Copper cables shall be provided.
- 5.13.6 The terminal blocks shall be pressure clamp type up to 35 sq. mm cable sizes and bolted lug type for higher sizes of cables. These shall be protected type and rated for 1100 Volts service. The minimum current rating of terminal block shall be 16 Amp. The construction shall be such that after the connection of cables by means of lugs, necessary clearance and creepage distance are available.
- 5.13.7 Where more than two cables in parallel are required to be terminated, a system of bus links shall be provided with adequate clearance and spacing.
- 5.13.8 Suitable clamps to support the vertical run of cables shall be provided.
- 5.13.9 The terminal block shall be grouped according to circuit functions and suitably numbered. 20% extra terminals shall be provided in the terminal block.
- 5.13.10 For power connections, suitable marking on the terminals shall be provided to identify the phases.
- 5.14 **Feeder Details**
- 5.14.1 The requirements of incomer, bus coupler and outgoing feeders shall be as indicated in the single line diagram, feeder details and corresponding schematic diagrams.
- 5.14.2 Interlocks shall be provided between incomers and bus section panels. The interlocks shall be either electrical or mechanical type. In addition, arrangement for defeating the interlock shall also be provided to facilitate manual changeover.
- 5.14.3 Auto changeover scheme, wherever specified, shall be provided.
- 5.15 **Dummy Panels**
- Dummy panels complete with bus-bar system in 400 mm width may be required for which unit price shall be indicated.
- 5.16 **Control Power Supply**
- 5.16.1 D.C. Power required for closing, tripping and indication of circuit breaker feeders shall be supplied at the bus coupler panel through two completely separate circuits by owner, one for tripping and other for closing and indication.
- 5.16.2 For receiving each external control supply, a double pole miniature circuit breaker shall be provided. This power shall be distributed inside the switchboard for each circuit breaker feeder having its MCB unit.
- 5.17 **Space Heater Power Supply**
- 5.17.1 Panel space heater shall be fed from a separate bus common for the whole board. This bus shall be fed from owner's supply for which a double pole MCB shall be provided in bus section panel.
- 5.17.2 Power supply for space heaters of motors shall be tapped from this bus by means of a MCB located in the motor feeder compartment. These MCBs shall be of triple pole and rated for 15 Amp.



 <div>पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></div> <div><b>SPECIFICATION - MEDIUM VOLTAGE SWITCH BOARDS</b></div>	PC288-TS-0805	0	 
		Document No.	Rev	
		Sheet 10 of 22		

## 6.0 COMPONENT DETAILS

Components of the switchgear shall ensure type of coordination 'C' as per IS:60947 (Part 4/ Section 1). Makes of all components shall be subject to owner's / consultant's approval

### 6.1 Circuit Breaker

- 6.1.1 The circuit breakers shall comply with the requirement of IS/IEC 60947.
- 6.1.2 All circuit breakers shall be of P2 (0-3 min - CO - 3 min - CO) category, capable of carrying the specified current at the site conditions and making/breaking of the system fault current.
- 6.1.3 Type test certificates from an independent testing authority shall be furnished along with the offer for each circuit breaker rating and type.
- 6.1.4 The circuit breakers controlling motors shall be suitable for DOL starting and stopping of induction motor a number of times.
- 6.1.5 The circuit breakers controlling capacitors shall be suitable for energizing and de-energizing the rated capacitor bank.
- 6.1.6 The circuit breakers shall be of the 3 phase, 4 pole horizontal draw out, horizontal isolation, air break type.
- 6.1.7 The circuit breaker shall be suitable for electrical or manual closing as specified. Manual operated breakers shall have independent manual spring closing mechanism. In case of electrically operated breaker, it shall have motor wound spring mechanism. In all cases tripping shall be by means of shunt trip coil.
- 6.1.8 All circuit breaker units of the same rating shall be physically and electrically interchangeable.
- 6.1.9 The circuit breakers shall be electrically and mechanically trip free and provided with anti-pumping feature.
- 6.1.10 Provision shall be made for slow closing for maintenance purposes. A suitable handle shall be provided one for each board for this purpose.
- 6.1.11 The circuit breakers shall have three positions i.e. service, test and isolated with the cubicle door closed. Necessary stoppers shall be provided to prevent the excessive movement of the breaker cradle than desired for the position. Service and test positions of the breaker shall have monitoring switch having 1NO+1NC contacts.
- 6.1.12 The circuit breaker shall be provided with emergency manual trip device, mechanical 'ON', 'OFF' and 'ISOLATED' position indicators and operation counter.
- 6.1.13 A maintenance truck/device for raising, lowering and withdrawal of the circuit breaker shall be supplied for each switch board.
- 6.1.14 The arc interrupting devices shall be capable of interrupting satisfactorily current from zero to the rated interrupting current when used on predominantly capacitive or inductive circuits, without requiring excessive maintenance of the contacts. The arc shall be restricted within the interrupting chamber and no emission of flame shall be allowed which may cause electrical breakdown or damage to insulation on the apparatus.
- 6.1.15 The main contacts shall be self aligning, adjustable and replaceable type.
- 6.1.16 The arcing contacts shall be easily accessible for maintenance and inspection and shall be easily replaceable type. They shall be provided with, contact face of special arc-resisting and non-pitting metal.

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></div> <div><b>SPECIFICATION - MEDIUM VOLTAGE SWITCH BOARDS</b></div>	<div>PC288-TS-0805</div>	<div>0</div>	<div><div>कोयला भारत</div><div><div>बी एच ई एल <b>BHEL</b></div></div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 11 of 22</div>		

6.1.17 Mechanical safety interlock shall be provided for safe operation and movement of the breaker.

6.1.18 The circuit breakers shall be provided with minimum of four normally open and four normally closed auxiliary switch contacts, over and above those required for its own control scheme, for Owner's use. The contacts shall be wired separately to the terminal board.

## 6.2 Moulded Case Circuit Breakers

6.2.1 The circuit breaker shall conform to IS/IEC 60947 and shall be of P2 category having rupturing capacity as per system requirement and mounted on a draw out chassis.

6.2.2 The circuit breaker shall be provided with spring assisted quick make quick break type manually operated trip free mechanism, mechanical 'ON', 'OFF' position indicators, thermal tripping devices of inverse characteristics, instantaneous short circuit tripping devices and necessary auxiliary and alarm switches. The MCCB Chassis shall be provided with service, test and isolated position and automatic safety shutter.

6.2.3 The thermal and short circuit tripping devices shall be adjustable type.

6.2.4 When used for motor circuits, shunt trip device shall be provided and the let through power of controlling MCCB shall be lower than the respective contactor.

6.2.5 In addition, under voltage trip shall be provided.

## 6.3 Switches

6.3.1 The switches shall be motor duty type AC 23 Category and shall comply with the requirements laid down in IS/IEC 60947. Switches up to 63 Amps shall be rotary type and those of 100 Amps. & above, link type.

6.3.2 'ON' and 'OFF' position of the switches shall be indicated on the module. Provision shall be made to lock the switch in the 'OFF' position.

6.3.3 The fixed contacts shall be shrouded type. All contacts shall be silver plated.

## 6.4 Fuses

6.4.1 The fuses shall be of non-deteriorating HRC cartridge link type and shall conform to IS: 13703. They shall be suitable for the load and service required in the circuit.

6.4.2 One fuse puller shall be supplied along with each board.

## 6.5 Air Break Contactors

6.5.1 The Air Break Contactors shall be of Category AC3/AC4, unless otherwise specified, conforming to IS: 60947 and flapper type.


6.5.2 The dropout voltage shall not exceed 65% of rated voltage.

6.5.3 Each contactor shall be provided with auxiliary contacts as required. The rating of the auxiliary contacts shall be 5 Amps. AC or 1 Amp DC at the specified control voltages. The spare auxiliary contacts shall also be wired up to the terminal blocks.

## 6.6 Bimetal Thermal Overload Relays

6.6.1 The contactor shall be provided with three pole bimetal thermal overload relays, unless other-wise specified. The bimetal relays shall be of suitable range, ambient temperature



<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></div> <div><b>SPECIFICATION - MEDIUM VOLTAGE SWITCH BOARDS</b></div>	<div>PC288-TS-0805</div>	<div>0</div>	<div><div>श्री एम आई एल <b>BHEL</b></div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 12 of 22</div>		

compensated and shall be separate mounting type. They shall be adjustable through graduated scale and shall be provided with changeover contact. Thermal relays having long time/current characteristics, operated through saturated C.T.s shall be supplied, wherever required.

6.6.2 Bimetal thermal relays shall conform to IS: 3231 and IS/IEC 60947 and shall have built-in single phasing preventor.

6.6.3 The bimetal relays shall be provided with a manual resetting device resettable after opening module door. Auto reset thermal relays are not acceptable.

#### 6.7 **Current Transformers**

6.7.1 The current transformers shall conform to IS: 2705.

6.7.2 C.T.s shall be Class F insulated and vacuum impregnated or resin cast. The C.T.s shall be rigidly mounted and shall be easily accessible for maintenance and testing.

6.7.3 The short time thermal withstand ratings of C.T.s shall be same as the thermal withstand rating of the breakers.

6.7.4 The C.T.s output shall be minimum 15VA for breaker feeders and 7.5 VA for the other feeders per phase and in any case, the output shall be adequate for the protection and metering duties involved with sufficient margin. The C.T.s shall have the following accuracies for the various applications:

#### **Application**

#### **Class of accuracy as per IS: 2705**

- |  |      |
|--|------|
| i) For metering service  | - 1  |
| ii) For use with protective relays                               | - 5P |
| iii) For use with restricted earth fault and differential relays | - PS |

6.7.5 The C.T. cores for metering and protection shall be separate.

6.7.6 The ratio of C.T.s shall be as specified in Feeder details.

6.7.7 All the C.T.s shall be provided with terminals and shorting links. One of the terminals of the C.T. shall be earthed. The polarity of the C.T.s shall be clearly marked.

6.7.8 Provision of Interposing C.T.s is not acceptable.

6.7.9 The C.T.s shall be capable of withstanding momentary open circuit on the secondary side without injurious effects.

#### 6.8 **Voltage Transformers**




6.8.1 The V.T.s shall be Class F insulated and vacuum impregnated or resin cast conforming to IS: 3156.

6.8.2 The primary nominal voltage shall be equal to the system nominal voltage. The secondary terminal voltage shall be 110 V.

6.8.3 The primary and secondary winding shall be protected by HRC fuses in each phase except in the ground phase of the secondary side.

6.8.4 The V.T.s shall be mounted on separate withdrawable carriage. The accuracy Class of V.T.s shall be 1.

6.8.5 The rated output of each V.T. shall be adequate for the relays, meters and associated wiring connected to it and shall not be less than 50 VA per phase.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>SPECIFICATION - MEDIUM VOLTAGE SWITCH BOARDS</b>	<b>PC288-TS-0805</b>	<b>0</b>	 श्री एम आई एल 
		Document No.	Rev	
		Sheet 13 of 22		

## 6.9 Control Transformers

These shall be air cooled Class F insulated and vacuum impregnated. The rating of control transformer shall be twice the hold on VA of all contactor/relays or 2.5 KVA whichever is high. It shall be free from hum and rigidly mounted. Epoxy cast transformers shall be preferred.

## 6.10 Transformers for Kondorffer Starting

These shall be three phase core type, Class F insulated and vacuum impregnated. Tapping at 90%, 80%, 70% & 60% shall be provided and terminals shall be brought out for easy change of tapping at site. The operating temperature shall not exceed 80°C. The transformers shall be suitable for taking 7.5 times the specified full load current of the motor continuously for 120 secs.

## 6.11 Relays

6.11.1 All protective relays shall be of latest version, microprocessor based numerical type with communication port and interlinked with online energy management system. 100% redundancy shall be provided for communication.

## 6.12 Timers

The timers shall be electronic pneumatic or synchronous type with manual/auto reset features as per the functional requirements. The time delay shall be 'ON' delay or 'OFF' delay type as specified. The repeat accuracy shall be 0.5% or better.

## 6.13 Single Phasing Preventor

6.13.1 Single phasing preventor relay shall be of the current operated type, suitable for the system voltage. The relay shall not operate for normal system voltage but operate positively in the event of unbalanced voltage more than the normal. The relay shall not operate in case of total interruption of power.

6.13.2 The relay shall be fail safe, self reset type and provided with flag indication. The relay operation shall be independent of the motor rating, loading and speed.

## 6.14 Instruments and Meters

6.14.1 All instruments shall be flush mounting type with square face of 96 mm x 96 mm. They shall be tropicalized and dust tight.

6.14.2 Meters shall be digital multifunctional meters with communication port for energy management at remote location.

6.14.3 All ammeters and voltmeters, to be provided separately, shall have 0-90° scale and shall be moving iron spring controlled type of class 1.5 accuracy as per IS: 1248. The scale range of the ammeters and voltmeters shall be as indicated in the Feeder details.

6.14.4 In case of motor feeders, the ammeters shall be graduated uniformly upto C.T. primary current and with compressed end scale upto 6 times C.T. primary current. Red pointer shall be provided, which shall be adjusted at site for indicating full load current of the motor.

## 6.15 Push Buttons and Control Switches

6.15.1 The switches and push buttons shall conform to utilization category AC11/DC11 as per IS: 60947. The contact shall be rated to make, break and carry inductive current of 5 Amp at 415 V AC and 1 Amp at 220 V DC.

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></div> <div><b>SPECIFICATION - MEDIUM VOLTAGE SWITCH BOARDS</b></div>	PC288-TS-0805	0	<div><div>श्री एम आई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 14 of 22		

- 6.15.2 The control switches shall be spring return rotary type, unless otherwise specified and provided with pistol grip type handle. The control switches for circuit breakers shall be additionally fitted with lost motion devices and sequencing devices.
- 6.15.3 The selector switches shall be stay put rotary type and provided with oval shape handles.
- 6.15.4 The push buttons shall be of momentary contact spring loaded type with a set of normally close and open contacts. The push button for 'Start' shall be shrouded type and coloured green, stop push button shall be un-shrouded type and coloured red and other push buttons shall be un-shrouded type coloured black. The fixing ring shall be metallic white.
- 6.15.5 Emergency stop push buttons, if specified, shall be lockable in pushed position.

#### 6.16 **Miniature Circuit Breakers**

- 6.16.1 The miniature circuit breakers shall conform to IS: 8828 and shall be of duty category M-9.
- 6.16.2 It shall be provided with overload and short circuit protective devices in a heat resistant housing.
- 6.16.3 A certificate for short circuit rating and Current-Time tripping curve shall be furnished along with the offer.

#### 6.17 **Signal Lamps**

- 6.17.1 Signal lamps shall be provided to indicate the various circuit conditions as shown in scheme drawings. The colour of the lamps for various functions shall be as follows :
- |       |    |   |
|-------|----|---|
| Red   | -- | Circuit breaker/switch/contactors closed. |
| Green | -- | Circuit breaker/switch/contactors open.   |
| White | -- | Trip circuit healthy.                     |
| Amber | -- | Alarm and auto trip.                      |
| Blue  | -- | Non-Trip                                  |
- 6.17.2 All lamps shall be of LED type with lumen output of 200 mili candela in axial direction.

### 7.0 **ACCESSORIES**




- 7.1 The supply shall include the following accessories:
- Maintenance truck/device for raising, lowering and withdrawal of circuit breaker, if required.
  - Fuse puller.
  - Test plug for relays.
  - Test plug for kWh meters.

#### 7.2 **Space Heater**

Each vertical section shall be provided with a thermostatically controlled space heater, rated for 240 V, 50 Hz and controlled through double pole miniature circuit breaker.

#### 7.3 **Name Plates**

- 7.3.1 The switchboard shall have large name plate on the top indicating its Name, Designation and Code No.
- 7.3.2 Each feeder shall be provided with name plate. Each single front panel shall have name plate indicating panel number both in front and back.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>SPECIFICATION - MEDIUM VOLTAGE SWITCH BOARDS</b>	PC288-TS-0805	0	 श्री एम आई एल 
		Document No.	Rev	
		Sheet 15 of 22		

- 7.3.3 All control switches, push buttons, lamps etc. shall have functional identification labels.
- 7.3.4 Name plate shall be of black Perspex with white engraving and of minimum 3mm thick.
- 7.4 Any other accessories required, but not specified, shall also be supplied to make the switchboard complete in all respects and ensure safe and proper operation.

## 8.0 PAINTING

- 8.1 The enclosure, after degreasing, pickling in acid, cold rinsing, phosphatising, passivating etc. shall be painted with two coats of anti-rust paint followed by two coats of anticorrosive paint.
- 8.2 Epoxy based paint shall be used.
- 8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.
- 8.4 Unless otherwise specified, the finishing shade shall be light grey having Shade No.631 as per IS: 5.
- 8.5 One litre of paint shall be supplied along with each board for touch up at site.

## 9.0 TESTS AND INSPECTION




- 9.1 All the switchboards shall be subjected to routine test as per IS: 8623 and their components as per relevant standards.
- 9.2 Additional tests, wherever specified, shall be carried out.
- 9.3 All the above tests shall be carried out in presence of Purchaser's representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and site inspection.
- 9.4 These inspections shall however, not absolve the vendor from their responsibility for making good any defect which may be noticed subsequently.

## 10.0 DRAWINGS AND DOCUMENTS

- 10.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.
- 10.2 All drawings and documents shall have the following description written boldly:
- Name of Client
  - Name of Consultant
  - Enquiry / Order Number with Project / Plant Name
  - Code No. & Description

## 11.0 SPARES

- 11.1 Commissioning Spares: Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval.
- 11.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>SPECIFICATION - MEDIUM VOLTAGE SWITCH BOARDS</b>	<b>PC288-TS-0805</b>	0	 कोयला इंडिया  BHEL
		Document No.	Rev	
		Sheet 16 of 22		

11.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.

11.4 All spare parts shall be identical to the parts used in the equipment

## 12.0 PACKING

12.1 The board shall be properly packed before despatch to avoid damage during transport, storage and handling.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

12.3 A sign to indicate the upright position of the panels to be placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.

## 13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

## ANNEXURE - I

### DOCUMENTATION FOR MEDIUM VOLTAGE SWITCHBOARDS

Sl.No.	Documentation Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheets	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	Feeder Details	N	Y	Y
4.	General arrangement and Foundation Drgs.	N	Y	Y
5.	Schematic and Wiring Diagrams	N	Y	Y
6.	Calculation for Bus-bar sizing	N	Y	N
7.	Terminal Arrangement Drgs.	N	Y	Y
8.	Illustrative and Descriptive Literature	N	N	Y
9.	Catalogues for bought out accessories.	N	N	Y
10.	Installation, Operation and maintenance manual.	N	N	Y
11.	Test Certificates			
	i) Type -- Switchboard	N	N	N
	-- Circuit Breaker	N	N	N
	-- MCCB's	N	N	N
	ii) Routine	N	N	Y
12.	Guarantee Certificates	N	N	Y
13.	Spare Parts List	N	N	Y

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N – No


	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>		<b>PC288-TS-0805</b>	<b>0</b>
	<b>SPECIFICATION - MEDIUM VOLTAGE SWITCH BOARDS</b>		Document No.	Rev
			Sheet 18 of 22	



### SPECIFICATION SHEET 415V SWITCHBOARD

CLIENT : JV OF CIL & BHEL		PROJECT : ELECTRICAL DIST. SYSTEM		PLANT: SYNGAS PURIFICATION UNIT	
ISSUED FOR : PROPOSAL <input type="checkbox"/>		ENQUIRY <input checked="" type="checkbox"/>		ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>	
<b>GENERAL</b>			<b>AMBIENT CONDITION</b>		
Ref. Stds. : IS & IEC			Temp. Max./Min./Design Ref. 46 / 1 / 50°C		
Encl. Docs. :			Relative Humidity 100 % Alt. above sea : <1000 M		
Vendor :			<b>Atmospheric Pollution</b>		
Vendor Ref. No. :			Dusts : Coal Dust		
			Vapour : Ammonia & Highly Corrosive		
			<b>Location</b>		
			Indoor <input checked="" type="checkbox"/> Outdoor <input type="checkbox"/>		
			Gr. Floor <input type="checkbox"/> 1 <sup>st</sup> floor <input checked="" type="checkbox"/>		
<b>Addl. Scope :</b>		Incoming Bus Duct <input checked="" type="checkbox"/>		Tie Bus Duct <input type="checkbox"/>	
		Erection & Comm. <input checked="" type="checkbox"/>		Supervision of Erection Comm. <input type="checkbox"/>	
TESTS: Routine <input checked="" type="checkbox"/> Type <input type="checkbox"/> Others <input type="checkbox"/>					
<b>BASIC DATA</b>					
<b>TAG NO.</b>	Item No.				
	Description				
	Code No.				
<b>REFERENCE DRAWINGS</b>	Single Line Diagram				
	Feeder Details				
	Auto Trip Alarm Scheme				
	Non Trip Alarm Scheme				
	Trip Circuit Supervision Scheme				
	Auto C/O Scheme				
	P.T. Bus Arrangement				
<b>SYSTEM DETAILS</b>	Nominal Voltage with Variation		415V $\pm$ 10%		
	Rated Frequency with Variation		50Hz $\pm$ 5%		
	Combined V & F Variation		$\pm$ 10%		
	No. of Phases & Wires		3 Ph & 4W		
	Insulation Level		2.5 KV		
	Fault Level		36 MVA		
	Earthing Mode		Solidly Earthed		
<b>BUS BARS</b>	<b>Rating</b>	Continuous			
		Short Time for 1 sec.	50 KA		
	Bare / Insulated		Insulated		
	Type of Insulation		Heat Shrinkable PVC sleeved		
<b>EXECUTION</b>	<b>Breaker Feeders</b>	I/C: ST / DT	ST		
		Others: ST / DT	DT		
	<b>Other Feeders</b>	Single front / Double front	Front		
		Fixed / Drawout	Drawout		
	Cable Entry : Top / Bottom		Bottom		
	Bus Duct Entry : Top / Bottom		--		
	Accessibility : Front / Back		Front / Back		
<b>CONTROL SUPPLY</b>	<b>Breaker Feeders</b>	Closing & Indication	110V DC		
		Tripping	110V DC		
	Contactors		240 V AC		
	Space Heater		240 V AC		
<b>MISC. DATA</b>	<b>Painting</b>	Type	Epoxy		
		Shade	631 of IS: 5		
	Period for which Spares required		2 Years		

Note: Specification Sheet shall be filled by the bidder and submitted with the bid.

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>		PC288-TS-0805	0	
	<b>SPECIFICATION - MEDIUM VOLTAGE SWITCH BOARDS</b>		Document No.	Rev	
			Sheet 19 of 22		


### TECHNICAL PARTICULARS 415V SWITCHBOARD

CLIENT : JV OF CIL & BHEL		PROJECT : ELECTRICAL DIST. SYSTEM		PLANT: SYNGAS PURIFICATION UNIT	
ISSUED FOR :		PROPOSAL <input type="checkbox"/>	ENQUIRY <input checked="" type="checkbox"/>	ORDER <input type="checkbox"/>	FINAL <input type="checkbox"/>
<b>GENERAL</b>					
Manufacturer's Type					
Ref. Standards					
Rated Operational Voltage with $\pm$ %					
Rated Insulation Voltage					
Rated Voltage of Aux. Circuits with $\pm$ %					
Rated Current					
Short Circuit Rating					
Degree of Protection of Enclosure					
Service Conditions : Indoor / Outdoor					
<b>DRAWOUT FACILITIES</b>	Circuit Breakers				
	P.Ts.				
	Motor Starters				
	Protective Relays				
	Meters				
<b>SINGLE FRONT / DOUBLE FRONT</b>	C.B. Feeders				
	Other Feeders				
Cable Entry :	Top / Bottom				
Accessibility :	Front / Back				
<b>MAXIMUM NOS. OF FEEDERS IN ONE PANEL</b>	Circuit Breakers				
	Motor Starters				
	Switch Fuse				
<b>SHEET STEEL TYPE &amp; THICKNESS</b>	Load Bearing member				
	Non Load Bearing member				
	Base Channel				
Material of Gaskets					
Material of External Hardware					
Operating Height : Max. / Min.					
Space Heater Rating of each Panel					
<b>PAINTING</b>	Method of Pre-treatment				
	Type				
	Thickness of Paint				
	Finishing Shade				
Dimensions : L X B X H / Dim. Drg. Ref. No.					
Shipping Dimensions of Largest Package					
Weight : Static / Dynamic					
<b>BUS - BARS</b>					
Material					
<b>SIZE</b>	HBB : Phase / Neutral				
	VBB : Phase / Neutral				
	Ground				
	Supporting Calculations Attached				
<b>MINIMUM CLEARANCE</b>	Between Phases				
	Between Phase & Earth				
Minimum Creepage Distance					
Current Rating : Continuous / Short Time					
Temp. Rise for : Cont. Load / Short Time Current					
<b>SUPPORT</b>	Material				
	BIL				
	Arrangement : Separate/Common				
Material of Bus-bar Insulation					
Shrouding Material for Joints					
No. & Type of Bolts					



	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>SPECIFICATION - MEDIUM VOLTAGE SWITCH BOARDS</b>	PC288-TS-0805	0	
		Document No.	Rev	
		Sheet 20 of 22		

CIRCUIT BREAKERS			
Make			
Maker's Type			
Ref. Standards			
Type of Circuit Breaker			
Short Circuit Category			
Maximum Operating Voltage			
No. of Poles			
<b>CURRENT RATING</b>	Continuous		
	1 second RMS		
	Momentary ( kA Peak )		
<b>BREAKING CURRENT</b>	Symmetrical KA		
	Asymmetrical KA		
	Sym. MVA at Rated Voltage		
Making Current ( Peak )			
<b>INSULATION LEVEL</b>	1 Min. PF withstand Voltage		
	Impulse withstand Voltage		
No. of Breaks per Pole			
<b>TYPE AND MATERIAL OF</b>	Main Contacts		
	Arcing Contacts		
Contact Pressure			
Type of Closing Mechanism			
Type of Tripping Mechanism			
Type of Arc Control Device			
Arc Pumping Features with Details			
Trip Free Features with Details			
Total Closing Time			
Interrupting Time at 10%, 50%, 100% of rated Interrupting Capacity		Total	
		Arcing Time	
<b>SPRING CHARGING MOTOR</b>	Rating		
	Voltage		
	Insulation		
	Duty		
Spring Charging Time			
<b>CONTROL VOLTAGE WITH RANGE</b>	Closing		
	Tripping		
	Alarm and Indication		
<b>POWER/ CURRENT REQUIRED FOR</b>	Closing		
	Tripping		
<b>AUXILIARY CONTACTS</b>	No. of Spare Contacts : NO / NC		
	Contact Rating : AC / DC		
	Convertible : Yes / No		
Net Weight of Breaker			
Type Testing Authority & Test Report Ref. No.			
CURRENT TRANSFORMERS			
Make / Maker's Type			
Ref. Standard			
Type of Primary Winding			
Ratio			
Rated Burden			
Accuracy Class			
ALF / ISF			
Insulation Class & Material			
Ref. Magnetisation Curve No.			
POTENTIAL TRANSFORMERS			
Make / Maker's Type			
Ref. Standard			
Winding Connection			

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>SPECIFICATION - MEDIUM VOLTAGE SWITCH BOARDS</b>	PC288-TS-0805	0	
		Document No.	Rev	
		Sheet 21 of 22		

Ratio	
Rated Burden	
Accuracy Class	
Insulation Class & Material	
<b>SWITCHES</b>	
Make / Maker's Type	
Ref. Standard	
Type of Switch	
Rated Operational Voltage	
Utilisation Category	
Rated Operational Current	
Short Time Withstand Current	
No. of Poles / Break	
Type Test Certificate Ref. No.	
<b>FUSES</b>	
Make / Maker's Type	
Ref. Standard	
Type of HRC Fuse	
Rated Voltage / Current	
Category of Duty	
Prospective Breaking Current	
<b>CURRENT TIME CURVE SHOWING PRE-ARCING AND TOTAL I<sup>2</sup>T VALUES</b>	Ref. No. Attached
<b>CONTACTORS</b>	
Make / Maker's Type	
Ref. Standard	
Rated Operational Voltage	
Utilisation Category	
Rated Duty	
Rated Thermal Current	
<b>OPERATING VOLTAGE OF COIL</b>	Pick up Max./Min. Drop off Max./Min.
Coil Consumption Pick up / Hold on	
<b>RELAYS</b>	
Make / Maker's Type	
Ref. Standard	
Operating Principle	
Setting Range	
Type of Mounting	
Burden	
Reset : Hand or Self	
Flag Indication Type	
Ref. Characteristic Curve Type	
Ref. Descriptive catalogue	
<b>INSTRUMENTS AND METERS</b>	
Make / Maker's Type	
Ref. Standard	
Operating Principle	
Scale Range	
Accuracy	
Size	
Type of Mounting	
<b>CONTROL SWITCHES</b>	
Make / Maker's Type	
Ref. Standard	
Contact Rating	
Utilisation Category	
<b>PUSH BUTTONS</b>	
Make / Maker's Type	
Ref. Standard	
Contact Rating	

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>  <b>SPECIFICATION - MEDIUM VOLTAGE SWITCH BOARDS</b>	PC288-TS-0805	0	
		Document No.	Rev	
		Sheet 22 of 22		

Utilisation Category	
<b>SIGNAL LAMPS</b>	
Make / Maker's Type	
Ref. Standard	
Rated Voltage / Watts	
Type of Lamp Holder	
Type of Globe	
<b>MINIATURE CIRCUIT BREAKER</b>	
Make / Maker's Type :	
Ref. Standards	
Rated Current	
Breaking Capacity	
<b>MOULDED CASE CIRCUIT BREAKERS</b>	
Make / Maker's Type	
Ref. Standard	
Current Rating	
Breaking Capacity	
Setting Range of Thermal Release	
Setting Range of Magnetic Release	
<b>CABLE GLANDS</b>	
Material	
Type	
<b>TERMINAL BLOCKS</b>	
Make	
Type	
Current Rating	

Note: Technical Particulars shall be filled by the bidder and submitted with the bid.

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</div>	PC288-TS-0806	0	<div></div>
		Document No.	Rev	
		Sheet 1 of 24		

# **TECHNICAL SPECIFICATION** **HIGH VOLTAGE SWITCH BOARDS**

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS	<b>PC288-TS-0806</b>	<b>0</b>	 कोयला इंडिया <b>Coal India</b>  <b>BHEL</b>
		Document No.	Rev	
		Sheet 2 of 24		

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	DESIGN AND CONSTRUCTIONAL FEATURES
6.0	COMPONENT DETAILS
7.0	ACCESSORIES
8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	DRAWINGS AND DOCUMENTS
11.0	SPARES
12.0	PACKING
13.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR HIGH VOLTAGE SWITCHBOARDS

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</b>	PC288-TS-0806	0	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 3 of 24		

## 1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well-packed condition of High Voltage Switch Boards.
- 1.2 This standard shall be read in conjunction with relevant part of Design Philosophy – Electrical , Schematic diagrams etc.

## 2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of the equipment shall comply with the latest issues of the following standard, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

IS: 3427 A.C. Metal enclosed switchgear and control gear for rated voltages above 1 kV up to and including 52 kV.

IS: 13118 Specification for high voltage alternating current circuit breakers.

IS: 5578 Guide for marking of insulated conductors.

IS: 11353 Guide for uniform system of marking and identification of conductors and apparatus terminals.

IS: 10118 Code of Practice for selection, installation and maintenance of switchgear and control gear.

Various components housed in the switchboards shall conform to the Indian Standards Specification as mentioned against the component details or IEC Specifications.

- 2.2 The design and operational features of all the equipment offered shall also comply with the provisions of the latest issue of the Indian Electricity Rules and other Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.
- 2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications / IEC Specification, the requirement specified herein shall prevail.

## 3.0 SERVICE CONDITIONS

### 3.1 Ambient Conditions

These shall be as indicated in Design Philosophy – Electrical.

### 3.2 System Details

These shall be as indicated in Design Philosophy – Electrical.

## 4.0 OPERATING REQUIREMENTS

The switchboards shall be suitable for operating at the specified rating continuously, with the specified voltage and frequency variations under the ambient conditions, without exceeding the permissible temperature rise and without any detrimental effect on any part.

## 5.0 DESIGN AND CONSTRUCTIONAL FEATURES

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</div>	PC288-TS-0806	0	<div> बी एच ई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 4 of 24		

## 5.1 General

- 5.1.1 The switchboards shall consist of an assembly of a series of floor mounting, identical, metal clad, cubicle type panels placed side by side to form a compact assembly and shall be extensible on either side.
- 5.1.2 The complete assembly shall be dust, damp and vermin proof having minimum degree of protection equivalent to IP4X as per IS/IEC:60529. However, in case some ventilation openings are to be provided, these may be permitted for equipment located indoors and such openings shall be covered by fine wire mesh ensuring minimum IP3X protection.
- 5.1.3 The framework of the cubicles shall be bolted / welded construction. The minimum thickness of sheet steel shall be 3 mm for base channel and 2 mm for other members. The doors and covers shall be fabricated from cold rolled sheet steel. Suitable reinforcement, wherever necessary, shall be provided.
- 5.1.4 The switchboard shall be mounted on the channel which shall be included in the vendor's scope.
- 5.1.5 Each cubicle shall be provided with front access door with handle lock and key for breaker compartment and a removable back cover. The door hinges shall be concealed type. Front doors of the panels shall mechanically stop in full open position to facilitate removal of breakers and for ease of maintenance.
- 5.1.6 All external hardware shall be cadmium plated. The hardware for fixing removable parts shall be provided with retaining devices.
- 5.1.7 The doors and the removable covers shall be provided with non-deteriorating neoprene gaskets. Gaskets without any discontinuity shall be preferred. Gaskets shall be held in position in groove, in shaped sheet steel work or these shall be U-type.
- 5.1.8 Each cubicle shall have separate compartment within the cubicle for circuit breaker, bus-bars, instrument transformers, metering and relaying devices and cable termination.
- 5.1.9 Inter-panel and inter-compartment fire resistant barrier shall be provided. Cast resin seal off bushing shall be provided in the bus compartment, through which connections to breaker compartment/cable compartment/bus compartment of adjacent panel shall be taken. Failure of one of the equipment shall not effect the equipment in the adjacent compartment.
- 5.1.10 All the components shall be accessible for inspection and maintenance without the necessity of removing the adjacent ones. Their mounting shall be accessible and ensure the necessary degree of safety.
- 5.1.11 The layout of the components inside the cubicle shall be liberal to facilitate maintenance and the interconnecting wiring between components shall not be subjected to undue stresses at the bends.
- 5.1.12 Mounting height of components requiring operation and maintenance shall not be lower than 300 mm and higher than 1800 mm.
- 5.1.13 All live parts which are accessible after opening of front and back door/cover shall be properly insulated or provided with insulating barrier to prevent accidental contact. Phase insulating barriers shall be provided between the breaker poles. Removal facility shall be provided for all such barriers.
- 5.1.14 Adequate arrangement for earthing shall be provided to safeguard the operator or other personnel from electric hazards under all conditions of operation.
- 5.1.15 The switchboard shall be provided with following interlocks and safety features:
  - i) The withdrawal and engagement of a circuit breaker shall not be possible unless it is in open position.

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</div>	<div>PC288-TS-0806</div>	<div>0</div>	<div> श्री एच ई एल </div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 5 of 24</div>		

- ii) The operation of a circuit breaker shall not be possible unless it is in fully service, test or isolated position.
- iii) It shall not be possible to close the circuit breaker in service position unless all auxiliary and control circuits are connected.
- iv) A breaker of the lower rating shall be prevented from engaging with the stationary element of higher rating.
- v) Insertion of the manual mechanism shall render the motorized mechanism inoperable.
- vi) Circuit breaker "ON", "OFF" indication shall be provided at the back of each panel.
- vii) Caution name plate shall be provided at the back of incomer panels where terminals are likely to remain live and isolation is possible only from remote end.
- viii) Automatic safety shutter, with padlocking facility for locking in closed position, to completely cover the spouts for bus-bars and cable connection when the breaker is withdrawn.

## 5.2 Bus-Bars and Connections

- 5.2.1 The bus-bars shall be for three phases. The bus-bars and connection shall be made of electrolytic grade copper of rectangular cross-section.
- 5.2.2 Bus-bars and connections shall be sleeved to protect against approach to live parts and to eliminate potential arcing points. Sleeving material shall have adequate electrical, thermal and mechanical properties to withstand impulse level, temperature rise during normal and short circuit condition and allow easy bending of bus bars.
- 5.2.3 The bus-bars shall be amply sized to carry the rated continuous current under the specified ambient temperature without exceeding the limits specified in IS: 8084. The thermal rating of the bus-bars shall be designed to withstand the system fault current for 3 seconds without exceeding the limiting temperature of 250°C for bare copper. Calculation for bus-bar sizing shall be furnished along with the offer.
- 5.2.4 Horizontal bus-bars shall run in a separate compartment through the entire length of the board and shall be of same cross-section throughout. Stepped bus-bars shall not be acceptable.
- 5.2.5 The bus-bars shall be arranged and colour coded according to IS: 5578 & IS: 11353.
- 5.2.6 The bus-bars chamber shall be sufficiently spacious and shall have separate screwed covers for maintenance purpose. It shall be adequately ventilated and shall allow the escape of the hot gases.
- 5.2.7 The bus-bars shall be rigidly supported at equal intervals to withstand the stresses due to full short circuit and also to take care of thermal expansion.
- 5.2.8 A minimum of two bolts shall be used per bus-bar joint. Only high tensile electro galvanized cadmium plated bolts, nuts and washers shall be used. The washers shall be spring and plain type. The bus-bar supports shall be of molded construction with built-in anti-tracking barriers. The support materials shall be of DMC or fiber glass reinforced thermosetting plastic.
- 5.2.9 The bus-bars, both horizontal and vertical, shall be PVC sleeved. Insulating shrouds shall be provided for all joints of insulated bus-bars.

## 5.3 Earth Bus

A continuous earth bus of Aluminium running along the lower part of the switchboard shall be provided with two end terminals with lugs for external connection. The earth bus shall be rated to carry three phase fault current for a period of 3 sec.



<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</div>	PC288-TS-0806	0	<div> बी एच ई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 6 of 24		

#### 5.4 **Bus Duct**

- 5.4.1 Suitable extension of bus-bars in proper phase sequence on the top, with connecting bolts shall be provided where connections between transformer and switchboard or between two halves of the switchboard is specified to be through bus duct.
- 5.4.2 Bus duct between two halves of the switchboard, if required, shall be supplied by the switchboard manufacturer. The bus-bars of interconnecting bus duct shall be similar to the main bus-bars of switchboard as specified above and shall conform to IS: 8084.
- 5.4.3 Bus duct between transformer and switchboard, if included in vendor's scope shall conform to IS: 8084.

#### 5.5 **Clearances and Creepage Distance**

The clearance and creepage distance shall be adequate to meet the BIL of the equipment.

#### 5.6 **Insulation**

- 5.6.1 The insulation used shall be non-hygroscopic and shall be of porcelain, epoxy resins or fiber glass molded with plastic. It shall be of adequate electrical, mechanical and thermal strength to give trouble free service during normal operation and short circuit conditions.
- 5.6.2 The insulation shall be treated suitably to withstand the tropical conditions and atmospheric pollution.

#### 5.7 **Control Wiring**

- 5.7.1 The switchboard shall be completely factory wired and ready for external connections.
- 5.7.2 The wiring shall be complete in all respect so as to ensure proper functioning of control, interlocking, protection, metering, indications and annunciations.
- 5.7.3 The wiring shall be carried out with flexible stranded PVC insulated copper conductor cables of 1100 Volt grade. The minimum size of wires shall be as follows:
- |                           |    |            |
|---------------------------|----|------------|
| C.T. Circuit              | -- | 2.5 Sq. mm |
| V.T. and Control Circuits | -- | 1.5 Sq. mm |
- 5.7.4 All wiring shall be provided with dependent both ends marking as per IS: 5578. Numbered ferrules, reading from the terminal outwards, shall be provided at both ends of all wiring for easy identification. These shall be interlocking type plastic ferrules.
- 5.7.5 Control wiring circuits, fed from a supply common to a number of panels, shall be so protected that failure of a circuit in one panel does not affect the operation of other panels.
- 5.7.6 The wiring to the equipment mounted on the doors shall be carried out with flexible multi-strand copper conductor cable and so supported that on opening of the door, there is no undue strain on wire leads.
- 5.7.7 The control cables shall be neatly arranged and properly supported.

#### 5.8 **External Cable Termination**

- 5.8.1 All power and control cables shall enter the switchboard from the bottom on the back of the panel. Sufficient space shall be provided for ease of connection and termination of cables.
- 5.8.2 All power cables and control cables shall be of type, number and size as indicated in Feeder Details.
- 5.8.3 The termination arrangement for single core cables shall be such that so as to minimize flow of eddy current and heating due to eddy currents.

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</div>	PC288-TS-0806	0	<div> बी एच ई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 7 of 24		

- 5.8.4 Heavy duty double compression type rolled Aluminium cable glands along with the cable lugs, as required shall be provided for termination of control cables and auxiliary power supply cables.
- 5.8.5 The cable glands shall be mounted on a removable gland plate, provided at a minimum height of 75 mm from the bottom of the switchboard. Two number spare knockouts of size 20 mm shall also be provided on the gland plate for future use.
- 5.8.6 Terminal blocks shall be provided at suitable locations inside the panels for termination of control and auxiliary power supply wiring. These terminal blocks shall be pressure clamp type up to 35 sq. mm cables and bolted lug type for higher sizes of cables. These shall be protected type and rated for 1100 Volt service. The minimum current rating of the terminal block shall be 16 Amp.
- 5.8.7 Where more than two cables in parallel are required to be terminated, a system of bus links shall be provided with adequate clearance and spacing.
- 5.8.8 The terminal block shall be grouped according to circuit functions and numbered suitably. 20% extra terminals shall be provided in the terminal block.
- 5.8.9 Suitable clamps to support the vertical run of cables shall be provided.
- 5.8.10 For power connections, suitable marking on the terminals shall be provided to identify the phases.
- 5.9 **Feeder Details**
- 5.9.1 The requirements of incomer, bus coupler and outgoing feeders shall be as indicated in the single line diagram, feeder details and corresponding schematic diagrams.
- 5.9.2 Non-paralleling interlocks shall be provided between incomers and bus section panels. The interlocks shall be either electrical or mechanical type. Arrangement for defeating the interlock shall also be provided.
- 5.9.3 Auto changeover scheme, wherever specified, shall be provided.
- 5.10 **Dummy Panels**
- Dummy panels complete with bus-bar system in 400 mm width shall be required for which unit price shall be indicated.
- 5.11 **Control Power Supply**
- 5.11.1 D.C. power required for closing, tripping and indication shall be supplied at the bus coupler panel through two completely separate circuits by the owner, one for tripping and another for closing and indication for the whole board.
- 5.11.2 For receiving each external control power supply, a double pole miniature circuit breaker shall be provided. This power shall be distributed inside the switchboard for each feeder having its MCB unit.
- 5.12 **Space Heater Power Supply**
- 5.12.1 Panel space heaters shall be fed from a separate bus, common for the whole board. This bus shall be fed from owner's supply for which a double pole MCB shall be provided in bus section panel.
- 5.12.2 Power supply for space heaters of motors shall be tapped from this bus by means of miniature circuit breakers located in the motor feeder panels. These MCB's shall be of triple pole and rated for 15 Amp.

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</div>	PC288-TS-0806	0	<div> बी एच ई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 8 of 24		

## 6.0 COMPONENT DETAILS

Makes of all components shall be subject to owner's / consultant's approval

### 6.1 Circuit Breakers

- 6.1.1 The circuit breakers shall comply with the requirements of IS: 13118.
- 6.1.2 All circuit breakers shall be of 0-3 min-CO-3 min-CO rated operating sequence capable of carrying the specified current at the site conditions and making/breaking of the system fault current.
- 6.1.3 Type test certificates from an independent testing authority shall be furnished along with the offer for each circuit breaker rating and type.
- 6.1.4 The circuit breakers controlling motors shall be suitable for DOL starting and stopping induction motor a number of times and shall have provision to limit over voltage to the value safe for motor insulation. Unless otherwise specified this value shall be taken as 2.5 times the rated voltage. The magnitude of the voltage surge produced by the breaker when switching off the smallest motor shall be indicated.
- 6.1.5 The circuit breakers controlling capacitors shall be suitable for energizing and de-energizing the rated capacitor bank.
- 6.1.6 The circuit breakers shall be of the 3 phase, single/double break, horizontal draw-out, vertical/horizontal isolation type. The medium of arc quenching shall be minimum Oil/Bulk oil/vacuum/SF6 as specified elsewhere.
- 6.1.7 The circuit breakers shall be suitable for electrical/manual closing as specified in Feeder details. Electrically operated circuit breakers shall preferably have motor wound spring closing mechanism with provision for manual closing arrangement. Manually operated circuit breakers shall have independent manual spring closing mechanism. In all cases tripping shall be by means of shunt trip coil.
- 6.1.8 All circuit breaker units of the same rating shall be physically and electrically interchangeable.
- 6.1.9 The circuit breakers shall be electrically and mechanically trip free and provided with anti-pumping feature.
- 6.1.10 The circuit breakers shall have three positions, i.e. service, test and isolated with the cubicle door closed. Necessary stoppers shall be provided to prevent the excessive movement of the breaker cradle than desired for the position. Service and test positions of the breaker shall have monitoring switch having 1NO+1NC contacts.
- 6.1.11 The circuit breakers shall be provided with emergency manual trip device, mechanical 'ON', 'OFF', 'ISOLATED' position and spring 'CHARGED', 'DISCHARGED' indicators and operation counter.
- 6.1.12 A maintenance truck/device, if required, for raising, lowering and withdrawals of the circuit breaker shall be supplied for each switchboard.
- 6.1.13 The arc interrupting devices shall be capable of interrupting satisfactorily current from zero to the rated interrupting current when used on predominantly capacitive or inductive circuits, without requiring excessive maintenance of the contacts. The arc shall be restricted within the interrupting chamber and no emission of flame shall be allowed which may cause electrical breakdown or damage to insulation on the apparatus.
- 6.1.14 Mechanical safety interlock shall be provided for safe operating and movement of the breaker.
- 6.1.15 The circuit breakers shall be provided with minimum of four normally open and four normally closed auxiliary switch contacts, over and above those required for its own control scheme, for owner's use. These contacts shall be wired separately to the

<div> पी डी आई एल <b>PDIL</b></div>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</b>	<b>PC288-TS-0806</b>	0	<div> कोई एच आई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 9 of 24		

terminal board.

6.1.16 The closing coil and other associated auxiliary relays shall operate satisfactorily at all voltages between 85% and 110% of the rated control voltage. The tripping coil and other associated relays shall operate satisfactorily at all voltages between 70% and 110% of the rated control voltage.

6.1.17 Cable earthing facility shall be provided in the circuit breaker for discharging of power cable through the circuit breaker contact with circuit breaker in drawn-out position. An integral earthing arrangement shall be preferred. In case the integral earthing arrangement is not feasible due to circuit breaker design, a separate earthing truck, which shall be inserted in place of circuit breaker, shall be provided per board.

6.1.18 Positive earthing of circuit breaker frame shall be maintained at every position of circuit breaker. The earthing contact shall be line/scraping type and not of point type.

## 6.2 Current Transformers

6.2.1 The current transformers shall conform to IS: 2705.

6.2.2 C.T.s shall be class F insulated and vacuum impregnated or resin cast type. The C.T.s shall be rigidly mounted and shall be easily accessible for maintenance and testing.

6.2.3 The short time thermal withstand ratings of the C.T.s shall be same as the thermal withstand ratings of the breakers.

6.2.4 The C.T.s output shall be minimum 15 VA per phase and in any case, the output shall be adequate for the protection and metering duties involved with sufficient margin. The C.T.s shall have the following accuracies for the various applications:

<u>Application</u>	<u>Class of Accuracy as per IS: 2705</u>
i) For metering service	1
ii) For use with protective relays	5 P
iii) For use with restricted earth fault and differential relays	PS

6.2.5 The C.T. cores for metering and protection shall be separate.

6.2.6 The ratios of the current transformers shall be as indicated in Feeder details.

6.2.7 All the C.T.s shall be provided with terminals and shorting links. One of the terminals of the C.T. shall be earthed. The polarity of the C.T. shall be clearly marked.

6.2.8 Provision of interposing C.T. is not acceptable.

6.2.9 The C.T.s shall be capable of withstanding momentary open-circuit on the secondary side without injurious effects.

## 6.3 Voltage Transformers

6.3.1 The V.T.s shall be class F insulated and vacuum impregnated or resin cast type conforming to IS: 3156.

6.3.2 The primary nominal voltage shall be equal to the system nominal voltage. The secondary terminal voltage shall be  $110 / \sqrt{3}$  V.

6.3.3 The rated output of each VT shall be adequate for the relays, meters and associated wiring connected to it with sufficient margin and shall not be less than 200 VA per phase.

6.3.4 The accuracy class of V.T.s shall be 1 as per IS: 3156.

6.3.5 The primary and secondary winding shall be protected by HRC fuses in each phase except in the grounded phase of the secondary side.

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</div>	PC288-TS-0806	0	<div> श्री एच ई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 10 of 24		

6.3.6 The V.T. shall be mounted on a with-drawable carriage. Shutters with padlocking facility, provided on high voltage sides, shall be so arranged that the live orifices are automatically closed when the V.T. is withdrawn.

6.3.7 Mechanical interlocking arrangement shall be provided so that the access to the high voltage fuse is possible only when the V.T. is fully withdrawn.

#### 6.4 Relays

6.4.1 All protective relays shall be of latest version, microprocessor based numerical type with communication port and interlinked with online energy management system. 100% redundancy shall be provided for communication.

#### 6.5 Timers

6.5.1 The timers shall be electronic, pneumatic or synchronous type with manual/ auto reset features as per the functional requirements. The timers shall be 'ON' delay or 'OFF' delay type as specified. The repeat accuracy shall be 0.5% or better.

#### 6.6 Instruments and Meters

6.6.1 All instruments shall be flush mounting type with square face of 96 mm x 96 mm. They shall be tropicalized and dust tight.

6.6.2 Meters shall be digital multifunctional meters with communication port for energy management at remote location.

6.6.3 All ammeters and voltmeters, to be provided separately, shall have 0-90° scale and shall be moving iron spring controlled type of class 1.5 accuracy as per IS: 1248. The scale range of the ammeters and voltmeters shall be as indicated in the Feeder details.

6.6.4 In case of motor feeders, the ammeters shall be graduated uniformly upto C.T. primary current and with compressed end scale upto 6 times C.T. primary current. Red pointer shall be provided, which shall be adjusted at site for indicating full load current of the motor.

#### 6.7 Push Buttons and Control Switches

6.7.1 The switches and push buttons shall conform to utilization category AC11/DC11 as per IS/IEC:60947. The contact shall be rated to make, break and carry inductive current of 5 Amps. at 415 V AC and 1 Amp. at 220 V DC.

6.7.2 The control switches shall be spring return rotary type, unless otherwise specified and provided with Pistol grip type handle. The control switches for circuit breakers shall be additionally fitted with lost motion devices and sequencing devices, if required.

6.7.3 The selector switches shall be stay put rotary type and provided with oval shape handles.

6.7.4 The push buttons shall be of momentary contact spring loaded type with a set of normally close and open contacts. The start push button shall be shrouded type and coloured green. The stop push button shall be un-shrouded type and coloured red and other push buttons shall be un-shrouded type and coloured black. The fixing ring shall be metallic white.

6.7.5 Emergency stop push buttons, if specified, shall be lockable in pushed position.

#### 6.8 Control Fuses

6.8.1 The fuses shall be non-deteriorating HRC cartridge link type and shall conform to IS: 13703. They shall be suitable for load and service required in the circuit.

6.8.2 One fuse puller shall be supplied along with each board.

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</div>	PC288-TS-0806	0	<div> श्री एच ई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 11 of 24		

## 6.9 Miniature Circuit Breakers

- 6.9.1 The miniature circuit breakers shall conform to IS: 8828 and shall be of duty category M-9.
- 6.9.2 It shall be provided with overload and short circuit protective devices in a heat resistant housing.
- 6.9.3 Type test certificate for short circuit rating and current time tripping curve shall be furnished along with the offer.

## 6.10 Signal Lamps

- 6.10.1 Signal lamps shall be provided to indicate the various circuit conditions as shown in scheme drawings. The colour of the lamps for various functions shall be as follow:

Red	-	Circuit breaker 'ON'
Green	-	Circuit breaker 'OFF'
White	-	Trip circuit healthy
Amber	-	Alarm and auto trip
Blue	-	Non-Trip

- 6.10.2 The lamps shall LED type with lumen output of 200 millicandella in axial direction.

## 7.0 ACCESSORIES

- 7.1 The supply shall include the following accessories.
- Maintenance truck/device for raising, lowering and withdrawal of circuit breaker, if required.
  - Earthing truck, in case the integral earthing arrangement is not feasible in the circuit breaker.
  - Fuse puller.
  - Test plug for relays.
  - Test plug for kWh meters.
  - Special tools and tackles, as required.

## 7.2 Space Heater

- 7.2.1 Each panel shall be provided with a thermostatically controlled space heater, rated for 240 V, 50 Hz and controlled through double pole miniature circuit breaker.

## 7.3 Name Plates

- 7.3.1 The switchboard shall have large name plate on the top to indicate its name and designation.
- 7.3.2 Each panel shall be provided with name plate both in front and back.
- 7.3.3 All control switches, push buttons, lamps etc. shall have functional identification labels.
- 7.3.4 Name plate shall be of black Perspex with white engraving and of minimum 3 mm thick.
- 7.4 Any other accessories required, but not specified, shall also be supplied to make the switchboard complete in all respects and ensure safe and proper operation.

## 8.0 PAINTING

- 8.1 The enclosure, after degreasing, pickling in acid, cold rinsing, phosphatising, passivating etc. shall be painted with two coats of anti-rust paint followed by two coats of anti-corrosive paint.



<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</div>	PC288-TS-0806	0	<div> कोई एच आई एल <b>PDIL</b></div>
		Document No.	Rev	
		Sheet 12 of 24		

- 8.2 Epoxy based paint shall be used.
- 8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.
- 8.4 Unless otherwise specified, the finishing shade shall be light grey having shade No.631 as per IS: 5.
- 8.5 One litre of paint shall be supplied along with each board for touch up at site.

## 9.0 TESTS AND INSPECTION

- 9.1 All the switchboards shall be subjected to routine test as per IS: 3427 and their components as per relevant standards.
- 9.2 Additional tests, wherever specified, shall be carried out.
- 9.3 All the above tests shall be carried out in presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and site inspection.
- 9.4 These inspection shall, however, not absolve the vendor from his responsibility for making good any defect which shall be noticed subsequently.

## 10.0 DRAWINGS AND DOCUMENTS

- 10.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.
- 10.2 All drawings and documents shall have the following description written boldly.
- Name of client
  - Name of consultant
  - Enquiry / Order Number with plant / project name
  - Code No. and Description

## 11.0 SPARES

- 11.1 Commissioning Spares: Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval.
- 11.2 Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 11.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 11.4 All spare parts shall be identical to the parts used in the equipment

## 12.0 PACKING

- 12.1 The switchboard shall be properly packed before dispatch to avoid damage during transport, storage and handling.
- 12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.
- 12.3 A sign to indicate the upright position of the panels to be placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.

## 13.0 DEVIATIONS

- 13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

**ANNEXURE - I**  
**DOCUMENTATION FOR HIGH VOLTAGE SWITCHBOARDS**

Sl. No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheets	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	Feeder Details	N	Y	Y
4.	General arrangement and Foundation Drawings	N	Y	Y
5.	Schematic/Wiring Diagrams	N	Y	Y
6.	Calculation for Bus-bar sizing	N	Y	N
7.	Terminal Arrangement Drawings	N	Y	Y
8.	Illustrative and Descriptive Literature	N	N	Y
9.	Catalogues for bought out accessories	N	N	Y
10.	Installation, Operation and maintenance manual	N	N	Y
11.	Test Certificates			
	i) Type - Switchboard	N	N	N
	- Circuit Breaker	N	N	N
	- MCB	N	N	N
	ii) Routine	N	N	Y
12.	Guarantee Certificates	N	N	Y
13.	Spare Parts List	N	N	Y

**Note:**

- 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
- 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N – No



	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</b>	PC288-TS-0806	0	
		Document No.	Rev	
		Sheet 14 of 24		

**SPECIFICATION SHEET  
11 KV SWITCHBOARD**

CLIENT : JV OF CIL & BHEL		PROJECT : ELECTRICAL DIST. SYSTEM		PLANT: SYNGAS PURIFICATION UNIT	
ISSUED FOR : PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/>		ORDER <input type="checkbox"/>		FINAL <input type="checkbox"/>	
<b>GENERAL</b>			<b>AMBIENT CONDITION</b>		
Ref. Stds. : IS <input checked="" type="checkbox"/> IEC <input checked="" type="checkbox"/>			Temp. Max./Min./Design Ref. : 46 / 1 / 50°C		
Encl. Docs. :			Relative Humidity: 100% Alt. above sea <1000 M		
Make :			<b>ATMOSPHERIC POLLUTION</b>		
Maker's Ref. No. :			Dusts : Coal Dust		
			Vapour : Ammonia & Highly Corrosive		
			<b>LOCATION</b>		
			Indoor <input checked="" type="checkbox"/> Outdoor <input type="checkbox"/>		
			Gr. Floor <input type="checkbox"/> 1 <sup>st</sup> floor <input checked="" type="checkbox"/>		
Incoming Bus Duct <input checked="" type="checkbox"/>		Tie Bus Duct <input type="checkbox"/>			
Erection & Comm. <input checked="" type="checkbox"/>		Supervision of Erection & Comm. <input type="checkbox"/>			
<b>TESTS:</b> Routine <input checked="" type="checkbox"/> Type <input type="checkbox"/> Others <input type="checkbox"/>					
<b>BASIC DATA</b>					
	Description				
<b>REFERENCE DRAWINGS</b>	Single Line Diagram				
	Feeder Details				
	P.T. Bus Arrangement		--		
<b>SYSTEM DETAILS</b>	Rated Voltage with variation		11 kV ± 10%		
	Rated Frequency with variation		50Hz ± 5%		
	Highest System Voltage		12 kV		
	Combined V & F Variation		± 10%		
	No. of Phases & Wires		3 Phase, 3 Wire		
	Insulation Level		75 kVp/ 28kV BIL		
	Fault Level		750 MVA for 3 sec.		
Earthing Mode		Non effectively earthed through resistor			
<b>BUS BARS</b>	<b>Rating</b>	Continuous	4000A		
		Short Time for 3 sec.	40KA for 3 sec.		
	Type of Insulation		Raychem Insulating heat shrinkable Sleeved		
<b>CIRCUIT BREAKER</b>	Type		Vacuum Circuit Breaker		
	<b>Breaking Capacity</b>	Symmetrical	40KA for 3 sec.		
		% DC Component	20% (Min.)		
	Making Capacity ( peak )		2.55 times Breaking Capacity		
<b>CONTROL SUPPLY</b>	Closing & Indication		110V DC		
	Tripping		110V DC		
	Alarm / Signal		110V DC		
	Space Heater		240V AC		
<b>MISC. DATA</b>	Cable Entry Top / Bottom		Bottom		
	Dummy Panel Req'd. Yes / No		As required		
	Width of Dummy Panel		--		
	No. of Dummy Panel		--		
	<b>PAINTING</b>	Type	Epoxy Based		
		Shade	631 of IS: 5		
	Spares Parts Req'd. for a Period of		2 Years		

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</b>	PC288-TS-0806	0	
		Document No.	Rev	
		Sheet 15 of 24		

**SPECIFICATION SHEET  
11 KV SWITCHBOARD**

CLIENT : JV OF CIL & BHEL		PROJECT : ELECTRICAL DIST. SYSTEM		PLANT: SYNGAS PURIFICATION UNIT	
ISSUED FOR : PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/>		ORDER <input type="checkbox"/>		FINAL <input type="checkbox"/>	
<b>GENERAL</b>			<b>AMBIENT CONDITION</b>		
Ref. Stds. : IS <input checked="" type="checkbox"/> IEC <input checked="" type="checkbox"/>		Temp. Max./Min./Design Ref. : 46 / 1 / 50°C			
Encl. Docs. :		Relative Humidity: 100%		Alt. above sea <1000 M	
Make :		<b>ATMOSPHERIC POLLUTION</b>	Dusts : Coal Dust		
Maker's Ref. No. :			Vapour : Ammonia & Highly Corrosive		
		<b>LOCATION</b>	Indoor <input checked="" type="checkbox"/> Outdoor <input type="checkbox"/>		
			Gr. Floor <input type="checkbox"/> 1 <sup>st</sup> floor <input checked="" type="checkbox"/>		
<b>ADDL. SCOPE</b>	Incoming Bus Duct <input type="checkbox"/>	Tie Bus Duct <input checked="" type="checkbox"/>			
	Erection & Comm. <input checked="" type="checkbox"/>	Supervision of Erection & Comm. <input type="checkbox"/>			
<b>TESTS:</b> Routine <input checked="" type="checkbox"/> Type <input type="checkbox"/> Others <input type="checkbox"/>					
<b>BASIC DATA</b>					
	Description				
<b>REFERENCE DRAWINGS</b>	Single Line Diagram				
	Feeder Details				
	P.T. Bus Arrangement		--		
<b>SYSTEM DETAILS</b>	Rated Voltage with variation		11 kV ± 10%		
	Rated Frequency with variation		50Hz ± 5%		
	Highest System Voltage		12 kV		
	Combined V & F Variation		± 10%		
	No. of Phases & Wires		3 Phase, 3 Wire		
	Insulation Level		75 kVp/ 28kV BIL		
	Fault Level		750 MVA for 3 sec.		
<b>BUS BARS</b>	<b>Rating</b>	Continuous	3150A		
		Short Time for 3 sec.	40KA for 3 sec.		
	Type of Insulation		Raychem Insulating heat shrinkable Sleeved		
<b>CIRCUIT BREAKER</b>	Type		Vacuum Circuit Breaker		
	<b>Breaking Capacity</b>	Symmetrical	40KA for 3 sec.		
		% DC Component	20% (Min.)		
Making Capacity ( peak )		2.55 times Breaking Capacity			
<b>CONTROL SUPPLY</b>	Closing & Indication		110V DC		
	Tripping		110V DC		
	Alarm / Signal		110V DC		
	Space Heater		240V AC		
<b>MISC. DATA</b>	Cable Entry Top / Bottom		Bottom		
	Dummy Panel Req'd. Yes / No		As required		
	Width of Dummy Panel		--		
	No. of Dummy Panel		--		
	<b>PAINTING</b>	Type	Epoxy Based		
		Shade	631 of IS: 5		
Spares Parts Req'd. for a Period of		2 Years			

Note: Specification Sheet shall be filled by the bidder and submitted with the bid.

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</b>	PC288-TS-0806	0	
		Document No.	Rev	
		Sheet 16 of 24		

### TECHNICAL PARTICULARS 11 KV SWITCHBOARD

CLIENT : JV OF CIL & BHEL		PROJECT : ELECTRICAL DIST. SYSTEM		PLANT: SYNGAS PURIFICATION UNIT	
ISSUED FOR : PROPOSAL <input type="checkbox"/>		ENQUIRY <input checked="" type="checkbox"/>		ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>	
<b>GENERAL</b>					
Make / Maker's Type :					
Ref. Standards					
Rated Operational Voltage with $\pm$ %					
Rated Insulation Voltage					
Rated Voltage of Aux. Circuits with $\pm$ %					
Rated Current					
Short Time Rating					
Degree of Protection of Enclosure					
Service Conditions : Indoor / Outdoor					
<b>DRAWOUT FACILITIES</b>	Circuit Breaker's				
	P.T.'s				
	Protective Relays				
	Meters				
<b>SHEET STEEL TYPE &amp; THICKNESS</b>	Base Channel				
	Others				
Material of Gaskets					
Material of External Hardware					
Operating Height : Max. / Min.					
Space Heater Rating of each Panel					
<b>PAINTING</b>	Method of Pre-treatment				
	Thickness of Paint				
	Type & Shade				
Final Temperature					
<b>PROVISIONS / FACILITIES</b>	Safety Shutters				
	Interlocks				
	Earthing Facility				
	Base Channels with Fdn. Bolts				
	Gland Plate with Glands				
	Limit of Maximum Nos. of Cables Termination Possible				
Dimensions : L X B X H / Dim. Drg. Ref. No.					
Shipping Dimensions of Largest Package					
Weight : Static / Dynamic					
Heat Dissipation					
<b>BUS – BARS</b>					
Material					
<b>SIZE</b>	HBB				
	VBB				
	Ground				
	Supporting Calculation Attached				
<b>MINIMUM CLEARANCE</b>	Between Phases				
	Between Phase & Earth				
Minimum Creepage Distance					
<b>CURRENT RATING</b>	Continuous				
	Short Time for 3 secs.				
Max. current density for bus-bars					
Temp. Rise for : Cont. Load / Short Ckt. Current					
<b>SUPPORT</b>	Material				
	Voltage Class				
	BIL				
	Arrangement : Separate/Common				
Power Frequency test Voltage for 1 Min. Duration					
Material of Bus-bar Insulation					
Material of Inter Panel / Compartment Barrier					
Shrouding Material for Joints					

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</b>	PC288-TS-0806	0	
		Document No.	Rev	
		Sheet 17 of 24		

Bus Bar Phase Identification Mark		
No. & Type of Bolts per Joint		
<b>CIRCUIT BREAKERS</b>		
Make / Maker's Type		
Ref. Standards		
Type of Circuit Breaker		
Principle / Collaborator		
Rated Operating Sequence		
Rated Voltage		
Rated Frequency		
No. of Poles		
<b>CURRENT RATING</b>	Continuous in IPH6 Enclosure	
	3 second RMS	
	Momentary ( Peak )	
<b>BREAKING CURRENT</b>	Symmetrical KA	
	Asymmetrical KA	
	% D.C. Component	
Making Current ( Peak )		
Derating Factor, if any for Site Condition		
<b>LIMITATION OF CURRENT RATING FOR</b>	Motor Duty	
	Capacitor Duty	
	Transformer Switching	
	Cable Charging	
Restriking Voltage ( Peak )		
<b>INSULATION LEVEL</b>	1 Min. PF withstand Voltage	
	Impulse withstand Voltage	
No. of Breaks per Pole		
<b>TYPE AND MATERIAL OF</b>	Fixed Contact	
	Moving Contact	
	Arcing Contact	
Type of Closing Mechanism		
Type of Tripping Mechanism		
<b>ARC CONTROL DEVICE</b>	Type	
	Material of Arc Chamber	
Details of Anti – Pumping Feature		
Details of Trip Free Feature		
Total Closing Time		
Total Interrupting Time at 10%, 50%, 100% of rated		
Interrupting Capacity		
<b>SPRING CHARGING MOTOR</b>	Rating	
	Voltage	
	Insulation	
	Duty	
	Type	
Spring Charging Time		
<b>VOLTAGE / CURRENT REQD. FOR</b>	Closing	
	Tripping	
	A.C. Supply	
<b>AUXILIARY CONTACTS</b>	No. of Spare Contacts NO / NC	
	Contact Rating Ac / Dc	
	Convertible Type	
<b>INSULATING OIL</b>	Ref. Standard	
	Volume of Oil Required	
Mounting Arrangement		
Temp. Rise of Different Parts		
<b>DETAILS FOR SF<sub>6</sub></b>	SF <sub>6</sub> Gas Pressure	
	Wt. Of SF <sub>6</sub> Gas per Breaker	
<b>DETAILS FOR SF<sub>6</sub></b>	Gas Leakage Detector Provided	
	Gas Density Monitor Provided	
<b>DETAILS FOR VCB</b>	Pressure inside the Interrupter	
	Contact Wear Indication Provided	

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</b>	PC288-TS-0806	0	
		Document No.	Rev	
		Sheet 18 of 24		

<b>RECOMMENDED TIME INTERVAL FOR</b>	Facility for Checking Loss of Vacuum Provided	
	Inspection of Drives	
	Inspection of Contacts	
	Quenching Devices	
	Replacement of Oil	
Dimensions : L X B X H / Dim. Drg. Ref. No.		
Type Testing Authority & Test Report Ref. No.		
Net Weight of Breaker		
<b>CURRENT TRANSFORMERS</b>		
Make / Maker's Type		
Ref. Standard		
Type of Primary Winding		
No. of Cores		
Ratio		
Rated Burden		
Accuracy Class		
ALF / ISF		
Thermal Limit		
Dynamic Limit		
Insulation Class / Material		
Basic Insulation Level		
Ref. Magnetisation Curve No.		
<b>POTENTIAL TRANSFORMERS</b>		
Make / Maker's Type		
Ref. Standard		
Winding Connection : Pri. / Sec.		
Ratio		
Rated Burden		
Accuracy Class		
Insulation Class / Material		
Basic Insulation Level		
Weight		
Dimension		
Rated Voltage Factor		
<b>SURGE DIVERTER</b>		
Type & Maker's Type		
Rated Voltage KV		
Nominal Discharge Current ( 8/20 $\mu$ sec. wave )		
Residual Voltage at Rated Discharge Current		
Power Frequency Spark Over Voltage		
1.2/50 $\mu$ sec. Spark Over Voltage		
<b>RELAYS</b>		
Application		
Make / Maker's Type :		
Ref. Standards		
Operating Principle		
Rated Voltage / Current		
Rated Burden		
Setting Range		
Type of Mounting		
Reset : Hand or Self		
Flag Indication Type		
Ref. Characteristic Curve Type		
Ref. Descriptive catalogue		
<b>INSTRUMENTS AND METERS</b>		
Application		
Make / Maker's Type :		
Ref. Standards		
Operating Principle		
Rated Burden		
Scale Range		

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</b>	PC288-TS-0806	0	
		Document No.	Rev	
		Sheet 19 of 24		

Accuracy	
Size	
Type of Mounting	
<b>CONTROL SWITCHES</b>	
Application	
Make / Maker's Type :	
Ref. Standards	
Contact Rating	
Utilisation Category	
<b>PUSH BUTTON</b>	
Make / Maker's Type :	
Ref. Standards	
Contact Rating	
Utilisation Category	
<b>SIGNAL LAMPS</b>	
Make / Maker's Type :	
Ref. Standards	
Rated Voltage / Wattage	
Type of Lamp Holder	
Type of Globe	
Accessibility from Front	
<b>MOULDED CASE CIRCUIT BREAKERS</b>	
Make / Maker's Type	
Ref. Standard	
Current Rating	
Breaking Capacity	
Setting Range of Thermal Release	
Setting Range of Magnetic Release	
<b>MINIATURE CIRCUIT BREAKER</b>	
Make / Maker's Type :	
Ref. Standards	
Rated Current	
Breaking Capacity	
<b>CABLE GLANDS</b>	
Material	
Type	
<b>TERMINAL BLOCKS</b>	
Make	
Type	
Current Rating	

Note: Technical Particulars shall be filled by the bidder and submitted with the bid.

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</b>	PC288-TS-0806	0	
		Document No.	Rev	
		Sheet 20 of 24		

### SPECIFICATION SHEET 3.3 KV SWITCHBOARD

CLIENT : JV OF CIL & BHEL		PROJECT : ELECTRICAL DIST. SYSTEM		PLANT: SYNGAS PURIFICATION UNIT	
ISSUED FOR :		PROPOSAL <input type="checkbox"/>	ENQUIRY <input checked="" type="checkbox"/>	ORDER <input type="checkbox"/>	FINAL <input type="checkbox"/>
<b>GENERAL</b>			<b>AMBIENT CONDITION</b>		
Ref. Stds. : IS <input checked="" type="checkbox"/> IEC <input type="checkbox"/>		Temp. Max./Min./Design Ref. : 46 / 1 / 50°C			
Encl. Docs. :		Relative Humidity: 100%		Alt. above sea <1000 M	
Make :		<b>ATMOSPHERIC POLLUTION</b>	Dusts : Coal Dust		
Maker's Ref. No. :			Vapour : Ammonia & Highly Corrosive		
		<b>LOCATION</b>	Indoor <input checked="" type="checkbox"/> Outdoor <input type="checkbox"/>		
			Gr. Floor <input type="checkbox"/> 1 <sup>st</sup> floor <input checked="" type="checkbox"/>		
<b>ADDL. SCOPE</b>	Incoming Bus Duct <input type="checkbox"/>	Tie Bus Duct <input type="checkbox"/>			
	Erection & Comm. <input checked="" type="checkbox"/>	Supervision of Erection & Comm. <input type="checkbox"/>			
<b>TESTS:</b>		Routine <input checked="" type="checkbox"/>	Type <input type="checkbox"/>	Others <input type="checkbox"/>	
<b>BASIC DATA</b>					
<b>TAG NO. &amp; QTY.</b>	Item No.				
	Switch board No.				
	Description				
<b>REFERENCE DRAWINGS</b>	Single Line Diagram				
	Feeder Details				
	Auto Trip Alarm Scheme				
	Non Trip Alarm Scheme				
	Trip Ckt. Supervision Scheme				
	Auto C/O Scheme				
	P.T. Bus Arrangement				
<b>SYSTEM DETAILS</b>	Rated Voltage with Variation		3.3 KV $\pm$ 10%		
	Rated Frequency with Variation		50Hz $\pm$ 5%		
	Highest System Voltage		3.6KV		
	Combined V & F Variation		$\pm$ 10%		
	No. of Phases & Wires		3 Phase, 3 Wire		
	Insulation Level		40KV		
	Fault Level		150MVA		
	Earthing Mode		Non effectively earthed through resistor		
<b>BUS BARS</b>	<b>Rating</b>	Continuous	1250A		
		Short Time for 3 sec.	26.24KA		
	Type of Insulation		Heat Shrinkable Raychem Sleeved		
<b>CIRCUIT BREAKER</b>	Type		Vacuum Circuit Breaker		
	<b>Breaking Capacity</b>	Symmetrical	26.24KA		
		% DC Component	20%		
	Making Capacity ( peak )		66.81KA		
<b>CONTROL SUPPLY</b>	Closing & Indication		110V DC		
	Tripping		110V DC		
	Alarm / Signal		110V DC		
	Space Heater		240V AC		
<b>MISC. DATA</b>	Cable Entry Top / Bottom		Bottom		
	Dummy Panel Reqd. Yes / No		No		
	Width of Dummy Panel		--		
	No. of Dummy Panel		--		
	<b>PAINTING</b>	Type	Epoxy Based		
		Shade	631 of IS: 5		
Spares Parts Reqd. for a Period of		2 Years			

Note: Specification Sheet shall be filled by the bidder and submitted with the bid.

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</b>	PC288-TS-0806	0	
		Document No.	Rev	
		Sheet 21 of 24		

### TECHNICAL PARTICULARS 3.3 KV SWITCHBOARDS

CLIENT : JV OF CIL & BHEL		PROJECT : ELECTRICAL DIST. SYSTEM		PLANT: SYNGAS PURIFICATION UNIT	
ISSUED FOR : PROPOSAL <input type="checkbox"/>		ENQUIRY <input checked="" type="checkbox"/>		ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>	
<b>GENERAL</b>					
Make / Maker's Type :					
Ref. Standards					
Rated Operational Voltage with $\pm$ %					
Rated Insulation Voltage					
Rated Voltage of Aux. Circuits with $\pm$ %					
Rated Current					
Short Time Rating					
Degree of Protection of Enclosure					
Service Conditions : Indoor / Outdoor					
<b>DRAWOUT FACILITIES</b>	Circuit Breaker's				
	P.T.'s				
	Protective Relays				
	Meters				
<b>SHEET STEEL TYPE &amp; THICKNESS</b>	Base Channel				
	Others				
Material of Gaskets					
Material of External Hardware					
Operating Height : Max. / Min.					
Space Heater Rating of each Panel					
<b>PAINTING</b>	Method of Pre-treatment				
	Thickness of Paint				
	Type & Shade				
Final Temperature					
<b>PROVISIONS / FACILITIES</b>	Safety Shutters				
	Interlocks				
	Earthing Facility				
	Base Channels with Fdn. Bolts				
	Gland Plate with Glands				
	Limit of Maximum Nos. of Cables Termination Possible				
Dimensions : L X B X H / Dim. Drg. Ref. No.					
Shipping Dimensions of Largest Package					
Weight : Static / Dynamic					
Heat Dissipation					
<b>BUS - BARS</b>					
Material					
<b>SIZE</b>	HBB				
	VBB				
	Ground				
	Supporting Calculation Attached				
<b>MINIMUM CLEARANCE</b>	Between Phases				
	Between Phase & Earth				
Minimum Creepage Distance					
<b>CURRENT RATING</b>	Continuous				
	Short Time for 3 secs.				
Max. current density for bus-bars					
Temp. Rise for : Cont. Load / Short Ckt. Current					
<b>SUPPORT</b>	Material				
	Voltage Class				
	BIL				
	Arrangement : Separate/Common				
Power Frequency test Voltage for 1 Min. Duration					
Material of Bus-bar Insulation					
Material of Inter Panel / Compartment Barrier					
Shrouding Material for Joints					



	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</b>	PC288-TS-0806	0	
		Document No.	Rev	
		Sheet 22 of 24		

Bus Bar Phase Identification Mark		
No. & Type of Bolts per Joint		
<b>CIRCUIT BREAKERS</b>		
Make / Maker's Type		
Ref. Standards		
Type of Circuit Breaker		
Principle / Collaborator		
Rated Operating Sequence		
Rated Voltage		
Rated Frequency		
No. of Poles		
<b>CURRENT RATING</b>	Continuous in IPH6 Enclosure	
	3 second RMS	
	Momentary ( Peak )	
<b>BREAKING CURRENT</b>	Symmetrical KA	
	Asymmetrical KA	
	% D.C. Component	
Making Current ( Peak )		
Derating Factor, if any for Site Condition		
<b>LIMITATION OF CURRENT RATING FOR</b>	Motor Duty	
	Capacitor Duty	
	Transformer Switching	
	Cable Charging	
Restriking Voltage ( Peak )		
<b>INSULATION LEVEL</b>	1 Min. PF withstand Voltage	
	Impulse withstand Voltage	
No. of Breaks per Pole		
<b>TYPE AND MATERIAL OF</b>	Fixed Contact	
	Moving Contact	
	Arcing Contact	
Type of Closing Mechanism		
Type of Tripping Mechanism		
<b>ARC CONTROL DEVICE</b>	Type	
	Material of Arc Chamber	
Details of Anti – Pumping Feature		
Details of Trip Free Feature		
Total Closing Time		
Total Interrupting Time at 10%, 50%, 100% of rated		
Interrupting Capacity		
<b>SPRING CHARGING MOTOR</b>	Rating	
	Voltage	
	Insulation	
	Duty	
	Type	
Spring Charging Time		
<b>VOLTAGE / CURRENT REQD. FOR</b>	Closing	
	Tripping	
	A.C. Supply	
<b>AUXILIARY CONTACTS</b>	No. of Spare Contacts NO / NC	
	Contact Rating Ac / Dc	
	Convertible Type	
<b>INSULATING OIL</b>	Ref. Standard	
	Volume of Oil Required	
Mounting Arrangement		
Temp. Rise of Different Parts		
<b>DETAILS FOR SF<sub>6</sub></b>	SF <sub>6</sub> Gas Pressure	
	Wt. Of SF <sub>6</sub> Gas per Breaker	
<b>DETAILS FOR SF<sub>6</sub></b>	Gas Leakage Detector Provided	
	Gas Density Monitor Provided	
<b>DETAILS FOR VCB</b>	Pressure inside the Interrupter	
	Contact Wear Indication Provided	

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</b>	PC288-TS-0806	0	
		Document No.	Rev	
		Sheet 23 of 24		

<b>RECOMMENDED TIME INTERVAL FOR</b>	Facility for Checking Loss of Vacuum Provided	
	Inspection of Drives	
	Inspection of Contacts	
	Quenching Devices	
	Replacement of Oil	
Dimensions : L X B X H / Dim. Drg. Ref. No.		
Type Testing Authority & Test Report Ref. No.		
Net Weight of Breaker		
<b>CURRENT TRANSFORMERS</b>		
Make / Maker's Type		
Ref. Standard		
Type of Primary Winding		
No. of Cores		
Ratio		
Rated Burden		
Accuracy Class		
ALF / ISF		
Thermal Limit		
Dynamic Limit		
Insulation Class / Material		
Basic Insulation Level		
Ref. Magnetisation Curve No.		
<b>POTENTIAL TRANSFORMERS</b>		
Make / Maker's Type		
Ref. Standard		
Winding Connection : Pri. / Sec.		
Ratio		
Rated Burden		
Accuracy Class		
Insulation Class / Material		
Basic Insulation Level		
Weight		
Dimension		
Rated Voltage Factor		
<b>SURGE DIVERTER</b>		
Type & Maker's Type		
Rated Voltage KV		
Nominal Discharge Current ( 8/20 $\mu$ sec. wave )		
Residual Voltage at Rated Discharge Current		
Power Frequency Spark Over Voltage		
1.2/50 $\mu$ sec. Spark Over Voltage		
<b>RELAYS</b>		
Application		
Make / Maker's Type :		
Ref. Standards		
Operating Principle		
Rated Voltage / Current		
Rated Burden		
Setting Range		
Type of Mounting		
Reset : Hand or Self		
Flag Indication Type		
Ref. Characteristic Curve Type		
Ref. Descriptive catalogue		
<b>INSTRUMENTS AND METERS</b>		
Application		
Make / Maker's Type :		
Ref. Standards		
Operating Principle		
Rated Burden		
Scale Range		

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</b>	PC288-TS-0806	0	
		Document No.	Rev	
		Sheet 24 of 24		

Accuracy	
Size	
Type of Mounting	
<b>CONTROL SWITCHES</b>	
Application	
Make / Maker's Type :	
Ref. Standards	
Contact Rating	
Utilisation Category	
<b>PUSH BUTTON</b>	
Make / Maker's Type :	
Ref. Standards	
Contact Rating	
Utilisation Category	
<b>SIGNAL LAMPS</b>	
Make / Maker's Type :	
Ref. Standards	
Rated Voltage / Wattage	
Type of Lamp Holder	
Type of Globe	
Accessibility from Front	
<b>MOULDED CASE CIRCUIT BREAKERS</b>	
Make / Maker's Type	
Ref. Standard	
Current Rating	
Breaking Capacity	
Setting Range of Thermal Release	
Setting Range of Magnetic Release	
<b>MINIATURE CIRCUIT BREAKER</b>	
Make / Maker's Type :	
Ref. Standards	
Rated Current	
Breaking Capacity	
<b>CABLE GLANDS</b>	
Material	
Type	
<b>TERMINAL BLOCKS</b>	
Make	
Type	
Current Rating	

Note: Technical Particulars shall be filled by the bidder and submitted with the bid.

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - BUS DUCT</div>	<div>PC288-TS-0807</div>	<div>0</div>	<div><div>कोयला भारत</div><div>बी एच ई एल</div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 1 of 8</div>		

# **TECHNICAL SPECIFICATION** **BUS DUCT**

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - BUS DUCT	PC288-TS-0807	0	
		Document No.	Rev	
		Sheet 2 of 8		

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	GENERAL DESIGN AND CONSTRUCTIONAL FEATURES
6.0	ACCESSORIES
7.0	LAYOUT
8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	DRAWINGS AND DOCUMENTS
11.0	SPARES
12.0	PACKING
13.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR BUS DUCT

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - BUS DUCT	PC288-TS-0807	0	
		Document No.	Rev	
		Sheet 3 of 8		

## 1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, manufacture testing at works and despatch in well packed condition of bus duct.
- 1.2 This standard shall be read in conjunction with relevant part of Design Philosophy - Electrical.

## 2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of following Indian Standards unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

- IS: 8084 - Interconnecting bus-bars for A.C. Voltage above 1 KV up to and including 36 KV.
- IS: 8623 - Specification for low voltage switchgear and control gear assemblies.
- IS: 5578 - Guide for marking of insulated conductors.
- IS: 11353 - Guide for uniform system of marking and identification of conductors and apparatus terminals.

- 2.2 The design and operational features of all the equipment offered shall also comply with the provisions of the latest issue of the Indian Electricity Rules and other relevant Statutory Acts and Regulations. The supplier shall wherever necessary, make suitable modifications in the equipment to comply with the above.

- 2.3 Wherever any requirement, laid down in this standard differs from those in Indian Standard Specifications, the requirement specified herein shall prevail.

## 3.0 SERVICE CONDITIONS

### 3.1 Ambient conditions

These shall be as indicated in Design Philosophy - Electrical.

### 3.2 System Details

These shall be as indicated in Design Philosophy - Electrical.

## 4.0 OPERATING REQUIREMENTS

The bus duct shall be suitable for operating at the rated capacity continuously under the ambient conditions and with the voltage and frequency variations without exceeding the permissible temperature rise and without any detrimental effect on any part.

## 5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

### 5.1 Enclosures

- 5.1.1 The sheet steel enclosure for enclosing and supporting the bus-bars shall be made out of 14 SWG sheet steel, bolted on the angle iron frame work.

- 5.1.2 The enclosure shall completely enclose the bus bars from all sides. It shall have degree of protection IP: 52 for indoor installation and IP: 55 with rain protection canopy for outdoor installation as per IS/IEC:60947. Where part of the bus duct is required for indoor installation and part for outdoor installation, the complete section shall be suitable for outdoor installation. Ventilation louvers, if necessary, shall be provided with fine wire mesh from inside, in that case the degree of protection shall be IP: 42. Neoprene gasket shall be provided on covers at joints.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - BUS DUCT	PC288-TS-0807	0	
		Document No.	Rev	
		Sheet 4 of 8		

5.1.3 Whether bus duct (with louvers) is installed outdoor or indoor, suitably rated space heater with thermostat control shall be provided at different locations inside the bus duct to avoid moisture condensation.

5.1.4 All external hardware of diameter less than 8 mm shall be stainless steel and those of diameter 8 mm and above shall be mild steel cadmium plated or zinc passivated.

## 5.2 Bus Bars and Connections

5.2.1 The bus-bars in LV Bus duct shall be of three phase and neutral, non-segregated and air insulated type.

The bus-bars in HV Bus duct shall be of three phase, phase-segregated with insulating material.

5.2.2 The bus bars shall be amply sized to carry the rated continuous current under the specified ambient temperature without exceeding the temperature limits specified in IS: 8084. The bus bars shall be designed to withstand the system fault current for one second without exceeding the total temperature of 200°C. Type test certificate of similar bus duct shall be furnished.

5.2.3 The bus-bars material shall be high conductivity Aluminium alloy conforming to grade E91E of IS: 5082/electrolytic grade copper.

5.2.4 The bus-bars shall be rectangular in shape and cross-sectional area of neutral bus-bars shall be half of phase bus-bars.

5.2.5 The sizes of bus-bars selected shall be subjected to approval by PDIL. The vendor shall furnish supporting calculations for bus-bars and enclosure sizes both under normal load and short circuit conditions as well as that of temperature rise along with the offer.

5.2.6 All the bus-bars shall be bare and without any painting. The bus-bars shall be arranged and provided with proper phase identification as per IS: 5578/11353.

## 5.3 Joints and Bends

5.3.1 Only lap joints shall be used for jointing the bus bars. The over lap shall be equal to the width of the bus bars.

5.3.2 The contact surfaces of the overlapping bus-bars shall be thoroughly cleaned followed by application of good quality electrical grease and bolted immediately. In case of Aluminium to copper joints, copper bus-bars in addition shall be preferably tinned.

5.3.3 The bolting schedule adopted shall ensure proper contact pressure. A minimum of two bolts shall be used per joint.

5.3.4 The contact pressure shall be 100-140 kg/cm<sup>2</sup>. Only high tensile, zinc passivated or galvanized steel bolts shall be used along with large diameter flat washers of adequate thickness.

5.3.5 At the bends, the bus-bars shall bend at a radius of 2t where the 't' is the thickness of the bus-bars and the radius is measured to the inside of bus-bars.

## 5.4 Flexible Joints

Flexible joints and connections shall consist of tinned laminated copper strips or Aluminium strips of required cross sectional area. Precautions as mentioned under 5.3.2 shall also be observed while marking joints with laminated copper plates. Filler plates of Aluminium as required shall be used.

## 5.5 Expansion Joints

Expansion joints, where necessary, to allow for longitudinal expansion and contraction of bus-bars and bus enclosures caused by temperature variation shall be provided.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - BUS DUCT	PC288-TS-0807	0	
		Document No.	Rev	
		Sheet 5 of 8		

## 5.6 Bus Bar Supports

5.6.1 The bus-bars shall be rigidly supported at equal intervals. The bus-bars supports shall be such that they withstand stresses to which they may be subjected under normal and short circuit conditions.

5.6.2 The supports shall be of moulded construction of fibre glass reinforced with thermosetting plastics or superior materials. The supports, where necessary, shall either have built-in anti-tracking barriers or painted with anti-tracking varnishes.

## 5.7 Clearances and Creepage Distance

5.7.1 The clearances and creepage distance shall not be lower than the values specified below for any part of the bus duct.

- |      |   |   |       |
|------|---|---|-------|
| i)   | Minimum clearance between two live parts                              | - | 25 mm |
| ii)  | Minimum clearance between a live part and accidentally dangerous part | - | 25 mm |
| iii) | Creepage distance   | - | 30 mm |

5.7.2 The clearances and creepage distance, as specified above, shall definitely be maintained throughout the bus bars system. Provision of bus-bar separators or barriers shall not be considered to reduce the clearances from the values specified above.

## 5.8 Terminal Chambers at Switchgear and Transformer End

5.8.1 The bus duct shall be suitable for bolting to the flanges provided at the transformer and switchgear end. The exact dimensions and details of these terminal chambers shall be made available at the time of execution.

5.8.2 Phase changeover arrangement wherever required shall be provided in one of the terminal chambers to connect the bus-bars between same phase terminals at switchgear and transformer ends.

## 6.0 ACCESSORIES

### 6.1 Earthing

Two continuous earth strips of Aluminium having minimum 300 sq. mm size shall be provided throughout the length of bus duct or shall be suitable for full short circuit fault current for 1 sec. whichever is more.

### 6.2 Drain Plug

Bus duct shall be provided with drain plug to remove condensed moisture when required.

### 6.3 Fire Barriers

Two sets of epoxy moulded fire barriers shall be provided on switchgear end as well as transformer end.

### 6.4 Name Plates

6.4.1 Each bus duct shall be provided with a name plate of stainless steel with letter embossed on them and located at convenient location.

6.4.2 The name plate shall contain all details as per IS: 8084.

### 6.5 Hardware

Required number of hardwares like bolts, nuts, plain washers, spring washers etc. shall be provided for jointing the bus duct with transformer as well as switchgears.

## 7.0 LAYOUT

7.1 The proposed bus duct routing between transformer and associated switchgear shall be as shown in the drawing enclosed with NIT. Where no layout drawing is enclosed, the



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - BUS DUCT	<b>PC288-TS-0807</b>	<b>0</b>	
		Document No.	Rev	
		Sheet 6 of 8		

schedule of quantities shall be followed for bidding. However, the exact routing and details of switchgear and transformer end chambers shall be supplied at the time of order or drawing approval.

- 7.2 The successful vendor shall prepare final layout drawing for each bus duct with bill of materials and submit the same for PDIL/Purchaser's approval.

## 8.0 PAINTING

- 8.1 The enclosure after degreasing, pickling in acid, rinsing, phosphatising, passivating etc. shall be painted with two coats of anti-rust paint followed by two coats of anticorrosive paint.

- 8.2 Epoxy based paint shall be used.

- 8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

- 8.4 Unless otherwise specified, the finishing shade shall be light grey having shade no. 631 as per IS: 5.

## 9.0 TESTS AND INSPECTION

- 9.1 The bus duct shall be subjected to routine tests as per relevant standard.

- 9.2 Wherever specified, temperature rise tests shall be carried out on a minimum 5 metre length bus duct of each rating.

- 9.3 The test shall be carried out in manufacturer's works in presence of purchaser's representative. In addition, the bus ducts shall be subjected to stage inspection at works and inspection at site for final acceptance.

- 9.4 These inspections shall, however, not absolve the vendor from his responsibility of making good any defect which may be noticed subsequently.

## 10.0 DRAWINGS AND DOCUMENTS

- 10.1 Drawings and documents as per Annexure - I shall be supplied, unless otherwise specified.

- 10.2 All drawings and documents shall have the following descriptions written boldly

- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

## 11.0 SPARES

- 11.1 Commissioning Spares: Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval.

- 11.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.

- 11.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.

- 11.4 All spare parts shall be identical to the parts used in the equipment

## 12.0 PACKING

- 12.1 The bus duct shall be properly packed before despatch to avoid damage during transport, storage and handling. It shall be wrapped in polythene bags to make it

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - BUS DUCT	PC288-TS-0807	0	
		Document No.	Rev	
		Sheet 7 of 8		

waterproof. An additional wrapping with bitumen paper shall also be provided to make it completely water proof before the equipment is packed in wooden crates.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

### 13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

**ANNEXURE - I**  
**DOCUMENTATION FOR BUS DUCT**

Sl.No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	General arrangement for each bus duct showing the complete layout.	N	Y	Y
2.	Design calculations	N	Y	N
	a) Bus bars sizing			
	b) Flexible sizing			
	c) Temperature Rise			
	d) Support Span			
3.	Specification sheet & Technical Particulars	N	Y	Y
4.	Switchgear end termination details for each rating of bus duct.	N	Y	Y
5.	Transformer end termination details for each rating of bus duct.	N	Y	Y
6.	Assembly drawing of rigid bends.	N	Y	Y
7.	Assembly drawing of bends with flexible	N	Y	Y
8.	Assembly drawing of straight run	N	Y	Y
9.	Transposition chamber details	N	Y	Y
10.	Installation, operation & maintenance manual	N	Y	Y
11.	Test Certificates			
	i) Type	N	N	N
	ii) Routine & others	N	N	Y
12.	Guarantee Certificates	N	N	Y
13.	List of spare parts	N	N	N

**Note:**

- 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
- 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - SHEET STEEL DISTRIBUTION BOARDS	PC288-TS-0808	0	 
		Document No.	Rev	
		Sheet 1 of 12		

# **TECHNICAL SPECIFICATION** **SHEET STEEL DISTRIBUTION BOARDS**

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - SHEET STEEL DISTRIBUTION BOARDS</div>	PC288-TS-0808	0	<div><div>श्री एच ई एल <b>BIHEL</b></div></div>
		Document No.	Rev	
		Sheet 2 of 12		

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	DESIGN AND CONSTRUCTIONAL FEATURES
6.0	COMPONENT DETAILS
7.0	ACCESSORIES
8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	DRAWINGS AND DOCUMENTS
11.0	SPARES
12.0	PACKING
13.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR SHEET STEEL DISTRIBUTION BOARDS

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - SHEET STEEL DISTRIBUTION BOARDS	PC288-TS-0808	0	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 3 of 12		

## 1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well-packed condition of Sheet Steel Distribution Boards.
- 1.2 This standard shall be read in conjunction with relevant part of Design Philosophy – Electrical.

## 2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of the equipment shall comply with the latest issue of the following Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

- |              |   |
|--------------|---|
| IS: 8623     | - Specification for low voltage switchgear and control gear assemblies.                         |
| IS/IEC:60947 | - Specification for Low-voltage Switchgear and Control gear                                     |
| IS: 5578     | - Guide for marking of insulated conductors.  |
| IS: 11353    | - Guide for uniform system of marking and identification of conductors and apparatus terminals. |
| IS: 10118    | - Code of practice for selection, installation and maintenance of switchgear and control gear.  |

Various components housed in the distribution board shall conform to the Indian Standard Specification as mentioned against the component details.

- 2.2 The design and operational features of the equipment offered shall also comply with the provisions of the latest issue of the Indian Electricity Rules and other Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.
- 2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specification the requirement specified herein shall prevail.

## 3.0 SERVICE CONDITIONS

### 3.1 Ambient Conditions

These shall be as indicated in Design Philosophy – Electrical.

### 3.2 System Details

These shall be as indicated in Design Philosophy – Electrical.

## 4.0 OPERATING REQUIREMENTS

The distribution board shall be suitable for operating at the specified rating continuously with the specified voltage and frequency variations under the ambient conditions, without exceeding the permissible temperature rise and without any detrimental effect on any part.

## 5.0 DESIGN AND CONSTRUCTIONAL FEATURES

### 5.1 General

- 5.1.1 The distribution board shall consist of an assembly of a series of floor mounting, identical, metal clad, dead front type panels of unitized design. The panels shall be placed side by side to form a compact assembly and shall be extensible on either side.
- 5.1.2 The complete assembly shall be dust, damp and vermin proof having minimum degree of protection equivalent to IP-52 as per IS/IEC:60947.
- 5.1.3 The frame work of the cubicles shall be of bolted/welded construction. The minimum thickness of steel shall be 2 mm for load bearing members, 1.6 mm for non-load bearing

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - SHEET STEEL DISTRIBUTION BOARDS	PC288-TS-0808	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 4 of 12		

members and 3 mm for base channel. The doors and covers shall be fabricated from cold rolled sheet steel. Suitable reinforcement, wherever necessary, shall be provided.

- 5.1.4 The door hinges shall be concealed type.
- 5.1.5 All external hardware shall be cadmium plated/zinc passivated. The hardware for fixing the removable parts shall be provided with retaining devices.
- 5.1.6 The doors and the removable covers shall be provided with non-deteriorating neoprene gaskets. Gaskets without any discontinuity shall be preferred. Gaskets shall be held in position in groove of shaped sheet steel work or these shall be of U type. Adhesive cement, if used, shall be of good quality so that the gaskets do not come off during service.
- 5.1.7 All the components shall be accessible for inspection and maintenance without the necessity for removal of the adjacent ones. In case of single front design all components shall be accessible from the front for maintenance and back opening doors/ openable covers for maintenance shall not be acceptable.
- 5.1.8 The layout of the components inside a module shall be liberal to facilitate maintenance and the interconnection of wiring between the components shall not be subjected to any undue stress at the bends.
- 5.1.9 Mounting height of components requiring operation and observation shall not be lower than 300 mm and higher than 1800 mm.
- 5.1.10 Inter panel barriers shall be provided.
- 5.1.11 Adequate arrangement for earthing shall be provided to safeguard the operator or other personnel from electric hazards under all conditions of operation.

## 5.2 Panel Arrangement

- 5.2.1 The distribution board shall be non-drawout type in single front configuration.
- 5.2.2 Each Panel shall have its horizontal bus-bar chamber running on the top with multi-tier module units in the centre and having vertical bus-bar chamber and cable alley on either side.
- 5.2.3 The modules shall be enclosed on all sides and shall be so arranged that larger ones are placed at the bottom portion of the panel. Fixed type modules shall be at least 300 mm from the base channel.
- 5.2.4 The number of modules in the panel shall not exceed six for motor starter feeders and eight for switch fuse/MCB/MCCB feeders. The minimum size of module shall be 300 mm and 200 mm for starter and switch fuse feeders. The incomer and bus coupler module sizes for ratings up to 400 A shall be half the panel size. For higher ratings they shall be housed in single panel.
- 5.2.5 The module door shall be so interlocked that it shall not be possible to open the door with switch in closed position. Defeat interlock facility shall be provided.
- 5.2.6 The relay, meters, switches and lamps shall be flush mounted. All components of one module shall be mounted on the same module on a rigid sheet steel chassis. A 20 mm dia. rotating knob on the door shall be provided for closing and opening.

## 5.3 Bus Bars and Connections

- 5.3.1 The bus-bar shall be suitable for the supply system. The bus-bar and connections shall be made of electrolytic copper or high conductivity aluminium alloy conforming to Grade E91E of IS: 5082.
- 5.3.2 The bus-bar shall be amply sized to carry the rated continuous current under the specified ambient temperature without exceeding the temperature of 90°C. The bus-bars shall also be designed to withstand the system fault current for 1 second without

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - SHEET STEEL DISTRIBUTION BOARDS	PC288-TS-0808	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 5 of 12		

exceeding the temperature of 200°C for bare aluminium and 250°C for bare copper. The minimum acceptable size of bus-bars shall be 250 sq. mm (Al). Calculation for the bus-bar sizing shall be furnished along with the offer.

- 5.3.3 In case of double front arrangement of distribution boards, different sets of vertical bus-bars shall be provided. The vertical bus-bars shall be PVC sleeved or shrouded by insulating barriers which shall have cut-outs to permit entry of power wires. It shall be possible to remove the shroud for inspection and maintenance. Neutral-bars shall be provided in this chamber.
- 5.3.4 Horizontal bus-bars shall be of same cross-section through out. Stepped bus-bars shall not be acceptable.
- 5.3.5 All bus-bars shall be arranged and colours coded according to IS: 5578/11353.
- 5.3.6 The horizontal bus-bar shall run in a separate bus chamber located at the top shall have separate screwed cover for inspection purpose.
- 5.3.7 The bus-bars shall be rigidly supported at equal intervals to withstand maximum short circuit stresses. The supports shall be of moulded construction with built in anti tracking barriers. The support material shall be of fibre glass reinforced thermosetting plastic.
- 5.3.8 All joints shall be suitably treated to avoid oxidation of contact surfaces and bimetallic corrosion. A minimum of two bolts with spring washers shall be used for horizontal bus-bar joints.
- 5.3.9 Horizontal bus bars shall be insulated with heat shrinkable PVC sleeves of reputed makes. Insulating shrouds shall be provided for all joints of insulated bus-bars.

#### 5.4 Clearance and Creepage Distances

- 5.4.1 The clearance and creepage distances shall not be lower than the values specified below :
- |      |   |    |       |
|------|---|----|-------|
| i)   | Minimum clearance between two live conductors                       | -- | 20 mm |
| ii)  | Minimum clearance between live part and accidentally dangerous part | -- | 20 mm |
| iii) | Minimum creepage distance   | -- | 28 mm |
- 5.4.2 The clearances and the creepage, as specified above, shall definitely be maintained in the bus-bar system. Provision of bus-bar insulations, separator or barriers shall not be considered to reduce the clearance from the values specified above.
- 5.4.3 At the termination points in the equipment, e.g. switches, contactors, thermal relays, etc. it is realized that above clearance shall not always be possible to be maintained. All such points where above clearance are not possible to be maintained shall, therefore, be insulated or taped.

#### 5.5 Insulation

- 5.5.1 The insulation used shall be non-hygroscopic and shall be of porcelain, Epoxy- resins or fibre glass moulded with plastic. It shall be of adequate electrical and mechanical strength to give trouble free service during normal operation and short circuit conditions.
- 5.5.2 The insulation shall be treated suitably to withstand the tropical conditions and atmospheric pollution.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - SHEET STEEL DISTRIBUTION BOARDS	PC288-TS-0808	0	
		Document No.	Rev	
		Sheet 6 of 12		

## 5.6 Power Wiring

- 5.6.1 The connections from bus-bar including neutral to individual units on the modules shall consist of PVC insulated flexible copper cable or tapped copper strip.
- 5.6.2 The power wiring size shall be decided based on the rating of the switch, after using a rating factor of not more than 50% over the current rating in free air. In any case the minimum size of power wiring shall not be less than 4 sq. mm copper.
- 5.6.3 The size of connection from incomer to horizontal bus-bar and from horizontal bus-bar to bus coupler shall not be less than the size adopted for horizontal bus-bar.

## 5.7 Control Wiring

- 5.7.1 The switch board shall be completely factory wired and ready for external connections.
- 5.7.2 The wiring shall be carried out with flexible stranded PVC insulated copper conductor cables of 1100 Volt grade. The size of wires shall be as follows:
- C.T. Circuit -- 2.5 sq. mm
- V.T. and Control Circuits -- 1.5 sq. mm
- 5.7.3 All wiring shall be provided with dependent both end marking as per IS: 5578. Numbered ferrules, reading from the terminals outwards, shall be provided at both ends of all wiring for easy identification. These shall be interlocking type plastic ferrules.
- 5.7.4 Control wiring circuits, fed from a supply common to a number of feeders, shall be so protected that failure of a circuit in one feeder does not affect the operation of the other feeders.
- 5.7.5 The wiring to the equipment mounted on the doors shall be carried out with flexible multi strand copper conductor cable and supported so that opening of the door, there is no undue strain on wire leads.
- 5.7.6 The control cables shall be neatly arranged and properly supported.

## 5.8 External Cable Termination

- 5.8.1 All power and control cables shall enter the distribution board from the bottom. Sufficient space shall be provided for ease of connection and termination of cables.
- 5.8.2 All cables shall be of 1.1 KV grade PVC insulated armoured and PVC sheathed except for single core cable which shall be unarmoured. The number and sizes of cable shall be as indicated in Feeder details.
- 5.8.3 Compression type cable glands along with the cable lugs as required shall be provided for termination of cables.
- 5.8.4 The cable glands shall be of rolled Aluminium heavy duty double compression type and shall be mounted on a removable gland plate, provided at a minimum height of 75 mm from the bottom of the distribution board. Two numbers spare knockouts of size 20 mm shall also be provided on the gland plates for future use.
- 5.8.5 For all power cables crimped type aluminium lugs for aluminium cables and tinned copper lugs for copper cables shall be provided.
- 5.8.6 The terminal blocks shall be pressure clamp type up to 35 sq. mm cable and bolted lug type for higher sizes of cables. These shall be protected type and rated for 1100 Volts service. The minimum current rating of terminal block shall be 16 Amp. The construction shall be such that after the connection of cables by means of lugs, necessary clearance and creepage distance are available.
- 5.8.7 Where more than two cables in parallel are required to be terminated, a system of bus links shall be provided with adequate clearance and spacing.

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - SHEET STEEL DISTRIBUTION BOARDS</div>	PC288-TS-0808	0	<div> बी एच ई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 7 of 12		

- 5.8.8 Suitable clamps to support the vertical run of cables shall be provided.
- 5.8.9 The terminal block shall be grouped according to circuit functions and suitably numbered. 20% extra terminals shall be provided in the terminal block.
- 5.8.10 For power connections, suitable marking on the terminals shall be provided to identify the phases.

## 5.9 Feeder Details

- 5.9.1 The requirements of incomer, bus coupler and outgoing feeders shall be as indicated in the single line diagram, feeder details and corresponding schematic diagram.
- 5.9.2 The bus coupler shall be so located that it is possible to maintain half of the bus-bars while the other half is still alive. Complete segregation of bus-bar connections to bus coupler shall be provided.
- 5.9.3 Castle key type mechanical interlocks shall be provided between incomers and bus section modules to avoid paralleling of incomers. In addition padlocking facilities shall be provided in OFF position.
- 5.9.4 Single phase loads shall be distributed as far as possible on all the three phases.

## 6.0 COMPONENT DETAILS

The components shall conform to type of co-ordination C as per IS/IEC:60947. Makes of all components shall be subject to owner's / consultant's approval

### 6.1 Moulded Case Circuit Breakers

- 6.1.1 The circuit breaker shall conform to IS/IEC:60947 and shall be of P2 category having rupturing capacity as per system requirement.
- 6.1.2 The circuit breaker shall be provided with spring assisted quick make quick break type manually operated trip free mechanism, mechanical ON/OFF position indicators, thermal tripping devices of inverse characteristics, instantaneous short circuit tripping devices and necessary auxiliary and alarm switches. The MCCB cubicle shall be provided with service, test and isolated position and automatic safety shutter.
- 6.1.3 The thermal and short circuit tripping device shall be adjustable type.
- 6.1.4 When used for motor circuit shunt trip devices shall be provided and the let through power of controlling MCCB shall be lower than the respective contactor.
- 6.1.5 In addition, under voltage trip shall be provided, if specified.

### 6.2 Switches

- 6.2.1 The switches shall be Motor duty type AC23 category and shall comply with the requirements laid down in IS/IEC:60947. Switches up to 63 Amps shall be rotary type and those of 100 Amp and above shall be link type.
- 6.2.2 'ON' and 'OFF' positions of the switches shall be indicated on the panel. Provision shall be made to lock the switch in the 'OFF' position.
- 6.2.3 The fixed contacts shall be shrouded and the contacts shall be silver plated.
- 6.2.4 Two Pole switches shall also isolate the neutral circuit along with phase circuit. 4 Pole / 2 Pole switches shall be used for 3 Phase/1 Phase circuits respectively.

### 6.3 Fuses

The fuses shall be of non-deteriorating HRC cartridge link type and conform to IS: 13703. They shall be suitable for the load and the service required in the circuit.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - SHEET STEEL DISTRIBUTION BOARDS	PC288-TS-0808	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 8 of 12		

#### 6.4 Air Break Contactors

- 6.4.1 The Air Break Contactor shall be of AC3 category unless otherwise specified, conforming to IS/IEC:60947 and flapper type. Gravity operated contactors are not acceptable.
- 6.4.2 The dropout voltage shall not exceed 65% of rated voltage.
- 6.4.3 Each contactor shall be provided with auxiliary contacts as required. The rating of the auxiliary contacts shall be 5 Amps. AC or 1 Amp DC at the specified control voltages. The spare auxiliary contacts shall also be wired terminal block.

#### 6.5 Bimetal Thermal Overload Relays

- 6.5.1 The contactor shall be provided with three pole bimetal thermal overload relays unless otherwise specified. The bimetal relays shall be of suitable range, ambient temperature compensated and shall be separate mounting type. They shall be adjustable through graduated scale and shall be provided with changeover contact.
- 6.5.2 Bimetal relays shall conform to IS: 3231 and shall have built in single phasing preventor.
- 6.5.3 The bimetal relays shall be provided with a manual reset device resetable after opening the cubicle door. Auto reset thermal relays are not acceptable.

#### 6.6 Current Transformers

- 6.6.1 The current transformers shall conform to IS: 2705.
- 6.6.2 Current Transformers shall be Class-F insulated and vacuum impregnated. The Current Transformers shall be rigidly mounted and shall be easily accessible for maintenance and testing.
- 6.6.3 The Current Transformers shall be of 7.5 VA output. The output shall be adequate for the instrument and metering duties involved with sufficient margin. The Current Transformers shall have the accuracy Class-1 for the metering duty.
- 6.6.4 All the Current Transformers shall be provided with terminals and shorting links. One of the terminals of C.T. shall be earthed. The polarity of the C.T. shall be clearly marked.
- 6.6.5 The C.T.s shall be capable of withstanding momentary open-circuit on the secondary side without injurious effects.

#### 6.7 Instruments and Meters

- 6.7.1 All instruments shall be flush mounting type with square face and shall be tropicalized and dust tight.
- 6.7.2 The size of the instruments shall be 96 mm x 96 mm for full and half size modules and 72 mm x 72 mm for lower size modules.
- 6.7.3 Dials shall be parallax free with scale marked in black on white background and shall be suitable for direct reading.
- 6.7.4 Zero adjusters shall be provided for operation from the front of the cases.
- 6.7.5 All ammeters and voltmeters shall have 0 - 240° scale moving iron spring controlled type and of Class 1.5 accuracy as per IS: 1248. The scale range of the ammeter and voltmeter shall be as indicated in the feeder details.
- 6.7.6 In case of motor feeders, the ammeter shall be graduated uniformly upto C.T. primary current and with a compressed end scale upto 6 times the C.T. primary current. Red pointer shall be provided, which can be adjusted at site for indicating full load current.
- 6.7.7 KWH meter shall be 3 phase 4 wire type. These shall conform to the requirements of relevant IS and shall be C.T. operated. The current coil shall be rated for 5 Amp.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - SHEET STEEL DISTRIBUTION BOARDS	PC288-TS-0808	0	
		Document No.	Rev	
		Sheet 9 of 12		

6.7.8 All kWh meters shall be provided with test blocks for current and voltage coils for testing them at site without interrupting their recording while in service.

## 6.8 Push Button and Control Switches

6.8.1 The switches and push buttons shall conform to utilization category AC 11/DC 11 as per IS/IEC:60947 . The contact shall be rated to make, break and carry inductive current of 5 Amp. at 415 V AC and 1 Amp at 220 V DC.

6.8.2 The control switches shall be spring return rotary type unless otherwise specified and provided with pistol grip type handle. The control switches for circuit breakers shall be additionally fitted with lost motion devices and sequencing devices.

6.8.3 The selector switches shall be stay-put rotary type and provided with oval shape handles.

6.8.4 The push buttons shall be of momentary contact spring loaded type with a set of normally close and open contacts. The push button for 'Start' shall be shrouded type and coloured green, stop push button shall be un-shrouded type and coloured red and other push buttons shall be un-shrouded type coloured black. The fixing ring shall be metallic white.

6.8.5 Emergency stop push buttons, if specified, shall be lockable in pushed position.

## 6.9 Miniature Circuit Breakers

6.9.1 The miniature circuit breakers shall conform to IS: 13032 and shall be of duty category M-9.

6.9.2 It shall be provided with overload and short circuit protective devices in a heat resistant housing.

6.9.3 A certificate of short circuit rating and current time tripping curve shall be furnished alongwith the offer.

## 6.10 Signal Lamps

6.10.1 Signal lamps shall be provided to indicate the various circuit conditions as shown in scheme drawings. The colour of the lamps for various functions shall be as follows:

Red	--	Switch/Contactor closed.
Green	--	Switch/Contactor open.

6.10.2 The lamps shall be LED type having lumen output 200 milli candela in axial direction.

6.10.3 It shall be possible to remove the globe from outside for replacement of lamps.

## 7.0 ACCESSORIES

7.1 The supplier shall include the following accessories.

- Fuse Puller.
- Test plug for kWh meters.

## 7.2 Space Heater

Each vertical section shall be provided with a thermostatically controlled space heater, rated for 240 V, 50 Hz and controlled through double pole miniature circuit breaker.

## 7.3 Name Plates

7.3.1 The distribution board shall have large name plate on the top to indicate its name and designation.

7.3.2 Each feeder shall be provided with name plate. Each single front panel shall have name plate both in front and back.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - SHEET STEEL DISTRIBUTION BOARDS	PC288-TS-0808	0	 कोयला COAL INDIA	 बी एच ई एल
		Document No.	Rev		
		Sheet 10 of 12			

- 7.3.3 All control switches, push buttons, lamps etc. shall have functional identification labels.
- 7.3.4 Name plate shall be of black perspex with white engraving and of minimum 3 mm thick.
- 7.3.5 Any other accessories required, but not specified shall also be supplied to make the distribution board complete in all respects to ensure safe and proper operation.

## 8.0 PAINTING

- 8.1 The enclosure after degreasing, pickling in acid, cold rinsing phosphatising, passivating etc. shall be painted with two coats of anti-rust paint followed by two coats of anticorrosive paint.
- 8.2 Epoxy based paint shall be used.
- 8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.
- 8.4 Unless otherwise specified, the finishing shade shall be light grey Shade No.631 as per IS: 5.
- 8.5 One litre of paint shall be supplied along with each board for touch up at site.

## 9.0 TESTS AND INSPECTION

- 9.1 The distribution boards shall be subjected to routine test as per IS: 8623.
- 9.2 Additional tests, wherever specified, shall be carried out.
- 9.3 All the above tests shall be carried out in presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and site inspection.
- 9.4 These inspections shall however, not absolve the vendor from his responsibility for making good any defect which shall be noticed subsequently.

## 10.0 DRAWINGS AND DOCUMENTS

- 10.1 Drawings and documents as per Annexure-I shall be supplied unless otherwise specified.
- 10.2 All drawings and documents shall have the following description written boldly:
- Name of client
  - Name of consultant
  - Enquiry / Order Number with plant / project name
  - Code No. and Description

## 11.0 SPARES

- 11.1 Commissioning Spares: Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval.
- 11.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 11.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 11.4 All spare parts shall be identical to the parts used in the equipment

## 12.0 PACKING

- 12.1 The distribution board shall be properly packed before despatch to avoid damage during transport, storage and handling.
- 12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - SHEET STEEL DISTRIBUTION BOARDS	PC288-TS-0808	0	 
		Document No.	Rev	
		Sheet 11 of 12		

12.3 A sign to indicate the upright position of the panels to be placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.

### 13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

## ANNEXURE - I



### DOCUMENTATION FOR SHEET STEEL DISTRIBUTION BOARDS

Sl.No.	Documents	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	Feeder Details	N	Y	Y
4.	General Arrangement and Foundation Drawings	N	Y	Y
5.	Schematic Diagrams with Terminal arrangement drawings	N	Y	Y
6.	Calculation for Bus-bar sizing	N	Y	N
7.	Illustrative and Descriptive literature	N	N	Y
8.	Catalogues for bought out accessories	N	N	Y
9.	Installation, Operation and Maintenance Manual	N	N	Y
10.	Test Certificates			
	-- Type (for MCCB & MCB)	N	N	N
	-- Routine	N	N	Y
11.	Guarantee Certificates	N	N	Y
12.	Spare Parts List	N	N	Y

#### Note:



1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - LIGHTING SUB DISTRIBUTION BOARDS</div>	PC288-TS-0809	0	<div><div>श्री एच डी एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 1 of 6		



# **TECHNICAL SPECIFICATION** **LIGHTING SUB DISTRIBUTION BOARDS**



<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - LIGHTING SUB DISTRIBUTION BOARDS</b></div>	<b>PC288-TS-0809</b>	<b>0</b>	<div> श्री एच ई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 2 of 6		

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	GENERAL DESIGN AND CONSTRUCTIONAL FEATURES
6.0	SPECIAL FEATURES FOR FLAME PROOF LIGHTING SUB DISTRIBUTION BOARDS
7.0	COMPONENT DETAILS
8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	DRAWINGS AND DOCUMENTS
11.0	SPARES
12.0	PACKING
13.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR LIGHTING SUB DISTRIBUTION BOARDS

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - LIGHTING SUB DISTRIBUTION BOARDS</b></div>	<b>PC288-TS-0809</b>	<b>0</b>	<div> श्री एच ई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 3 of 6		

## 1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well packed condition of lighting sub distribution boards.
- 1.2 This standard shall be read in conjunction with relevant part of Design Philosophy - Electrical.

## 2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of the following Indian Standards. Equipment complying with equivalent IEC standards shall also be acceptable
- IS/IEC:60947 - Low voltage switchgear and control gear
- IS: 8623 - Specification for low voltage switchgear and control gear assemblies
- 2.2 The design and operational features of the equipment offered shall also comply with the provisions of latest issue of the Indian Electricity Rules and other relevant statutory acts and regulations. The supplier shall, wherever necessary, make suitable modification in the equipment to comply with the above.
- 2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

## 3.0 SERVICE CONDITIONS

### 3.1 Ambient Conditions

These shall be as indicated in Design Philosophy - Electrical.

### 3.2 System Details



These shall be as indicated in Design Philosophy - Electrical.

## 4.0 OPERATING REQUIREMENTS

The lighting sub-distribution boards shall be suitable for operating continuously under the ambient conditions and with the voltage and frequency variations, without exceeding the specified temperature rise and without any detrimental effect on any part.

## 5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

- 5.1 The lighting sub distribution boards shall be fabricated out of 2.5 mm thick cold rolled sheet steel and shall be suitable for mounting on wall/structure. These shall have dust and vermin proof construction conforming to IP-54 as per IS/IEC:60947. For outdoor installation, the enclosure shall conform to IPW-55. Suitable canopy made out of 2 mm thick Aluminium sheet shall be supplied along with the board.
- 5.2 The miniature circuit breakers shall be so mounted inside the enclosure that their operating knobs project outside for easy operation. The cut-out for the knobs on the enclosure shall be lined with gasket for dust proofness. For further protection against ingress of dust, the portion where the knobs have protruded out, shall be provided with another external front cover, internally hinged at the top, gravity operated and with a knurled knob at the bottom. The external cover shall be flushed with the main cover. Continuous neoprene gasket shall be provided to make the board completely dust and weather proof.
- 5.3 All external hard ware of diameter less than 8 mm shall be of stainless steel and those of diameter 8 mm and above shall be of mild steel cadmium plated or zinc passivated.

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - LIGHTING SUB DISTRIBUTION BOARDS</b></div>	<div>PC288-TS-0809</div>	<div>0</div>	<div> श्री एच ई एल <b>BHEL</b></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 4 of 6</div>		

- 5.4 The sub-distribution boards to be located indoors shall have top entry arrangement for outgoing cables and bottom entry for incoming cable. However for outdoor locations, all cable entries shall be from the bottom only.
- 5.5 Three phase and neutral bus bar system of adequate size shall be provided to which all outgoing and incoming MCB's shall be connected.
- 5.6 The internal wiring shall be carried out by means of single core PVC insulated 2.5 sq. mm stranded copper conductor cables.
- 5.7 Two earthing terminals outside the board shall be provided.
- 5.8 Suitable label inscription consisting of black perspex with engraving for the board and circuit nos. of all outgoing feeders shall be provided. The label inscription of the board shall contain description and code no. The circuit nos. of outgoing feeders shall be serially indicated as 1L, 2L.....17L, 18L.
- 5.9 The board shall be complete with terminal block, cable glands, cable lugs and other accessories as specified.

## **6.0 SPECIAL FEATURES FOR FLAME PROOF LIGHTING SUB DISTRIBUTION BOARDS**

- 6.1 The enclosure shall be in addition of flame proof execution as per IS: 2148.
- 6.2 The enclosure group and temperature class shall be as indicated in Design Philosophy – Electrical.
- 6.3 The enclosure shall be of cast iron/cast Aluminium alloy (4600 as per IS: 617).
- 6.4 Cables shall enter the terminal chamber through flame proof compression type cable glands. From terminal chamber to the main enclosure connection shall be made through bushings. Direct entry of external cables into the main enclosure shall not be accepted.
- 6.5 The sub-distribution board shall be of 6 way type.
- 6.6 Individual earth terminals shall be provided for the earth conductor of the outgoing cables beside the phase and neutral terminals.
- 6.7 The sub-distribution board must be certified by Central Mining Research Institute, Dhanbad or other statutory authority for use in specified hazardous area.

## **7.0 COMPONENT DETAILS**

- 7.1 The lighting sub-distribution board shall be wired and have components as per SD-8083 (copy attached).

### **7.2 Miniature Circuit Breaker (MCB)**

The MCB shall be of duty category M-9 and shall conform to IS/IEC:60898-1:2002. It shall be provided with overload and short circuit protective devices. MCB shall be of C Curve Type.



- 7.2.1 The incoming MCB's or switches shall be of triple pole and switched neutral type and outgoing MCB's of single pole and switched neutral type, single phase earth leakage protection in each phase of the incomer shall be provided.

### **7.3 Terminal Block**

Pressure clamp type terminal blocks shall be provided both for incoming and outgoing cables. The rating of the terminal block shall be at least 1.5 times the rating of the MCB.

### **7.4 Cable Glands**

Heavy duty double compression type Aluminium cable glands suitable for PVC insulated, armoured and PVC sheathed 1.1 KV grade incoming and outgoing cables shall be provided.

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - LIGHTING SUB DISTRIBUTION BOARDS</div>	PC288-TS-0809	0	<div> श्री एच ई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 5 of 6		

## 8.0 PAINTING

- 8.1 The enclosure after suitable pre-treatment shall be painted with two coats of anti rust paint followed by two coats or anticorrosive paint.
- 8.2 Epoxy based paint shall be used.
- 8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.
- 8.4 The finishing shade shall be light grey shade no.631 as per IS: 5.

## 9.0 TESTS AND INSPECTION

- 9.1 All the lighting sub-distribution boards shall be subjected to routine tests as per IS: 8623.
- 9.2 Additional tests, wherever specified, shall be carried out on one lighting sub-distribution board of each type.
- 9.3 The above mentioned tests shall be carried out in the manufacturer's works in the presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection at works and inspection at site for final acceptance.
- 9.4 The purchaser's inspection shall, however, not absolve the vendor from his responsibility for making good any defects which may be noticed subsequently.

## 10.0 DRAWINGS AND DOCUMENTS

- 10.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.
- 10.2 All drawings and documents shall have the following description written boldly.
- Name of client
  - Name of consultant
  - Enquiry / Order Number with plant / project name
  - Code No. and Description

## 11.0 SPARES



- 11.1 Commissioning Spares: Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval.
- 11.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 11.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 11.4 All spare parts shall be identical to the parts used in the equipment.

## 12.0 PACKING

- 12.1 The equipment shall be properly packed to safeguard against weather conditions and handling during transit. It shall be wrapped in polythene bags and an additional wrapping of bitumen paper shall also be provided to make it completely water proof before the equipment is packed in wooden crates.
- 12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

## 13.0 DEVIATIONS

- 13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - LIGHTING SUB DISTRIBUTION BOARDS</div>	PC288-TS-0809	0	<div> श्री एच ई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 6 of 6		

## ANNEXURE - I

### DOCUMENTATION FOR LIGHTING SUB DISTRIBUTION BOARDS

SL.N O.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet	N	Y	Y
2.	Technical particulars	N	Y	Y
3.	General arrangement Drgs.	N	Y	Y
4.	Certificate for flameproofness from statutory testing authority wherever applicable	N	N	Y
5.	Schematic diagram	N	Y	Y
6.	Descriptive literature of Various equipment	N	N	Y
7.	Guarantee certificate	N	N	Y
8.	Test certificate	N	N	Y

#### Note:

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

<div><div><div>पी डी आई एल PDIL</div></div></div>	<div><div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div><div>TECHNICAL SPECIFICATION - INDUCTION MOTOR</div></div>	PC288-TS-0810	0	<div><div><div>कोयला भारत</div></div><div><div>बी.एच.एल.</div></div></div>
		Document No.	Rev	
		Sheet 1 of 12		

## TECHNICAL SPECIFICATION INDUCTION MOTOR

<div><div><div>पी डी आई एल PDIL</div></div></div>	<div><div><div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div><div>TECHNICAL SPECIFICATION - INDUCTION MOTOR</div></div></div>	PC288-TS-0810	0	<div><div><div>श्री रम्य इ एन COAL INDIA</div></div><div><div>BHEL</div></div></div>
		Document No.	Rev	
		Sheet 2 of 12		

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	GENERAL DESIGN FEATURES
5.0	PERFORMANCE
6.0	COUPLING DETAILS
7.0	ACCESSORIES
8.0	VIBRATIONS
9.0	NOISE LEVEL
10.0	PAINTING
11.0	TESTS AND INSPECTION
12.0	PACKING
13.0	DRAWINGS AND DOCUMENTS
14.0	SPARES
15.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR INDUCTION MOTORS

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - INDUCTION MOTOR	PC288-TS-0810	0	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 3 of 12		

## 1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well-packed condition of medium voltage and high voltage induction motors.
- 1.2 This standard shall be read in conjunction with relevant part of Design Philosophy - Electrical.

## 2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of IS-325 and other relevant Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.
- 2.2 The design and operational features of the equipment offered shall also comply with the provisions of latest issue of the Indian Electricity Rules and other relevant Statutory Rules & Regulations. The supplier shall, whenever necessary, make suitable modification in the equipment to comply with the above mentioned rules.
- 2.3 Flame proof motors shall, in addition, comply with the requirements laid down in IS: 2148.
- 2.4 Increased safety motors shall, in addition, comply with the requirements laid down in IS: 6381.
- 2.5 Motors with type of protection "n" shall, in addition, comply with the requirements laid down in IS: 9628.
- 2.6 Wherever any requirement laid down in this standard differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

## 3.0 SERVICE CONDITIONS

### 3.1 Ambient Conditions

The ambient conditions shall be as indicated in the Design Philosophy - Electrical.

### 3.2 System Details

- 3.2.1 The details of power system to which the motors will be connected shall be as indicated in the Design Philosophy - Electrical.
- 3.2.2 The motors shall be suitable for connection to a power system where transient disturbances are very likely to occur. During the transient disturbances, voltage of the system may completely disappear and return in a short time with the motors still running and connected. Under this condition, the return of voltage may occur at such an instant that the induced e.m.f. in the motor is in phase with the applied voltage giving rise to current surges which may reach a value equal to 1.6 times the starting current and also cause transient torques of large magnitudes.

## 4.0 GENERAL DESIGN FEATURES

### 4.1 Enclosure

- 4.1.1 The enclosure of motors for indoor and outdoor services shall be IP-54 and IPW-55 respectively as per IS/IEC:60529, unless otherwise specified.
- 4.1.2 Motors for outdoor service shall be provided with special seals for the enclosure, joints, bearing housing, terminal boxes etc. so that no extra protective covering for ingress of water shall be required.
- 4.1.3 Vertical motors for outdoor installation shall be provided with a rain protective hood.
- 4.1.4 All external hardware shall be zinc passivated or cadmium plated.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - INDUCTION MOTOR	PC288-TS-0810	0	 कोयला  बी एच ई एल
		Document No.	Rev	
		Sheet 4 of 12		

4.1.5 The enclosure shall be provided with threaded metallic plug to permit drainage of condensed water from the inside.

#### 4.2 **Cooling**

4.2.1 All motors shall be totally enclosed fan cooled conforming to IC-0141 as per IS: 6362 unless otherwise specified.

4.2.2 In case of CACA construction, the same shall conform to IC-0161 as per IS: 6362.

4.2.3 In case of CACW construction, the same shall conform to ICW 37A 91 as per IS: 6362.

4.2.4 Wherever service conditions are such that corrosive agents are present in the surroundings, the following materials of construction for cooling tubes shall be adopted, unless otherwise specified.

For CACA motor - Aluminium tubes having minimum thickness of 1.6 mm

For CACW motor - Low carbon alloy steel

4.2.5 In case of CACW motors, the cooling tubes and flanges shall also be suitable for the cooling water analysis. Trays shall be provided for collection of leaking water with arrangement for its drainage.

4.2.6 The cooling fans shall be suitable for bidirectional rotation of motors. These shall be fastened to the motor shaft by means of compensating rings or will be balanced independent of the motor. Guide key or reference points shall be supplied to prevent wrong assembly. The cooling air shall be sucked from the non-driving end.

4.2.7 The cooling fans shall be made of non-sparking materials such as cast Aluminium (LM-6 alloy) / cast iron.

#### 4.3 **Direction of Rotation**

4.3.1 Motors shall be suitable for both directions of rotation. In case of any design limitation, the same shall be indicated in the offer.

4.3.2 In either case, a plate showing the direction of rotation corresponding to the phase terminal markings shall be fitted at the driving end shield of the motors.

#### 4.4 **Stator**

4.4.1 The stator laminations shall be made from suitable magnetic sheet iron varnished on both sides. Where ventilation is required, these shall be arranged in suitable packs, each pack being separated by spacers to form ventilating ducts for circulation of air.

4.4.2 The slot shall be open type with coils so arranged that the coils can be easily removed for inspection and repair.

#### 4.5 **Rotor**

4.5.1 The rotor shall be of squirrel cage construction, unless otherwise specified.

4.5.2 For small motors, the squirrel cage shall preferably be of pressure die-cast construction. For large motors, the rotor bars and the end rings shall be of copper or copper alloy. The bars shall be firmly placed in slots to prevent vibration during start up / locked rotor condition. Conductor ends shall be securely fixed to the end rings using the latest brazing techniques. Retaining rings shall be provided for high speed machines for the end rings. The rotor cage shall be designed for the required starting and duty cycles.

4.5.3 Wherever wound rotor is specified, the windings shall have the same features as detailed for the stator windings. The rotor voltage shall not exceed the stator voltage.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - INDUCTION MOTOR	PC288-TS-0810	0	 कोयला भारत  बी एच ई एल
		Document No.	Rev	
		Sheet 5 of 12		

4.5.4 The rotor shall be dynamically balanced and shall rotate perfectly with no preferential stop points. The rotor shall be constructed such as to allow the removal or addition of material for balancing.

4.5.5 The rotor shaft shall be electrically and magnetically so balanced that the induced shaft voltage does not exceed 200 millivolt. Otherwise the bearing housing at non-driving end shall be insulated for 2 KV.

#### 4.6 **Windings and Insulation**

4.6.1 The motor coils shall be made out of insulated electrolytic grade copper conductor. Successive coils shall be connected by accessible joints, well brazed and finished smooth to prevent damage to insulation.

4.6.2 The motors shall be insulated assuming the power system neutral as isolated.

4.6.3 All motors shall be insulated with F insulation with tropical and fungicidal treatments.

4.6.4 Wherever class F insulation is specified, the windings shall be easily replaceable type and the temperature rise shall not exceed that of class B insulation.

4.6.5 The winding coils shall be dried, properly impregnated with suitable varnishes to withstand the site conditions and properly baked. At least two additional impregnations and baking shall be applied to the assembled stator coil, making a total of three impregnations and baking. Finally the windings shall be painted with special anti-acid and anti-alkali paints to withstand the site conditions.

4.6.6 The windings shall be well brazed and capable of withstanding thermally and mechanically the transient disturbances specified under clause 3.2.2.

4.6.7 Lead-in wire between the windings and the outside terminals shall be made through bushings in H.V. motors. For M.V. motors, heat resistant insulated conductors shall be used as lead-in wire.

4.6.8 The windings shall be star connected for high voltage motors and delta connected for medium voltage motors.

#### 4.7 **Slip Rings and Brushes**

4.7.1 Slip rings shall be located in the non-driving side. The material of construction shall be copper alloy. The slip rings and the brush gear shall be cooled by the motor cooling fan.

4.7.2 For explosion proof motors, the slip rings and brush gear shall be housed in a flameproof housing. In case this is not possible, the housing shall be pressurised type with flameproof pressure switch for interlocking with the motor. In either case, glass covers shall be provided for inspection.

4.7.3 The starting rheostats shall be designed for intermittent duty and rated for 10 minutes. Where speed regulation is required, the rheostats and the controllers shall be suitable for such duty and be continuously rated. Auxiliary contacts shall be provided on the controllers for connections to the motor supply controls to prevent wrong operations during starting.

#### 4.8 **Bearings**

4.8.1 All motors shall be provided with bearings suitable for the application. The bearings must be guaranteed to ensure a smooth operation and a life not shorter than 30,000 hrs.

4.8.2 Where external thrusts are specified, the motors shall be fitted with special roller thrust bearings capable of withstanding the specified thrust. In such cases, the guaranteed life of the bearings shall not be less than 20,000 hours.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - INDUCTION MOTOR	PC288-TS-0810	0	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 6 of 12		

- 4.8.3 The bearing housing shall be effectively sealed against ingress of dust and water and creep age of lubricants along the shaft.
- 4.8.4 The bearing shall be suitable for both directions of rotation of the motor.
- 4.8.5 All motors shall be provided with on-line grease lubrication arrangement for both DE and NDE side bearings except for motors of frame size 112 and less and flange mounted M.V. motors. The arrangement shall be complete with grease nipple and drain plug located at convenient locations.
- 4.8.6 All oil lubricated bearings shall be fitted with oil level indicator and resistance temperature detector/dial type thermometer with alarm and trip contacts.
- 4.8.7 Self cooled bearing system shall be preferred.
- 4.8.8 The manufacturer shall specify the type of lubricant and the time interval of lubrication for the bearings of each motor.
- 4.8.9 The bearing temperature shall not exceed 90°C for grease lubricated bearings and 70°C for oil lubricated bearings.
- 4.8.10 Wherever shaft end-play has been specified, the bearings shall be capable of providing the specified end-play.
- 4.9 **Terminal Box**
- 4.9.1 All the terminal boxes shall have identical degree of protection as that of the motor.
- 4.9.2 The power terminal box shall be mounted on the right hand side of the motor as viewed from the coupling end. For M.V. Motors, design of terminal boxes shall be such that it may be possible to arrange top/bottom/side entry of cables at site.
- 4.9.3 The power terminal boxes shall be as follows:
- For H.V. motors - Phase segregated type capable of with standing the system fault level for 0.2 Sec. or more.
  - For M.V. motors - Manufacturer's standard box with epoxy or SRBF moulded terminal board.
- 4.9.4 The mounting arrangement of power and neutral side terminal boxes for HV motors shall be identical so that it shall be possible to interchange the boxes at site.
- 4.9.5 In case of H.V. motors, all the six leads of the motors shall be taken out, three on one side and three on the other side to separate terminal boxes. However, neutral shorting link shall be provided on the neutral box for star connection.
- 4.9.6 In case of M.V. motors, all the six leads of the motors shall be taken out to a common terminal box. Shorting links for delta connections shall be provided in the terminal box for motors 112 frame and above.
- 4.9.7 For increased safety motors and for motors with type of protection "n", the terminals shall be provided with positive locking device so that they do not become loose during normal operation.
- 4.9.8 The power terminal boxes shall have adequate clearances in between the terminals and also between the terminals and cable gland for proper termination of cables. Where more than one cable is required to be terminated in parallel, the spacing in the box shall be adequate for easy termination.
- 4.9.9 Separate terminal boxes shall be provided for connection of power, control and space heater cables.
- 4.9.10 All terminal boxes shall be complete with heavy duty double compression type cable glands and lugs/connectors to receive the external cables.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - INDUCTION MOTOR	PC288-TS-0810	0	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 7 of 12		

4.9.11 Where cross linked polyethylene cables are specified, the terminal box shall be suitably designed for proper termination of such cables.

4.9.12 The cable lugs shall be of tinned copper and suitable for crimping.

#### 4.10 **Geared Motors**

Where geared motors are specified, the gears shall be oil lubricated, heavy duty as per AGMA class III and capable of transmitting the rated motor power continuously. They shall be capable of withstanding moderate shock loads having a service factor of 2 and the starting duties. They shall be silent and smooth in operation. Inspection glass shall be provided to indicate the oil level in the gear box.

### 5.0 **PERFORMANCE**

#### 5.1 **Starting**

5.1.1 The motors shall be capable of being started direct-on-line, unless otherwise specified.

5.1.2 The starting torque of each motor shall be higher than the initial resisting torque of the driven load throughout the starting period even at a feeding voltage of 85% of the rated voltage for normal purpose motor and 80% of the rated voltage for special purpose motor.

5.1.3 The starting current of 415 V Motors shall not exceed the values indicated in IS: 12615. Also there shall be no further positive tolerance on the values of starting current.

The starting current of 11 KV & 3.3 KV motors shall not exceed 550% of FLC. No positive tolerance is acceptable over 550% FLC.

5.1.4 The motors shall be suitable for the following starting cycle:

- With the motor at ambient temperature - 2 successive starts and 3rd start after 5 minutes.
- With the motor at steady state load temperature - 1 immediate start and 2nd start after 5 minutes. This sequence shall be repeated in the next hour.

5.1.5 Speed switch shall be provided, wherever required, to fulfil the starting conditions.

#### 5.2 **Locked Rotor Condition**

5.2.1 The locked rotor withstand time ( $t_E$ ), under hot condition at 110% of rated voltage shall be more than the starting time of the motor coupled to the load even at the lowest stipulated starting voltage by 2 secs. for motors, having starting time up to 10 secs. and by 5 secs. for motors, having starting time more than 10 secs.

5.2.2 For increased safety motors,  $t_E$  under hot condition shall not be less than 10 secs. The value of  $t_E$  shall be determined in the presence of purchaser's representative unless test certificate from an independent testing authority is submitted for similar motors. The time  $t_E$  and the locked rotor current shall be stamped on the name plate as well as indicated in the test certificates.

5.2.3 For deciding the time  $t_E$  in all cases, the temperature of the insulated stator and rotor shall not exceed the value stipulated under clause no. 5.4.3.

#### 5.3 **Running**

5.3.1 All motors shall be continuous maximum rated (S1 duty as per IS: 325), unless otherwise specified.

5.3.2 The motors shall be capable of delivering the rated output without exceeding the specified temperature rise under the system voltage and frequency variation conditions.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - INDUCTION MOTOR	PC288-TS-0810	0	 श्री रघु ईश्वर 
		Document No.	Rev	
		Sheet 8 of 12		

5.3.3 The motors shall be suitable for running at the rated load for 5 minutes duration at 80% voltage and for 1 Sec. duration at 70% voltage, without exceeding the specified temperature rise.

#### 5.4 **Temperature Rise**

5.4.1 The total temperature of the stator winding under full load running condition shall not exceed the values permissible for the specified insulation class. For increased safety motors, the total temperature shall be 10°C less than for normal motors.

5.4.2 For explosion proof motors, the maximum surface temperature shall not exceed the values applicable for temperature class of the hazardous gases / vapours present in the surrounding area. However for type 'n' motors, the maximum allowable temperature shall not exceed 200°C.

5.4.3 In case of starting and locked rotor conditions stipulated under clause nos. 5.1.4 and 5.2.1 respectively, the maximum temperature in the rotor shall not exceed the following values:

- For squirrel cage rotor - 300°C
- For wound rotor - As applicable to the insulation class
- For explosion proof motor - As per temperature class of the hazardous gases / vapours, without exceeding the above temperature as applicable

### 6.0 **COUPLING DETAILS**

6.1 Unless otherwise specified, all motors shall be coupled to the driven equipment through flexible coupling.

6.2 Normally the coupling half for the motor shaft shall be supplied by the driven equipment supplier. The coupling half shall be keyed on the shaft with a tapered joint or shrunk with a straight joint. For this purpose, the motor manufacturer shall coordinate all details of the coupling system with the driven equipment manufacturer, wherever required.

6.3 Where rigid coupling is specified, the motor shaft shall have the desired class of accuracy.

6.4 For all vertical flange mounted motors, the limitations on shaft extension, run out, perpendicularity and eccentricity, as required by the driven machine supplier shall be complied with by the motor supplier.

6.5 i) If the motor is to be coupled to a reciprocating pump or compressor requiring fluctuating torque, the motor supplier shall ensure that the inertia of the driving and driven machine assembly shall be such that the variation in the armature current shall not exceed  $\pm 66\%$  of the rated current while delivering full load.

ii) The measurement of armature current shall be done with the oscillograph.

iii) The additional fly wheel, if any, shall be assembled at such a distance from the motor so as to allow easy inspection of the windings.

iv) All necessary coordination with driven equipment manufacturer shall be carried out by the motor manufacturer.

6.6 i) Wherever belt drive is specified, the motor supplier shall ensure that the shaft extension and the bearings are suitable for the duty specified.

ii) Unless otherwise specified, the slide rails for all belt driven motors shall be supplied by the motor manufacturer.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - INDUCTION MOTOR	PC288-TS-0810	0	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 9 of 12		

## 7.0 ACCESSORIES

The motors shall be complete with all the accessories.

### 7.1 Space Heaters

7.1.1 Space heaters rated for 240 V A.C. shall be provided to keep the winding dry for all high and medium voltage motors, except for motors rated below 30 KW which shall be suitable for space heating by connecting 24 V A.C to any of the two motor winding terminals.

7.1.2 The location of the space heaters shall be such as to allow easy access for inspection, maintenance and replacement.

### 7.2 Name Plates

7.2.1 The name plates shall be of stainless steel with letters embossed on them.

7.2.2 The name plate shall contain all the relevant details as per IS: 325 and in addition shall indicate the following:

- i) The description and code no. of motor
- ii) Degree of protection of enclosure
- iii) Temperature rise of windings under running condition
- iv) Designation of bearings
- v) Recommended type of lubricant and interval of lubrication
- vi) Direction of rotation
- vii) Mounting Arrangement

7.2.3 Flameproof motors shall have additional name plate containing relevant particulars as per IS: 2148.

7.2.4 Increased safety motors shall have additional name plate containing relevant particulars as per IS: 6381.

7.2.5 Motors with type of protection “n” shall have additional name plate containing relevant particulars as per IS: 9628.

### 7.3 Embedded Temperature Detectors

7.3.1 All high voltage motors shall be provided with 6 nos. of evenly distributed embedded resistance temperature detectors for measurement of winding temperature. These shall be located in positions at which the highest temperatures are likely to occur.

7.3.2 In addition, the high voltage motors shall be provided with

- i) 1 no. RTD for hot air temperature measurement
- ii) 2 nos. RTDs (1 on each side) for bearing temperature measurement of oil lubricated bearings. For grease lubricated bearings, RTD shall be provided only where specified

7.3.3 These RTDs shall be of platinum having 100 ohm resistance at 0°C and temperature coefficient as  $3.850 \times 10^{-3}$ .

7.3.4 The RTDs shall be 3 lead type having power frequency insulation level of 2KV.

7.3.5 The RTDs shall comply with the requirements laid down in IS: 2848.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - INDUCTION MOTOR	PC288-TS-0810	0	 श्री रघु ईश्वर 
		Document No.	Rev	
		Sheet 10 of 12		

#### 7.4 **Dial Type Thermometers**

- 7.4.1 In high voltage motors, the measurement of hot air and bearing temperature (of oil lubricated bearings) by dial type thermometers shall be provided wherever specified.
- 7.4.2 The arrangement shall consist of a dial type of mercury-in-steel thermometer so mounted that its stem shall be located in the maximum temperature region.
- 7.4.3 The thermometer shall have two potential free contacts for alarm and trip.
- 7.4.4 All contacts shall be rated for 2 Amps. at 110 V D.C.
- 7.4.5 For bearing temperature measurement, separate thermometers shall be provided for each bearing.
- 7.4.6 For grease lubricated bearings, temperature measurement arrangement shall be provided only where specified.

#### 7.5 **Oil Supply System**

- 7.5.1 For large sized motors, where forced oil lubrication system is considered, a common oil supply system for the motor and the driven equipment shall be provided by the driven equipment manufacturer.
- 7.5.2 However, the motor supplier shall quote separate price for the complete oil system of the motor.
- 7.5.3 The system shall be suitable for location near the motor.
- 7.5.4 The oil supply system for each motor shall include:
- i) 2 Nos. 100% rated motor driven pumps with motors
  - ii) 1 No. oil tank complete with oil level gauge and thermometer
  - iii) 1 No. oil cooler
  - iv) 1 No. oil filter
  - v) 1 No. differential pressure switch for filter
  - vi) 2 Nos. pressure switches
  - vii) Necessary piping
  - viii) Necessary control and interlocks

#### 8.0 **VIBRATIONS**

The motor vibrations measured at the bearings must not exceed the limits specified in IS: 12075.

#### 9.0 **NOISE LEVEL**

The motor noise level shall not exceed 85 dB measured at a distance of 1 metre from the motor.

#### 10.0 **PAINTING**

- 10.1 Enclosures of the motor and its accessories shall be painted with two coats of anti-rust paint and two coats of anti-corrosive paint after suitable pre-treatment.
- 10.2 Epoxy paint shall be used.
- 10.3 Unless otherwise specified, the finishing shade shall be light grey having shade No. 631 as per IS: 5.

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><b>TECHNICAL SPECIFICATION - INDUCTION MOTOR</b></p></div>	PC288-TS-0810	0	<div></div>
		Document No.	Rev	
		Sheet 11 of 12		

## 11.0 TESTS AND INSPECTION

- 11.1 All motors shall be routine tested as per relevant standards.
- 11.2 Additional tests, wherever specified, shall be carried out on one motor of each rating.
- 11.3 For high voltage motors of each rating, polarization index test shall also be carried out.
- 11.4 All the above mentioned tests shall be carried out in the presence of purchaser's representative. In addition, the motor shall be subject to stage inspection at works and inspection at site for final acceptance.
- 11.5 These inspections shall, however, not absolve the vendor from their responsibility for making good any defects which may be noticed subsequently.

## 12.0 PACKING

- 12.1 The motors shall be properly packed to safeguard against weather conditions and handling during transit.
- 12.2 The shaft shall be properly clamped / supported.
- 12.3 Rust inhibiting agents shall be applied to fittings and sliding surfaces.
- 12.4 All flanges shall be closed with blanking plates to avoid entry of foreign materials.
- 12.5 The loose pieces of the motor / spare parts / Instruments shall be separately wrapped in moisture resistant paper and marked with identification marks and name plate of the corresponding motors.
- 12.6 The packing box / crate shall include a copy of installation, operation and maintenance manual.

## 13.0 DRAWINGS AND DOCUMENTS

- 13.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.
- 13.2 All drawings and documents shall have the following descriptions written boldly:
- Name of client
  - Name of consultant
  - Enquiry / order number with plant / project name
  - Motor Code No. and Description

## 14.0 SPARES

- 14.1 Commissioning Spares: Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval.
- 14.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 14.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 14.4 All spare parts shall be identical to the parts used in the equipment

## 15.0 DEVIATIONS

- 15.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.



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**ANNEXURE - I**  
**DOCUMENTATION FOR INDUCTION MOTORS**

Sl. No.	Document Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet and Technical Particulars	N	Y	Y
2.	Dimensional Drawings	N	Y	Y
3.	Drawings and data for air / water heat exchangers, if necessary	N	Y	Y
4.	Drawings and data for oil system, if necessary	N	Y	Y
5.	Characteristic curves			
	a) Thermal withstand curve	N	Y	Y
	b) Load Vs FL current	N	Y	Y
	c) Load Vs Efficiency	N	Y	Y
	d) Load Vs Power factor	N	Y	Y
	e) Load Vs Speed	N	Y	Y
	f) Voltage Vs Thermal Withstand time	N	Y	Y
	g) Starting current Vs Time	N	Y	Y
6.	Connection diagram for RTDs, thermometer etc.	N	Y	Y
7.	Terminal Box drawings	N	Y	Y
8.	Illustrative and Descriptive catalogues	N	N	Y
9.	Catalogues of bought out accessories	N	N	Y
10.	Spare parts list	N	N	Y
11.	Installation, Operation and Maintenance manual	N	N	Y
12.	Test certificates			
	a) Routine	N	N	Y
	b) Type	N	N	Y
	c) For enclosure	N	N	Y
13.	Guarantee Certificates	N	N	Y

**Note:**

- 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
- 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

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		Document No.	Rev	
		Sheet 1 of 7		

# **TECHNICAL SPECIFICATION** **INTERLOCKING SWITCH SOCKET AND PLUG**

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	GENERAL DESIGN AND CONSTRUCTIONAL FEATURES
6.0	SPECIAL FEATURES FOR FLAME PROOF SWITCH SOCKET AND PLUGS
7.0	COMPONENT DETAILS
8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	DRAWINGS AND DOCUMENTS
11.0	PACKING
12.0	SPARES
13.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR INTERLOCKING SWITCH SOCKET AND PLUG

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - INTERLOCKING SWITCH SOCKET AND PLUG</b>	PC288-TS-0811	0	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 3 of 7		

## 1.0 SCOPE

- 1.1 The standard covers the technical requirements of design, manufacture, testing at works and delivery in well packed condition of interlocking switch socket and plug.
- 1.2 The standard shall be read in conjunction with relevant part of Design Philosophy - Electrical.

## 2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of IS-4160/ IEC-309 and other relevant Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.
- 2.2 The design and operational features of the equipment offered shall also comply with the provisions of latest issue of Indian Electricity Rules and other statutory acts and regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.
- 2.3 Wherever any requirement, laid down in this standard differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

## 3.0 SERVICE CONDITIONS

### 3.1 Ambient conditions

These shall be as indicated in Design Philosophy - Electrical.

### 3.2 System details

These shall be as indicated in Design Philosophy - Electrical.

## 4.0 OPERATING REQUIREMENTS

The equipment shall be suitable for operating at the rated capacity continuously without exceeding the specified temperature rise and without any detrimental effect on any part.

## 5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

- 5.1 The switch socket shall be heavy duty industrial type. The interlocking arrangement shall be such that it is not possible to insert or withdraw the plug with the switch in 'ON' position.
- 5.2 The switch sockets shall have dust, hose and weather proof construction conforming to IPW55 as per IS/IEC:60947 and shall be suitable for outdoor use without any extra protection. All jointing surfaces shall be smoothly machined and of sufficient width to prevent ingress or dust. Further the covers shall be provided with continuous gaskets made of neoprene to prevent ingress of dust and moisture.
- 5.3 The enclosure of switch sockets and plugs shall be of cast aluminium alloy 4600 and suitable for fixing on wall / structure.
- 5.4 The enclosure shall be largely dimensioned in order to avoid temperature rise inside it which may damage the insulating materials and gaskets employed therein.

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		Document No.	Rev	
		Sheet 4 of 7		

- 5.5 The insulating materials used shall be non-hygroscopic, mould proof and treated with suitable varnish to withstand the ambient conditions.
- 5.6 All external hardware of diameter less than 8 mm shall be of stainless steel and those of diameter 8 mm or above shall be of mild steel cadmium plated or zinc passivated.
- 5.7 Suitable arrangement for looping of cables from one switch socket to the other shall be provided. For switch sockets rated above 63A, looping shall be done from busbars and for switch sockets rated 63A and below, looping may be done from terminal block. Necessary terminals, cable glands and lugs for looping shall be provided. Also one no. The readed plug for each switch socket shall be supplied loose.
- 5.8 All the relevant information shall be provided on engraved name plate made of aluminium.

5.9 The enclosure shall be provided with two earthing terminals outside the body.

## 6.0 SPECIAL FEATURES FOR FLAME PROOF SWITCH SOCKET AND PLUGS

- 6.1 The enclosure shall be in addition of flame proof execution as per IS: 2148.
- 6.2 The enclosure group and temperature class shall be as indicated in Design Philosophy - Electrical.
- 6.3 Cable shall enter the terminal chamber through flame proof compression type cable glands. From the terminal to the main enclosure, the connection shall be made through proper bushings. Direct entry of external cables into the main enclosure shall not be accepted.
- 6.4 An additional earthing terminal inside the terminal chamber shall be provided.
- 6.5 Switch socket, plug and cable glands must be certified by the Central Mining Research Institute, Dhanbad or any other statutory authority for use in the specified hazardous area.
- 6.6 Further interlocking shall be provided so that the contacts cannot be energised when the plug and socket are separated.

## 7.0 COMPONENT DETAILS

Makes of all components shall be subject to owner's / consultant's approval

### 7.1 Air Break Switches

- 7.1.1 The switches shall be quick make, quick break rotary type and of utilisation category AC-23 as per IS/IEC:60947.
- 7.1.2 Switches shall be hand operated from outside the cover. The switch handle shall remain fixed to the front cover while removing the front cover.

### 7.2 H.R.C. Fuses

- 7.2.1 The sockets shall be provided with link type HRC fuses.
- 7.2.2 The fuses shall be capable of withstanding a short circuit current of 50 KA and shall be delayed action type conforming to IS: 13703. These shall be mounted on a shrouded base.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - INTERLOCKING SWITCH SOCKET AND PLUG</b>	PC288-TS-0811	0	 कोयला इण्डिया  BHEL
		Document No.	Rev	
		Sheet 5 of 7		

### 7.3 Socket Outlets

- 7.3.1 The socket outlet shall be located in the lower part of the enclosure and shall be provided with a threaded aluminium cover attached to the body with G.I. chain, to protect the socket after extraction of the plug. Spring loaded automatic shutter shall not be acceptable.
- 7.3.2 The socket contacts shall maintain satisfactory spring pressure and contact with the corresponding plug under normal service conditions.
- 7.3.3 The socket contacts shall be sunk well below the surface of the socket- outlets so as to make it impossible to be touched unintentionally.
- 7.3.4 An earthing contact shall be provided in the socket outlet which shall ensure making and breaking respectively of its contact with the earthing pin of the plug before and after making and breaking of the corresponding current carrying contacts.

### 7.4 Plugs

- 7.4.1 The plugs shall be so constructed so that these can be easily fitted in to the socket outlets.
- 7.4.2 These shall be provided with knurled knob arrangement for screwing on the body of the socket so that it can be securely fixed on the top.
- 7.4.3 The plug base and cover shall be firmly secured to each other and shall be sufficiently robust in construction to withstand normal usage.
- 7.4.4 The plug pins shall preferably be of single part. The earthing pin shall be slotted with a single slot and shall be larger in dimension than other pins.
- 7.4.5 The plug and socket contacts shall be self aligning type with best electrical continuity.
- 7.4.6 The plug shall be provided with dust proof cable entry suitable for receiving TRS flexible heavy duty copper conductor cable of specified size. The arrangement shall be such that the conductors are relieved from strain including twisting where they are connected to the terminals and that the outer surface of the cable at the place of entry is not damaged.
- 7.4.7 Insulating barriers forming an integral part of the plug shall ensure separation of metals and bare flexible conductors at different potentials.

### 7.5 Cable Termination

- 7.5.1 Switch socket shall have cable termination arrangement on the upper part of the housing and shall be provided with side entries, one on either side, through heavy duty double compression type rolled aluminium cable glands suitable for 1.1 KV grade PVC insulated armoured and PVC sheathed cables of size.
- 7.5.2 The terminal blocks shall be pressure clamp type for switch socket rated up to 63A and bolted lug type for higher ratings. The terminals shall be rated for at least 1.5 times the switch rating.

## 8.0 PAINTING

- 8.1 The enclosure after suitable pre-treatment shall be painted with two coats of anti-rust paint followed by two coats of anti-corrosive paint.
- 8.2 Epoxy based paint shall be used.
- 8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

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		Document No.	Rev	
		Sheet 6 of 7		

- 8.4 The finishing shade shall be light grey shade no.631 as per IS: 5, unless specified otherwise.

## 9.0 TESTS AND INSPECTION

- 9.1 The switch sockets and plugs shall be subjected to routine tests as per IS-4160 and other relevant standards.
- 9.2 Wherever specified, additional tests shall be carried out on one switch socket and plug of each rating.
- 9.3 The tests shall be carried out in the manufacturer's works in the presence of purchaser's representative. In addition to the above tests, the equipment shall be subject to stage inspection at works and inspection at site for final acceptance.
- 9.4 These inspections shall, however, not absolve the vendor from their responsibility for making good any defect which may be noticed subsequently.

## 10.0 DRAWINGS AND DOCUMENTS

- 10.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.
- 10.2 All drawings and documents shall have the following descriptions written boldly.
- Name of client
  - Name of consultant
  - Enquiry / Order Number with plant / project name
  - Code No. and Description

## 11.0 PACKING

- 11.1 The switch socket and plug shall be properly packed to safeguard against weather conditions and handling during transit. It shall be wrapped in polythene bags and an additional wrapping of bitumen paper shall also be provided to make it completely water proof before the equipment is packed in wooden crates.
- 11.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

## 12.0 SPARES

- 12.1 Commissioning Spares: Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval.
- 12.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 12.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 12.4 All spare parts shall be identical to the parts used in the equipment

## 13.0 DEVIATIONS

- 13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

## ANNEXURE – I

### DOCUMENTATION FOR INTERLOCKING SWITCH SOCKET AND PLUG


Sl.No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	General arrangement and foundation drawing	N	Y	Y
4.	Schematic / wiring diagram	N	Y	Y
5.	Illustrative and descriptive literature	N	N	Y
6.	Catalogue for bought out accessories	N	N	Y
7.	Installation operation and maintenance manual	N	N	Y
8.	Test Certificates			
	a) Type	N	N	Y
	b) Routine	N	N	Y
9.	Guarantee Certificate	N	N	Y
10.	Certificate of flameproofness from statutory testing authority wherever applicable.	N	N	Y
11.	Spare parts list with identification marks	N	N	Y

**Note:**

- 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
- 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No





 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - BATTERY CHARGER	PC288-TS-0813	0	 श्री एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 1 of 13		

# **TECHNICAL SPECIFICATION** **BATTERY CHARGER**

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - BATTERY CHARGER</div>	PC288-TS-0813	0	<div><div>श्री एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 2 of 13		

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	DESIGN AND OPERATIONAL REQUIREMENTS
5.0	CONSTRUCTIONAL FEATURES
6.0	COMPONENT DETAILS
7.0	ACCESSORIES
8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	DRAWINGS AND DOCUMENTS
11.0	SPARES
12.0	PACKING
13.0	DEVIATIONS
ANNEXURE - I	REQUIREMENT OF PROTECTIONS, METERING, CONTROL AND INDICATIONS / ANNUNCIATIONS FOR BATTERY CHARGER
ANNEXURE - II	DOCUMENTATION FOR BATTERY CHARGER

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT TECHNICAL SPECIFICATION - BATTERY CHARGER</b>	PC288-TS-0813	0	
		Document No.	Rev	
		Sheet 3 of 13		

## 1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well packed condition of Battery Charger Units.
- 1.2 The standard shall be read in conjunction with relevant part of Design Philosophy - Electrical.

## 2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of the equipment covered by this specification shall comply with the latest issue of IS: 8623 Specification for low voltage switchgear and control gear assemblies and other relevant Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.
- 2.2 The design and operational features of the equipment shall also comply with provisions of the latest issue of the Indian electricity Rules and other relevant Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications to comply with the above.
- 2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

## 3.0 SERVICE CONDITIONS

### 3.1 Ambient Conditions




These shall be as indicated in Design Philosophy - Electrical.

### 3.2 System Details

These shall be as indicated in Design Philosophy - Electrical.

## 4.0 DESIGN AND OPERATIONAL REQUIREMENTS



- 4.1 The Battery Charger Unit and its components shall be suitable for operating at the specified rating continuously with the specified voltage and frequency variations under the ambient conditions without exceeding the temperature rise limits specified in relevant standards and without any detrimental effect on any part.
- 4.2 The battery charger board shall consist of two units as follows:
- Float cum load cum -- Boost Charger To supply continuous load and keep the battery in state in float mode. In Boost mode, for Initial charging of Battery and after power restoration subsequent to failure, to recharge the battery while simultaneously supplying load current.
  - A stand by unit for (a) above.
- 4.3 The rated voltage of the float charger for lead acid battery shall be 2.2 Volt/ Cell and final charging voltage of the boost charger shall be 2.75 Volt/ Cell. The rated voltage of the float charger for Ni-Cd shall be minimum 1.4 Volt/ Cell and final charging voltage of the boost charger shall be minimum 1.7 Volt/ Cell. The rated output voltage of the charger under 4.2 (a) above shall be adjustable by  $\pm 5\%$  of the rated value manually.

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - BATTERY CHARGER</b></div>	<div>PC288-TS-0813</div>	<div>0</div>	<div><div>श्री एच ई एल</div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 4 of 13</div>		



- 4.4 Charging unit stated under 4.2 (a) above shall be fully automatic using silicon controlled rectifiers (SCR) common for Float and Boost service. Charger D.C. output voltage shall be maintained within  $\pm 2\%$  irrespective of the input supply variations and load variation of 0 to 100% by closed loop voltage feed back control system. The charger shall be provided with current limit feature.
- 4.5 The output voltage of the float charger shall be monitored and in case voltage falls below 90% of the rated voltage the stand by charger shall be automatically switched 'ON' with audio-visual alarm and annunciation. Time delay features shall be incorporated to avoid spurious changeover.
- 4.6 Boost charging shall be achieved through the same silicon controlled rectifier (SCR) which shall regulate the charger output automatically by current control closed loop system. Provision for manual adjustment of charger output shall also be made. Charger shall maintain its output current constant at starting rate/ finishing rate of battery charging current irrespective of variation in input supply and battery condition.
- 4.7 Transfer from float charging to boost charging and vice versa shall be automatic as per the battery charge condition.
- 4.8 During boost charging operation, arrangement shall be made so that DC power to load is not interrupted even if AC power fails during this operation. During Boost charge period, battery backup to load shall be arranged by a tapping from suitable point of the battery.
- 4.9 Suitable dropper diodes shall be provided to reduce the voltage across the load to 105% of the rated voltage at rated load current. When power supply to the charger fails, the dropper diodes shall be by-passed automatically through contactor so that full battery output voltage is available to the load.
- 4.10 Provision of suitable filters shall be made so that the ripple in output voltage shall not exceed 3% and 10% for float and boost charger respectively.
- 4.11 It shall be ensured that during boost charging, no over/under charging of cells takes place.
- 4.12 All the automatic features specified above shall also have provision of manual arrangement for control of charging rates and transfer from one charger to others.
- 4.13 Charger unit shall be provided with all required indication, metering, protection, control and alarm annunciation devices for safe and reliable operation and shall include at least as indicated in Annexure-I.

## 5.0 CONSTRUCTIONAL FEATURES

- 5.1 Each of the charger units shall be housed in separate metal clad cubicles of identical size suitable for floor mounting and arranged to form a compact switchboard.
- 5.2 The complete assembly shall be dust, damp and vermin proof type equivalent to IP-43 as per IS/IEC:60947. In case it is necessary to provide openings for ventilation, these shall be closed from inside by fine wire mesh. Forced ventilated panel shall not be acceptable.
- 5.3 The frame work of cubicles shall be of bolted/welded construction, fabricated out of cold rolled sheet steel of not less than 2 mm thickness. The thickness of base channel shall not be less than 3 mm, suitable reinforcement, wherever necessary, shall be provided.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT TECHNICAL SPECIFICATION - BATTERY CHARGER</b>	PC288-TS-0813	0	
		Document No.	Rev	
		Sheet 5 of 13		

- 5.4 Hinged doors shall be provided on both the front and back side for easy access. The door hinges shall be concealed type.
- 5.5 The doors and the removable covers shall be provided with non-deteriorating neoprene gaskets. Gaskets without any discontinuity shall be preferred. Gaskets shall be held in position in groove in shaped steel work or these shall be 'U' type. Only one joint per gasket shall be permitted. Adhesive cement, if used, shall be of good quality so that the gaskets do not come off during service.
- 5.6 The mounting of the components shall be such that these are accessible for checking and replacement without the necessity of removing the adjacent ones, at the same time ensuring necessary degree of safety.
- 5.7 It shall be possible to carry out maintenance of one charger when the other is in operation.
- 5.8 The meters, switches and lamps shall be flush mounted type. All components of one unit shall be mounted on the same unit.
- 5.9 All the live parts shall be insulated. Parts which can not be insulated shall be provided with insulating barriers. These barriers shall provide shielding of all live parts to prevent accidental contact when the door is open. However, for the parts requiring handling normally, such as fuses/lamps etc., separate barriers shall be provided. The barriers in all cases shall cover the cable lug portions and shall be firmly secured, stable and durable. It shall, however, be possible to remove such barriers, if required.
- 5.10 At the equipment termination points, insulated phase barriers, PVC bolt caps, PVC hoses or insulating ribs shall be provided.
- 5.11 The outgoing terminal blocks shall be shrouded type or provided with insulating barriers.
- 5.12 Adequate arrangement for earthing shall be provided to safeguard the Operator or other personnel from electric hazards under all conditions of operation.
- 5.13 **Clearances and Creepage**
- The clearances and creepage distances shall not be lower than the values specified below:
- |      |   |   |       |
|------|---|---|-------|
| i)   | Minimum clearance between two live parts      | : | 20 mm |
| ii)  | Minimum clearance between a live part & earth | : | 20 mm |
| iii) | Minimum creepage distance                     | : | 28 mm |
- 5.14 **Insulation**
- 5.14.1 The insulation used shall be non-hygroscopic and may be of porcelain, epoxy resin or glass fibre moulded with plastic. It shall be of adequate electrical and mechanical strength to give trouble free service during normal operation and short circuit conditions.
- 5.14.2 The insulation shall be treated suitably to withstand the tropical conditions and atmospheric pollution as specified.
- 5.15 **Wiring**
- 5.15.1 The switch board shall be completely factory wired and ready for external connections.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - BATTERY CHARGER	PC288-TS-0813	0	
		Document No.	Rev	
		Sheet 6 of 13		

- 5.15.2 The wiring shall be complete in all respect so as to ensure proper functioning of control, protection, interlocking and measurement.
- 5.15.3 The wiring shall be carried out with flexible stranded PVC insulated copper conductor cables of 1100 V grade of minimum 1.5 Sq.mm size.
- 5.15.4 All wiring shall be marked with dependent both ends marking as per IS: 5578. Numbered ferrules, reading from the terminals outwards, shall be provided at both ends for easy identification. These shall be interlocking type plastic ferrules.
- 5.15.5 The control cables shall be neatly arranged and properly supported on PVC wiring channel.

## 5.16 Cable Termination



- 5.16.1 The boards shall be designed for bottom entry of the power and control cables. Sufficient space shall be provided for ease of connection and termination of cable.
- 5.16.2 Provision for receiving one 415 V, 3 phase 4 wire incoming supply lines, one for each charger shall be made. However, DC output for battery and load shall be looped inside the panel and only one outgoing supply each for battery and load shall be provided.
- 5.16.3 The termination of cables shall be done through cable glands which shall be suitable for the cables.
- 5.16.4 Heavy duty double compression type rolled Aluminium cable glands shall be provided. The cable glands shall be mounted on a removable gland plate, provided at a minimum height of 75 mm from the bottom of the switchboard. Two spare knockouts of size 20 mm shall also be provided on the gland plate for future addition of control cables.
- 5.16.5 For all power cables, crimped type cable lugs of same material as of conductor shall be provided.
- 5.16.6 The internal power wiring shall be terminated in the terminal blocks for connection to the outgoing cables, These terminal blocks shall be pressure clamp type up to 35 Sq.mm, cable and bolted lug type for higher sizes of cables, These shall be protected type and rated for 1100 V service. The minimum current rating of terminal block shall be 16 Amp. The construction shall be such that after the connection of cables by means of lugs, necessary clearances and creepage distances are available.
- 5.16.7 Not more than two wires shall be connected to any terminal. If necessary a number of terminals shall be jumpered together to provide wiring points.
- 5.16.8 Wherever necessary, suitable clamps to support the vertical run of cables shall be provided.
- 5.16.9 The terminal blocks shall be grouped according to circuit functions and suitably numbered. 20% extra terminals shall be provided in the terminal block.
- 5.16.10 For power connection, suitable marking on the terminals shall be provided to identify the phases.

## 5.17 Earth Bus

- 5.17.1 A continuous earth bus of Aluminium of suitable size minimum 32 x 6 mm shall be run all over the length in the lower part of the board with two ends connected to the external earth terminals of the board.

## 6.0 COMPONENT DETAILS

### 6.1 Rectifier Transformer

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - BATTERY CHARGER</div>	PC288-TS-0813	0	<div><div>श्री एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 7 of 13		

This shall be double wound, air cooled, 3 phase type. Class 'F' insulating materials shall be used, with temperature rise limited to Class 'B'. The windings shall be vacuum impregnated.

## 6.2 Thyristors and Diodes

The thyristors and diodes shall be properly selected to have adequate safety margin. A factor of safety of minimum 4 shall be taken for voltage surges and 2 for current ratings. The thyristors and diodes shall be mounted on their respective heat sinks which shall preferably be made of extruded Aluminium properly machined and providing intimate contact with the stud for heat dissipation. Each thyristor/ diode shall be protected with properly designed snubber circuit.

## 6.3 Air Break Switches

The switches shall be heavy duty quick make, quick break type conforming to IS/IEC 60947. Switches shall be snap action rotary type. 'ON'-'OFF' position of the switch shall be boldly indicated. The handle of switches shall remain fastened to the door even when the door is opened after turning the switch 'OFF'. The AC input switch shall not be directly mounted on the door.

## 6.4 Fuses

For protection of thyristors/ diodes, semi-conductor fuses shall be provided. All other fuses shall be HRC cartridge link type. They shall be suitable for the load and service required.

## 6.5 Contactors

The contactor shall be air break type of category AC-3/ DC-1 as per IS/IEC 60947. DC contactor shall be provided with arc chutes and magnetic blow out coil. The contactors shall not drop out even when the coil voltage drops to 65% of rated voltage.

## 6.6 Thermal Overload Relays

Adjustable bimetal thermal overload relays shall be provided. The bimetal relays shall be ambient temperature compensated. The thermal relays shall be provided with a manual resetting device on the door.

6.7 All ammeters and voltmeters shall be class 1.5 as per IS 1248 and shall be flush mounted type of minimum size 96 x 96 mm. Ammeters and Voltmeters for A.C. service shall be of moving iron type and that for D.C. service shall be moving iron or moving coil type. Zero adjuster shall be provided for operation from the front of the cases.

## 6.8 Printed Circuit Boards (PCBs)

The PCBs shall conform to IS 7405. These shall be of fibre or epoxy glass moulded of minimum thickness 1.5 mm and shall have gold plated contacts and silver or nickel plated tracks. All PCBs shall be of plug-in type contained in a dust proof box. PCBs shall be self diagnostic type and shall be provided with status indication. Metering points shall be provided on each PCB and the PCBs shall be clamped in position so that vibration or long usage does not result in loose contacts.



## 6.9 Timers

The timers shall be electronic, pneumatic or synchronous type conforming to IS: 5834 with manual/auto reset features as per the functional requirements. The repeat accuracy shall be within 5%.

## 6.10 Control and Selector Switches

6.10.1 All the control and selector switches shall be of rotary type with thermal utilization category of AC 11 or DC 11 as per IS/IEC:60947.

6.10.2 The control switches shall be spring return type and provided with pistol grip type handles.

6.10.3 The selector switches shall be stay-put type and provided with oval handle.

## 6.11 Signal Lamps

6.11.1 Signal lamps shall be provided to indicate the various circuit conditions and these shall be placed at a suitable height. The colour of the lamps for various functions shall be as follows:

Red	--	Circuit 'ON'
Green	--	Circuit 'OFF'
Amber	--	Alarm and auto trip.

6.11.2 The lamps shall be LED type having lumen output of 200 millicandella in axial direction.

## 6.12 Audio Visual Alarm Annunciation

6.12.1 A solid state audio-visual alarm annunciation system shall be provided for the board. Audible annunciation shall be provided by means of hooter with provision of remote alarm and acknowledgment. Visual annunciation shall be provided by flashing of the respective facia window. The facia window shall have translucent glass or plastic cover with inscription in black letters. Each facia window shall be provided with two lamps connected in parallel. The cover plate of the facia window shall be flush with the panel and shall be capable of easy removal to facilitate replacement of lamps.

6.12.2 The following operating sequence shall be adopted for audio visual alarm and indication:

System Condition	Visual Signal	Audible Signal
Normal	OFF	OFF
Abnormal	Flashing	ON
Acknowledge	Steady ON	OFF
Return to normal	OFF	OFF
Test	Steady ON	ON



## 7.0 ACCESSORIES

The supply shall include the following accessories:

### 7.1 Space Heater

Each cubicle of the board shall be provided with a thermostatically controlled space heater, rated for 240 V, 50 Hz and controlled through double pole miniature circuit breaker. The space heater supply shall be tapped from incomer power supply.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT TECHNICAL SPECIFICATION - BATTERY CHARGER</b>	PC288-TS-0813	0	
		Document No.	Rev	
		Sheet 9 of 13		

## 7.2 Name Plates

- 7.2.1 The board shall have a large name plate on the top to indicate its name and designation.
- 7.2.2 Each cubicle shall be provided with a name plate.
- 7.2.3 All control switches, push buttons, lamps etc. shall have function identification labels.
- 7.2.4 Name plate shall be of black perspex with white engraving of minimum 3 mm thickness.
- 7.3 Fuse Puller
- 7.4 Any other accessories required but not specified shall also be supplied to make the board complete in all respects and ensure its safe and proper operation.

## 8.0 PAINTING

- 8.1 The enclosure after suitable pre-treatment shall be painted with two coats of anti-rust paint followed by two coats of anti-corrosive paint.
- 8.2 Epoxy based paint shall be used.
- 8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.
- 8.4 Unless otherwise specified the finishing shade shall be light grey having Shade No. 631 as per IS 5.




## 9.0 TESTS AND INSPECTION

- 9.1 The board shall be subjected to routine tests as per IS 8623 and other relevant standards. Heat run test, if required, shall be carried out.
- 9.2 Additional tests, wherever specified shall be carried out on one board of each rating.
- 9.3 All the above tests shall be carried out in presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and site inspection.
- 9.4 These inspections shall however, not absolve the vendor from his responsibility for making good any defects which may be noticed subsequently.



## 10.0 DRAWINGS AND DOCUMENTS

- 10.1 Drawings and documents as per Annexure-II shall be supplied unless otherwise specified.
- 10.2 All drawings and documents shall have the following description written boldly:
- Name of client
  - Name of consultant
  - Enquiry / Order Number with plant / project name
  - Code No. and Description

## 11.0 SPARES

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT TECHNICAL SPECIFICATION - BATTERY CHARGER</b>	PC288-TS-0813	0	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 10 of 13		


- 11.1 Commissioning Spares: Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval.
- 11.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 11.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 11.4 All spare parts shall be identical to the parts used in the equipment
- 12.0 PACKING**
- 12.1 The board shall be properly packed before despatch to avoid damage during transport, storage and handling.
- 12.2 The packing box shall contain a copy of the installation, operation and maintenance manual along with one set of drawings.
- 12.3 A sign to indicate the upright position of the panels to be placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.
- 13.0 DEVIATIONS**
- 13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - BATTERY CHARGER</div>	PC288-TS-0813	0	<div><p>बी एच ई एल <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 11 of 13		

## ANNEXURE - I

### REQUIREMENT OF PROTECTIONS, METERING, CONTROL AND INDICATIONS / ANNUNCIATIONS FOR BATTERY CHARGER

Sl. No.	Description	To be mounted on		
		Float cum Load Charger	Standby Float cum Load Charger	Boost Charger
1	2	3	4	5
1.	<b>A.C. Input Side</b>			
	i) ON/OFF Switch	Yes	Yes	Yes
	ii) HRC Fuses	Yes	Yes	Yes
	iii) Contactor	Yes	Yes	Yes
	iv) Thermal O/L Relay	Yes	Yes	Yes
	v) Single phasing and Phase Reversal	Yes	Yes	Yes
	vi) Voltmeter with SS	Yes	Yes	Yes
	vii) Ammeter with SS	Yes	Yes	Yes
	viii) Signal Lamp (ON/OFF)	Yes	Yes	Yes
2.	<b>Rectifiers</b>			
	i) Semiconductor fuses	Yes	Yes	Yes
	ii) Filters with fuses	Yes	Yes	Yes
	iii) Surge Suppressors	Yes	Yes	Yes
3.	<b>DC Output Side</b>			
	i) ON/OFF Switch	Yes	Yes	Yes
	ii) HRC Fuses	Yes	Yes	Yes
	iii) Blocking Diodes	Yes	Yes	Yes
	iv) Voltmeter	Yes	Yes	Yes
	v) Ammeter	Yes	Yes	Yes
	vi) Signal Lamp (ON/OFF)	Yes	Yes	Yes
	viii) Charging Ammeter (on demand type)	Yes	Yes	Yes

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - BATTERY CHARGER</div>	<div>PC288-TS-0813</div>	<div>0</div>	<div><div>श्री एच ई एल <b>BHEL</b></div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 12 of 13</div>		

Sl. No.	Description	To be mounted on		
		Float cum Load Charger	Standby Float cum Load Charger	Boost Charger
1	2	3	4	5
4.	<b>Common Items</b> i) Droper Diodes ii) Solid State facia annunciator for : -- Automatic changeover from one charger to another -- Rectifier fuse failure in float/standby float/boost -- Incoming supply failure float/standby float/boost -- DC output under voltage -- Earth fault -- Single phasing and phase reversal -- Filter fuse failure float/standby float/boost iii) Battery isolating switch and HRC fuses iv) Battery under voltage relay v) Battery earth fault relay vi) DC Contactor	Yes  Yes	Yes	Yes          Yes  Yes Yes Yes

**NOTE:** Any other components as required for satisfactory operation of the battery charger shall be provided.

**ANNEXURE - II**  
**DOCUMENTATION FOR BATTERY CHARGER**

Sl.No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	General arrangement drawings showing overall dimensions of the charger board and mounting details of various equipment inside the charger panel	N	Y	Y
4.	Foundation plan indicating certified dimensions, floor openings, weight, clearance etc.	N	Y	Y
5.	Schematic and Wiring Diagrams	N	Y	Y
6.	Descriptive literature of the charger and various components mounted in the panel.	N	N	Y
7.	Characteristics curves for the charger and all other static and control devices, relays etc.	N	N	Y
8.	Installation, Operation and Maintenance manual	N	N	Y
9.	Guarantee Certificates	N	N	Y
10.	Test Certificates	N	N	Y
11.	Spare parts list with identification marks	N	N	Y

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – BATTERY	PC288-TS-0814	0	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 1 of 6		

# **TECHNICAL SPECIFICATION** **BATTERY**

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – BATTERY	PC288-TS-0814	0	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 2 of 6		

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	GENERAL DESIGN AND CONSTRUCTIONAL FEATURES
6.0	ACCESSORIES
7.0	TESTS AND INSPECTION
8.0	DRAWINGS AND DOCUMENTS
9.0	SPARES
10.0	PACKING
11.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR BATTERY

<div> पी डी आई एल <b>PDIL</b></div>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – BATTERY	PC288-TS-0814	0	<div> बी एच ई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 3 of 6		

## 1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, manufacture, testing at works and despatch in well packed condition of batteries and accessories.
- 1.2 This standard shall be read in conjunction with the relevant part of Design Philosophy - Electrical.

## 2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of the battery shall conform to the latest issue of the following standards:

- IS: 1651            --    Stationary cells & batteries, lead-acid type (with tubular positive plate)
- IS: 1652            --    Stationary cells & batteries, lead-acid type with plante positive plates.
- IS: 10918           --    Vented type nickel cadmium batteries

All accessories shall also conform to the relevant Indian Standard. Equipment complying with equivalent IEC standards shall also be acceptable.

- 2.2 The design and operational features of the equipment offered shall comply with the provisions of the latest issue of the Indian Electricity Rules and other Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.
- 2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard specifications, the requirement specified herein shall prevail.

## 3.0 SERVICE CONDITIONS

### 3.1 Ambient Conditions

These shall be as indicated in Design Philosophy - Electrical.

### 3.2 System Details

These shall be as indicated in Design Philosophy - Electrical.

## 4.0 OPERATING REQUIREMENTS

The battery shall be able to deliver rated ampere hours when discharged at the 10 hours rate of discharge to a final voltage of 1.85 V per cell for Lead Acid and at the 5 hours rate of discharge to a final voltage of 1.1 V per cell for Ni-Cd battery under the ambient conditions indicated in Design Philosophy - Electrical.

## 5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

- 5.1 The battery shall be of lead acid plante type and rated for 220V. Each battery bank shall consist of 110 number of cells.
- 5.2 Each cell shall be contained in a closed top container preferably transparent and unbreakable and shall incorporate positive plates, negative plates and separators of adequate dimensions. Lead acid battery shall be of plante plate type (positive plate).



	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – BATTERY</b>		PC288-TS-0814	0
			Document No.	Rev
			Sheet 4 of 6	



- 5.3 The battery bank shall be complete with all necessary components such as lids, plugs, separators and buffers, inter-cell connectors, lead coated bolts and nuts, cell insulators etc.
- 5.4 The required quantity of electrolyte plus 10% extra quantity shall be supplied in suitable non-returnable containers along with the battery.

## 6.0 ACCESSORIES

The following accessories shall be supplied with each battery bank:-

- (a) 1 Set -- Battery Stand constructed out of teak wood without the use of any metal fastenings and coated with 3 coats of anti-acid paint. The stand shall be properly designed so that each cell shall be easily accessible for inspection, topping up etc. However, for Ni-Cd battery mild steel stand with alkali resistant paint may also be accepted
- (b) 1 Set -- Inter-row, inter-tier and inter-stand connectors and takeoffs. These shall be sized suitably to have adequate current carrying capacity and mechanical strength
- (c) 1 Set -- Cell Insulators
- (d) 1 Set -- Stand Insulators
- (e) 1 No. -- Centre zero cell testing voltmeter scaled 3-0-3 volts
- (f) 2 Nos. -- Syringe type Hydrometers for measuring the specific gravity of the electrolyte
- (g) 2 Nos. -- Gravity correction thermometers, mercury-in-glass type
- (h) 1 Set -- Connecting bolt wrenches
- (i) 1 No. -- Rubber syringe for tapping cells
- (j) 1 No. -- Wall mounting type teak wood holder for Hydrometer and Thermometer.
- (k) 1 No. -- Acid/Alkali resisting funnel.
- (l) 1 No. -- Acid/Alkali resisting jug.
- (m) 1 Pair -- Rubber gloves.
- (n) 1 No. -- Rubber Apron.

All other accessories, not specified above, but required for satisfactory operation and maintenance shall also be supplied.

## 7.0 TESTS AND INSPECTION

- 7.1 Type tests shall be carried out as per relevant standards on two cells in the presence of Purchaser's representative.
- 7.2 Acceptance tests shall be carried out as per relevant standards on each cell after installation at site.
- 7.3 In addition, the battery shall be subjected to stage inspection at works and inspection at site for final acceptance.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT TECHNICAL SPECIFICATION – BATTERY</b>	PC288-TS-0814	0	 कोई एच आई एल <b>o/hel</b>
		Document No.	Rev	
		Sheet 5 of 6		

7.4 These inspections shall, however, not absolve the vendor from his responsibilities for making good any defect which may be noticed subsequently.

## 8.0 DRAWINGS AND DOCUMENTS

8.1 Drawings and documents as per Annexure-I shall be furnished by the Vendor unless otherwise specified.

8.2 All drawings and documents shall have following description written boldly:

- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

## 9.0 SPARES

9.1 Commissioning Spares: Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval.

9.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.

9.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.

9.4 All spare parts shall be identical to the parts used in the equipment

## 10.0 PACKING

The battery cells and accessories shall be properly packed to safeguard against weather conditions and rough handling. It shall be wrapped in polythene bags with an additional wrapping bitumen paper to make it completely water proof before it is packed in crates. The packing box shall contain a copy of the installation operation and maintenance manual.

## 11.0 DEVIATIONS

11.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

## ANNEXURE – I

### DOCUMENTATION FOR BATTERY

Sl. No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	Dimensional drawings showing the cell arrangement on stand (Plan, front and side elevation) for each type of battery.	N	Y	Y
4.	Illustrative and descriptive literature giving the complete details of construction of battery	N	N	Y
5.	Operation and maintenance instructions	N	N	Y
6.	Test Certificates			
	-- Type	N	N	N
	-- Acceptance	N	N	Y
7.	Guarantee Certificates	N	N	Y
8.	Spare Parts lists	N	N	Y

#### Note:

- 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
- 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - CABLES	PC288-TS-0815	0	 कोयला इंडिया  BHEL
		Document No.	Rev	
		Sheet 1 of 7		

# TECHNICAL SPECIFICATION CABLES

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - CABLES	PC288-TS-0815	0	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 2 of 7		

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	GENERAL DESIGN AND CONSTRUCTIONAL FEATURES
6.0	SPECIAL PURPOSE CABLES
7.0	CABLE DRUM
8.0	TESTS AND INSPECTION
9.0	DRAWINGS AND DOCUMENTS
10.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR CABLES

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - CABLES</b>	<b>PC288-TS-0815</b>	0	
		Document No.	Rev	
		Sheet 3 of 7		

## 1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, manufacture, testing at works and dispatch in well packed condition of power and control cables.
- 1.2 The standard shall be read in conjunction with relevant part of Design Philosophy - Electrical and other relevant references as specified therein.

## 2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of cables covered by this standard shall comply with the latest issue of following Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

- |                    |    |   |
|--------------------|----|---|
| IS: 1554 Part (I)  | -- | PVC insulated (heavy duty) electric cables for working voltages upto and including 1100 volts.                    |
| IS: 1554 Part (II) | -- | PVC insulated (heavy duty) electric cables for working voltages from 3.3 KV upto and including 11 KV.             |
| IS: 7098 Part (I)  | -- | Cross linked polyethylene insulated PVC sheathed cables for working voltages upto and including 1100 volts.       |
| IS: 7098 Part (II) | -- | Cross linked polyethylene insulated PVC sheathed cables for working voltages from 3.3 KV upto and including 33 KV |
| IS: 694            | -- | PVC insulated cables for working voltages upto and including 1100 volts   |
| IS: 5831           | -- | PVC insulation and sheath of electric cables  |

- 2.2 The design and operational features of the cables offered shall also comply with the provisions of latest issue of the Indian Electricity Rules and other relevant Statutory Rules & Regulations. The supplier shall, whenever necessary, make suitable modification in the cables to comply with the above mentioned rules.

- 2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

## 3.0 SERVICE CONDITIONS

### 3.1 Ambient Conditions

These shall be as indicated elsewhere in Design Philosophy - Electrical.

### 3.2 System Details

These shall be as indicated elsewhere in Design Philosophy - Electrical.

## 4.0 OPERATING REQUIREMENTS

The cables shall be suitable for operating continuously at the rated capacity as specified in relevant I.S. under the ambient conditions without exceeding the permissible temperature rise and without any detrimental effect on any part.

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - CABLES</div>	<div>PC288-TS-0815</div>	<div>0</div>	<div><div>कोयला भारत</div><div><div>बी एच ई एल <b>bhel</b></div></div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 4 of 7</div>		

## 5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

5.1 The design, manufacture and workmanship of cables shall be in accordance with the latest practice.

5.2 All materials to be used shall be new, unused and of the best quality.

### 5.3 Conductors

The power cables shall be of stranded Aluminium / copper round or shaped conductors and control cables shall be of annealed high conductivity stranded copper round conductors. The conductors shall comply with the requirements of IS: 8130.

### 5.4 Insulation

The conductor insulation shall be XLPE and shall comply with relevant IS.

### 5.5 Fillers

The cables shall have suitable fillers wherever required, laid up with conductors to provide substantially circular cross section before the inner sheath is applied.

### 5.6 Inner Sheath

Inner sheath, wherever applicable shall be ST1/ ST2 type compound applied by extrusion process except for paper cables for which it shall be of lead or lead alloy.

### 5.7 Armouring

All power and control cables shall be armoured. The single core cables shall be armoured with hard drawn Aluminium taps/ wires or any other suitable nonmagnetic material. All other cables shall have galvanized steel wire / strip armouring.

### 5.8 Outer Sheath

The outer sheath shall be ST1/ ST2 type compound applied by extrusion process and suitable to withstand atmospheric pollution, resistance to termites, fire retardant and coloured black.

### 5.9 Screening

Screening over conductor and insulation shall be provided as per relevant standard unless specified otherwise. The screening for control cables if specified shall be of aluminium, mylor or equivalent and provided with tinned drain wire which shall be continuous and permanently connected to the screen.

### 5.10 Identification

The individual cores of cables shall be coloured as per relevant IS. Where it is not possible to distinguish the cores by colour, coloured strip shall be applied on the cores or core nos. shall be marked on each core at regular intervals. All cables shall carry the manufacturer's name or trade mark, the cable size, voltage rating and year of manufacture at intervals not exceeding 100 meters. Running meter markings shall also be provided throughout the length of the cable.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - CABLES	PC288-TS-0815	0	 कोयला इंडिया  BHEL
		Document No.	Rev	
		Sheet 5 of 7		

#### 5.11 Dimension

The overall dia. and dia. under armour of the cables shall be indicated by the vendor in the technical particulars. These shall be guaranteed with a tolerance of  $\pm 5\%$  but not exceeding 2 mm.

5.12 The cut ends of the cables shall be sealed by means of non-hygroscopic materials.

### 6.0 SPECIAL PURPOSE CABLES

#### 6.1 Flame Retardant Low Smoke Cables

Flame retardant low smoke cables shall have outer sheath of PVC having following values.

- Minimum oxygen index	- 29%
- Minimum temperature index	- 250°C
- Maximum acid gas generation	- 20%
- Maximum smoke density rating	- 60%

#### 6.2 Heat Resistant Cables

Heat resistant cables shall be of silicon rubber insulated laid circular with asbestos worming and overall glass fibre braided and varnished. Silicon rubber insulating compound shall conform to IS: 6380 and the constructional features shall conform generally to IS: 9968.

### 7.0 CABLE DRUM

7.1 The cables shall be supplied in non-returnable wooden drums (or steel drums if specified) of heavy construction. The wood used for construction of the drums shall be properly seasoned, sound and free from defects.

7.2 Cables shall be supplied in specified drum lengths. Where no such indication is given, standard drum lengths may be offered.

7.3 The tolerance on each drum of cable shall not exceed  $\pm 2.5\%$ . However, no negative tolerance on HV cables is acceptable.

7.4 All cable drums shall have stencilled data as per relevant IS as well as the purchaser's order no., item no. & drum no.

### 8.0 TESTS AND INSPECTION

8.1 The following tests shall be carried out on the cables as per relevant IS.

- |      |                  |   |   |
|------|------------------|---|---|
| i)   | Routine Tests    | - | On all cables                                     |
| ii)  | Acceptance tests | - | On representative length of each size             |
| iii) | Type tests       | - | Wherever specified on one cable drum of each size |

8.2 In addition, the following tests shall be carried out on all fire retardant low smoke cables as per IS or as per the following standards:



<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - CABLES</div>	<div>PC288-TS-0815</div>	<div>0</div>	<div><div>कोयला इंडिया लि. Coal India Ltd.</div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 6 of 7</div>		

- i) Oxygen and temperature index test as per ASTM-D-2863
- ii) Acid gas emission test as per IEC-754 Part-I
- iii) Smoke density test as per ASTM-D-2843
- iv) Flammability test as per IEC-332 Part-I or IS-10810

8.3 All the above mentioned tests shall be carried out in the presence of purchaser's representative. In addition, the cables shall be subjected to stage inspection at works and inspection at site for final acceptance.

8.4 These tests and inspections shall, however, not absolve the vendor from their responsibility for making good any defect which may be noticed subsequently.

## 9.0 DRAWINGS AND DOCUMENTS

9.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

9.2 All drawings and documents shall have the following descriptions written boldly.

- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

## 10.0 DEVIATIONS

10.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - CABLES	PC288-TS-0815	0	 कोयला इंडिया  BHEL
		Document No.	Rev	
		Sheet 7 of 7		

## ANNEXURE - I

### DOCUMENTATION FOR CABLES

Sl. No.	Document Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	Illustrative and Descriptive catalogues	N	N	Y
4.	Installation, Termination and Jointing Instructions	N	N	Y
5.	Test certificates			
	a) Routine	N	N	Y
	b) Type	N	N	Y
6.	Guarantee Certificates	N	N	Y

#### Note:

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - PREFABRICATED LADDER TYPE CABLE RACKS</b>	<b>PC288-TS-0816</b>	0	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 1 of 6		

# **TECHNICAL SPECIFICATION** **PREFABRICATED LADDER TYPE CABLE RACKS**

 <div>प्री डी आई एल <b>PDIL</b></div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div> <div>TECHNICAL SPECIFICATION - PREFABRICATED LADDER TYPE CABLE RACKS</div>	PC288-TS-0816	0	 <div>कोई एम आई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 2 of 6		

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	GENERAL DESIGN AND CONSTRUCTIONAL FEATURES
4.0	MARKING
5.0	TESTS AND INSPECTION
6.0	DRAWINGS AND DOCUMENTS
7.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR PREFABRICATED LADDER TYPE CABLE RACKS

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - PREFABRICATED LADDER TYPE CABLE RACKS	PC288-TS-0816	0	 कोई एच आई एल 
		Document No.	Rev	
		Sheet 3 of 6		

## 1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, fabrication, testing at works and delivery in well-packed condition of prefabricated ladder type cable racks.
- 1.2 The standard shall be read in conjunction with Drawing Nos. PDS: E 530 to 538 (9 Sheets).

## 2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of the cable racks covered by this standard shall comply with the latest issue of following and other relevant Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

- IS: 733 -- Wrought aluminium and aluminium alloy bars, rods and sections for general engineering purposes
- IS: 2629 -- Recommended practice for hot dip galvanising on iron and steel
- IS: 4759 -- Hot dip zinc coatings on structural steel and other allied products

- 2.2 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

## 3.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

- 3.1 Ladder type cable racks shall be fabricated as per attached Drawing Nos. PDS: E 530 to PDS: E 538 (9 Sheets).
- 3.2 Cable racks and accessories such as coupler plate, tees, bend, elbows etc. shall be fabricated from 3 mm thick mild steel galvanised sheet or 4 mm thick aluminium 19000 H2 alloy sheet extrusion conforming to designation No. 64430 and condition WP as per IS: 733.
- 3.3 G.I. racks and accessories shall have zinc coating of 800 gm/sq. metre applied by hot dip galvanising process. Galvanising shall be uniform, adherent, smooth and free from defects.
- 3.4 The finished rack and accessories shall be free from sharp edges and corners, burrs and un-evenness. Stepped arrangement of bending is not acceptable. The channel members in the bending shall have uniform curvature and shall be made out of single piece.
- 3.5 The racks shall be supplied in minimum length of 2.4 metre.
- 3.6 Each straight length and bend shall be supplied with two coupling plates fitted at each side channel at one end. The coupling plates shall be supplied with bolts, nuts and washers fitted at the other four holes for fixing to adjoining member.
- 3.7 Coupling plate shall be designed to permit longitudinal adjustment upto  $\pm 10$  mm and skew upto  $10^\circ$ .

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - PREFABRICATED LADDER TYPE CABLE RACKS	PC288-TS-0816	0	 को ई एच डी एल 
		Document No.	Rev	
		Sheet 4 of 6		

- 3.8 Clamping arrangement as per attached drawings shall be provided for fixing the rack with the cross support as required.
- 3.9 All the bends, tees and junctions shall be made sufficiently rigid by providing suitable reinforcement on rungs as required.
- 3.10 The rungs shall be connected to the side channels by continuous welding alongwith three sides of rung. Aluminium rack shall be welded by TIG welding process.
- 3.11 All hard wares such as nuts, bolts, washers and crank bolts shall be cadmium plated.
- 3.12 Tolerances in various dimension shall be follows:
- |           |    |          |
|-----------|----|----------|
| Length    | -- | ± 5 mm   |
| Width     | -- | ± 2 mm   |
| Height    | -- | ± 1 mm   |
| Bend      | -- | ± 1 mm   |
| Thickness | -- | ± 0.2 mm |

Positive tolerance on total quantity upto ± 5% is acceptable. However, negative tolerance on total quantity is not acceptable.

#### 4.0 MARKING

The packing shall be clearly marked on the outside (on top side & ends) in indelible ink with the following minimum details:

- Part No.
- Size of Tray (Length x Width x Height)
- No. of Tray / Section, Total Weight
- Material Specification
- Client's Name
- Purchase Order No.
- Manufacturer's Name

#### 5.0 TESTS AND INSPECTION

- 5.1 Following tests shall be carried out on prefabricated cable racks:

Visual inspection and checking for

- i) Quality and thickness of raw material
- ii) Dimensions as per drawing.
- iii) Quality of welding (before galvanising for G.I. racks)
- iv) Preparation of metal surfaces (for G.I. racks).

- 5.2 After galvanising, G.I. cable racks shall be subjected to following tests as per IS:4759.

- i) Mass of galvanising coating -- At any location the thickness of zinc coating shall not be less than 90 micron. However, average thickness of zinc coating shall not be less than 113 micron.

 <div>पी डी आई एल <b>PDIL</b></div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div> <div>TECHNICAL SPECIFICATION - PREFABRICATED LADDER TYPE CABLE RACKS</div>	PC288-TS-0816	0	 
		Document No.	Rev	
		Sheet 5 of 6		

- ii) Uniformity of galvanising coating.
- iii) Adhesion of galvanising coating.
- iv) 3 samples from each lot shall be taken for testing.
- v) From each lot and size of rack, measure length of 10 trays and average length to be multiplied by number of trays to arrive for total length.

5.3 All the above tests shall be carried out in the manufacturer's works in the presence of Purchaser's representative. In addition to the above tests, the cable racks and its accessories shall be subjected to stage inspection at works and inspection at site for final acceptance.

5.4 These tests and the Purchaser's inspection shall, however, not absolve the vendor from their responsibility for making good any defect which may be noticed subsequently.

## 6.0 DRAWINGS AND DOCUMENTS

6.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

6.2 All drawings and documents shall have the following descriptions written boldly.

- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

## 7.0 DEVIATIONS

7.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - PREFABRICATED LADDER TYPE CABLE RACKS</b>	<b>PC288-TS-0816</b>	0	
		Document No.	Rev	
		Sheet 6 of 6		

## ANNEXURE - I

### DOCUMENTATION FOR PRE-FABRICATED LADDER TYPE CABLE RACKS

Sl. No.	Document Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Illustrative and Descriptive catalogues	N	N	Y
2.	Installation, Termination and Jointing Instructions	N	N	Y
3.	General Arrangement Drawings, showing details of rack, coupling pieces, fasteners, etc.	N	Y	Y
4.	Test certificates	N	N	Y
5.	Guarantee Certificates	N	N	Y

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - LOCAL CONTROL STATION	PC288-TS-0817	0	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 1 of 8		

# **TECHNICAL SPECIFICATION** **LOCAL CONTROL STATION**

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - LOCAL CONTROL STATION	PC288-TS-0817	0	 श्री एच ई एल <b>BIHEL</b>
		Document No.	Rev	
		Sheet 2 of 8		

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATIONAL REQUIREMENTS
5.0	GENERAL DESIGN & CONSTRUCTIONAL FEATURES
6.0	SPECIAL FEATURES FOR FLAMEPROOF LOCAL CONTROL STATION
7.0	COMPONENT DETAILS
8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	DRAWINGS AND DOCUMENTS
11.0	SPARES
12.0	PACKING
13.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR LOCAL CONTROL STATIONS

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - LOCAL CONTROL STATION	PC288-TS-0817	0	
		Document No.	Rev	
		Sheet 3 of 8		

## 1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well-packed condition of Local Control Stations.
- 1.2 This standard shall be read in conjunction with relevant part of Design Philosophy - Electrical and other relevant references as specified therein.

## 2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of IS/IEC:60947 and other relevant Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.
- 2.2 The design and operational features of the equipment offered shall also comply with the provisions of latest issue of the Indian Electricity rules and other relevant statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modification in the equipment to comply with the above.
- 2.3 Wherever any requirement, laid down in this standard differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

## 3.0 SERVICE CONDITIONS

### 3.1 Ambient Conditions

These shall be as indicated elsewhere in Design Philosophy - Electrical.

### 3.2 System Details

These shall be as indicated elsewhere in Design Philosophy - Electrical.

## 4.0 OPERATIONAL REQUIREMENTS

This equipment and associated components shall be suitable for operating satisfactorily under the specified ambient and system conditions.

## 5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

- 5.1 The Control Stations shall be suitable for control voltage not exceeding 500V, 50 Hz AC or 220V D.C.
- 5.2 The enclosure shall be of die cast Aluminium alloy LM-6. As an alternative to cast Aluminium, fibre glass enclosure is also acceptable.
- 5.3 The equipment shall have dust, hose and weather proof construction equivalent to IPW-55 as per IS/IEC:60947. These shall be suitable for outdoor location without any additional protection or cover.
- 5.4 A rain-hood shall be offered as an additional item. It shall be made of 14 gauge Aluminium sheet bent to shape. In case of fibre glass enclosure, these can be made of fibre glass.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - LOCAL CONTROL STATION	PC288-TS-0817	0	 कोयला कोयला  बी.एच.एल.
		Document No.	Rev	
		Sheet 4 of 8		

- 5.5 All external hardware of diameter less than 8 mm shall be of stainless steel and those of diameter 8 mm and above shall be of mild steel cadmium plated or zinc passivated. For fibre glass enclosure Nylon PVC bolts of diameter 8 mm may be used.
- 5.6 The control station shall preferably be with bolted cover. The bolts for retaining the cover in position shall be provided with 10 mm dia. stainless steel and these shall be so arranged that they do not pierce into the door gasket.
- 5.7 All the components shall be mounted on a base plate inside the enclosure. Necessary actuating system for control switch, push button, non yellowing acrylic/ glass cover for ammeter and indication lamps shall be provided on the front cover. No wiring shall be carried out on the front cover.
- 5.8 The layout of components in the control station shall be liberal and standardised.
- 5.9 All mating surfaces shall be smoothly machined and shall be of sufficient width of at least 6 mm. The covers shall be provided with continuous gasket made of neoprene or synthetic rubber to prevent ingress of dust and moisture. The gasket shall be held in position in groove provided in the enclosure and shall be pressed all around uniformly by suitably shaped projection of the door. Gaskets simply glued to the surface are not acceptable.
- 5.10 The enclosure shall be suitable for mounting on wall or on steel structure. 4 Nos. holes suitable for 12 mm bolts shall be provided outside the enclosure for fixing the control stations.
- 5.11 The internal wiring shall be carried by means of single core PVC insulated 1.5 sq. mm stranded copper conductor cable. All termination shall be made with crimping type proper size lugs and shall be properly ferruled.
- 5.12 The control stations shall be completely factory wired and ready for external cable connection.
- 5.13 For easy identification, numbering ferrules shall be provided on all wiring at both ends i.e. equipment end and terminal block end. Terminals for external wiring shall be numbered
- 5.14 The enclosure shall be provided with two earthing terminals with studs of 8 mm. dia. projecting outside the enclosure for connection to earth. These terminals shall not pierce through the enclosure and shall be marked with earthing symbol.
- 5.15 Each control station shall be provided with minimum 2 mm thick stainless steel name plates or consisting of black Perspex with white engraving indicating the code number and description of the equipment controlled by it. Similar labels shall be provided for all indication lamps, push buttons and control switches. The name plate and label shall be fixed with screws only.

## **6.0 SPECIAL FEATURES FOR FLAME PROOF LOCAL CONTROL STATION**

- 6.1 The enclosure shall be in addition, of flameproof execution as per IS: 2148.
- 6.2 The control stations shall be suitable for hazardous area of enclosure group and temperature class as indicated in Design Philosophy - Electrical.
- 6.3 Cables shall enter the terminal box through flame proof cable gland. From the terminal chamber to the main enclosure, the connections shall be made through proper

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - LOCAL CONTROL STATION</div>	PC288-TS-0817	0	<div> श्री एच ई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 5 of 8		

bushings. Direct entry of external cables into the main enclosure shall not be accepted. All entries shall be provided with stainless steel inserts.

6.4 An additional earthing terminal inside the terminal chamber shall be provided.

6.5 Local control stations and cable gland must be certified by the Central Mining Research Institute, Dhanbad or any other statutory authority for use in the specified hazardous area.

## 7.0 COMPONENT DETAILS

### 7.1 Trip-Neutral-Close Switch

TRIP-NEUTRAL-CLOSE switch shall be double pole, 3 position, pistol grip, rotary type having self spring return feature to neutral position. The contacts shall be of phosphor bronze and shall be provided with two breaks in series. Mechanical sequence device to prevent two successive movements to the same position shall be fitted. The switch shall be capable of being padlocked in the 'TRIP' position.

### 7.2 'Auto-Manual' Switch

'Auto-Manual' switch shall be single pole stay put type having three positions "AUTO-OFF-MANUAL". Provision shall be made to padlock the switch in the "OFF" position.

### 7.3 Selector Switch / Lock Service Switch

These shall be single pole stay put type having two position with a pistol grip handle and capable of being padlocked in one of the position.

7.4 All the switches shall be rotary type with snap or wiping action contact and having a set of normally open and closed contacts in each position. All switches shall be provided with pistol grip handle.

### 7.5 'Off-Auto-On' Switch

7.5.1 'OFF-AUTO-ON' switch shall be in minimum three stack configuration, each stack having three positions with spring return from 'ON' to 'Auto' position and lockable in 'OFF' position by means of padlock.

7.5.2 The switch shall have sliding contact between 'AUTO' and 'ON' position. In 'OFF' position the contact shall be completely broken from 'AUTO' position.

### 7.6 Push Buttons

These shall be spring loaded, with a set of normally closed and open contacts. The push buttons for 'start' shall be shrouded type and coloured green while 'stop' push buttons shall be un-shrouded type and coloured red. Provision shall be made to padlock the 'stop' push button in 'OFF' position. The fixing ring shall be metallic white. An oil proof rubber cap shall preferably be provided.

7.7 The switches and push buttons shall conform to utilization category AC11/ DC11 as per IS/IEC:60947. The contact shall be rated to make, break and carry inductive current of 5 Amp. at 415 V AC and 1 Amp of 220V DC. The contact arrangement shall be as shown in the terminal drawings. Built in locks instead of padlocking are not acceptable.

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - LOCAL CONTROL STATION</b>		PC288-TS-0817	0
			Document No.	Rev
			Sheet 6 of 8	



## 7.8 Indication Lamps

- 7.8.1 LED type indication lamps shall be provided to indicate the various circuit conditions as shown in the terminal drawings.
- 7.8.2 The LEDs shall provide good illumination through a viewing angle of 180°. The LEDs shall have lumen output of 200 milli Candella in the axial direction.
- 7.8.3 The colour of the LED indication for various functions shall be as follows:-
- |       |   |                                    |
|-------|---|------------------------------------|
| RED   | : | For 'ON' Indication                |
| GREEN | : | For 'OFF' Indication               |
| WHITE | : | For "Ready for Service" Indication |

## 7.9 A.C. Ammeters

The ammeter shall be flush mounting, moving iron spring controlled type, of accuracy class 1.5 as per IS:1248, with square face of minimum size 72 mm x 72 mm having scale range 0-240°. The ammeter shall be provided with uniform scale up to CT primary current and compressed end scale up to 6 times the CT primary current. Adjustable red pointer shall be provided to indicate the full load current of the motors. Zero adjusters shall be provided for operation from the front of the meter. All ammeters shall be operated through 1Amp. CTs only.

## 7.10 D.C. Ammeters

The D.C. ammeter shall be shunt operated. These shall be moving coil or moving iron type of accuracy class 1.5 as per IS: 1248.

## 7.11 Terminal Blocks

All control stations shall be provided with terminal blocks. Terminal blocks shall be located at a minimum distance of 50 mm from the bottom of the enclosure. The terminal blocks for the control station shall be suitable for conductor sizes of 2.5 mm<sup>2</sup>. These shall be of pressure clamp type design mounted on the base channel. The minimum rating of terminal block shall be 16 Amp.

## 7.12 Cable Glands

The cables for the external connections, shall enter the terminal chamber through heavy duty double compression type rolled Aluminium cable glands suitable for 2.5 sq. mm PVC insulated, armoured, and PVC sheathed copper conductor 1.1 KV grade cables. The number and cores of control cables shall be as per requirement. The cable gland shall be fitted in a threaded hole.

## 8.0 PAINTING

- 8.1 The enclosure after suitable pre-treatment shall be painted with two coats of anti-rust paint followed by two coats of anticorrosive paint.
- 8.2 Epoxy based paint shall be used.
- 8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - LOCAL CONTROL STATION</b>		PC288-TS-0817	0
			Document No.	Rev
			Sheet 7 of 8	



- 8.4 Unless otherwise specified, the finishing shade shall be of light grey having shade no. 631 as per IS: 5.

## 9.0 TESTS AND INSPECTION

- 9.1 All equipment shall be routine tested as per relevant standards.
- 9.2 Additional tests, wherever specified, shall be carried out.
- 9.3 All the above mentioned tests shall be carried out in the presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection at works and inspection at site for final acceptance.
- 9.4 These inspections shall, however, not absolve the vendor from their responsibility for making good any defect which may be noticed subsequently.

## 10.0 DRAWINGS AND DOCUMENTS

- 10.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.
- 10.2 All drawings and documents shall have the following descriptions written boldly.
- Name of client
  - Name of consultant
  - Enquiry / Order Number with plant / project name
  - Code No. and Description

## 11.0 SPARES

- 11.1 Commissioning Spares: Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval.
- 11.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 11.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 11.4 All spare parts shall be identical to the parts used in the equipment

## 12.0 PACKING

- 12.1 The local control stations shall be properly packed to safeguard against weather conditions and handling during transit. It shall be wrapped in polythene bags and an additional wrapping of bitumen paper shall also be provided to make it completely water proof before the equipment is packed in wooden crates.
- 12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

## 13.0 DEVIATIONS

- 13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

## ANNEXURE - I

### DOCUMENTATION FOR LOCAL CONTROL STATIONS

Sl. No.	Document Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	General Arrangement Drawings	N	Y	Y
4.	Schematic Diagrams	N	Y	Y
5.	Illustrative and Descriptive catalogues	N	N	Y
6.	Catalogues of bought out accessories	N	N	Y
7.	Spare parts list	N	N	Y
8.	Installation, Operation and Maintenance manual	N	N	Y
9.	Test certificates			
	a) Routine	N	N	Y
	b) Type (only for flameproof equipment)	N	N	Y
	c) For enclosure	N	N	Y
10.	Guarantee Certificates	N	N	Y

**Note:**

- 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
- 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT TECHNICAL SPECIFICATION - JUNCTION BOX</b>	<b>PC288-TS-0818</b>	0	 कोयला इण्डिया  बी एच ई एल
		Document No.	Rev	
		Sheet 1 of 7		

# **TECHNICAL SPECIFICATION** **JUNCTION BOX**

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - JUNCTION BOX	PC288-TS-0818	0	 श्री एम आई एल 
		Document No.	Rev	
		Sheet 2 of 7		

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	GENERAL DESIGN & CONSTRUCTIONAL FEATURES
5.0	SPECIAL FEATURES FOR JUNCTION BOXES FOR HAZARDOUS AREA
6.0	PAINTING
7.0	TESTS & INSPECTION
8.0	PACKING
9.0	DRAWINGS AND DOCUMENTS
10.0	SPARES
11.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR JUNCTION BOXES

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - JUNCTION BOX</div>	<div>PC288-TS-0818</div>	<div>0</div>	<div><div>श्री एम आई एल <b>BHEL</b></div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 3 of 7</div>		

## 1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, manufacture, testing and inspection at works and delivery in well packed condition of junction boxes.
- 1.2 This standard shall be read in conjunction with relevant part of Design Philosophy - Electrical and other relevant references as specified their in.

## 2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of relevant Indian standards unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.
- 2.2 Flameproof & increased safety junction boxes shall in addition, comply with the requirement as laid down in IS: 2148 & IS: 6381 respectively.
- 2.3 The design and constructional features of the junction boxes offered shall also comply with the provision of latest issue of the Indian Electricity Rules and other relevant Statutory Rules & Regulations. The supplier shall, whenever necessary, make suitable modification in the equipment to comply with the above mentioned rules.
- 2.4 Wherever any requirement laid down in this standard differs from that in Indian Standard specifications, the requirement specified herein shall prevail.

## 3.0 SERVICE CONDITIONS

### 3.1 Ambient Conditions

These shall be as indicated in Design Philosophy - Electrical.

### 3.2 System Details

The details of power supply system shall be as indicated in Design Philosophy – Electrical.

## 4.0 GENERAL DESIGN & CONSTRUCTIONAL FEATURES

- 4.1 The junction boxes shall be dust and weather proof and suitable for installation outdoors without extra protection. The degree of protection shall be IP-55 as per IS/IEC:60529.
- 4.2 The junction boxes shall be of die cast aluminium alloy LM-6 with domed / suspension covers.
- 4.3 The casting of the junction boxes and their cover shall be pressure die cast. The casting shall be uniform and free from blow holes. All mechanical surfaces shall be free from burrs, dents and internal roughness.
- 4.4 All external hardware of diameter less than 8 mm shall be of stainless steel and those of diameter 8 mm and above shall be of mild steel cadmium plated or zinc passivated. For fibre glass enclosure Nylon PVC bolts of diameter 8 mm may be used.
- 4.5 The clearances and creepage distances shall be maintained inside the junction boxes as per relevant Indian standard.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - JUNCTION BOX	PC288-TS-0818	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 4 of 7		

- 4.6 The junction boxes shall be suitable for wall / structure / ceiling mounting and necessary arrangement for mounting the same shall be provided.
- 4.7 The junction boxes shall be provided with continuous gasket made of neoprene or synthetic rubber to prevent ingress of dust. The gasket shall be held in position in groove provided in the enclosure and shall be pressed all around uniformly by suitably shaped projection of the door. Gaskets simply glued to the surface are not acceptable.
- 4.8 The junction boxes housing terminal block shall be moulded type made of DMC / Fibre glass. Threaded terminals shall be made of brass (nickel plated or tinned) and provided with two tightening threaded nuts and four washers all made of brass (nickel plated or tinned). The terminals shall have two shorting links each horizontally placed connecting three terminals.
- 4.9 The terminal block shall be fitted with junction boxes base by means of 2 nos. 1/2" long nickel plated brass screws.
- 4.10 The junction boxes shall be provided with two nos. external earthing terminals and 1 no. internal earthing terminal.
- 4.11 All live parts inside the junction boxes shall be insulated and shall withstand a test voltage of 2.5 KV for 1 minute.
- 4.12 The junction boxes shall be provided with heavy duty double compression type rolled Al cable glands to suit the cable entries.
- 4.13 Threaded blanking plugs shall be provided for junction boxes to plug out the entries not in use as indicated in bill of quantities enclosed.
- 4.14 The junction boxes shall be provided with a blank stainless steel tag plate fastened to the junction box top cover with two stainless steel screws. The plate shall be at least 25 mm wide, 100 mm long and 1 mm thick.
- 4.15 For flameproof / increased safety junction boxes, the manufacturer shall submit copies of test certificates from statutory authorities clearly stating that the junction boxes as well as cable glands / blanking plugs are suitable for hazardous area.
- 4.16 **15 Amp. Junction Box**
- 4.16.1 The junction boxes shall be 4 way dome cover type.
- 4.16.2 The dimensions of the junction boxes with their cover and accessories shall be generally as per PDS: E-547.
- 4.16.3 The junction boxes housing terminal block shall be moulded type made of DMC / Fibre glass as per Drg. no. PDS: E-557.
- 4.17 **63 Amp. Junction Box**
- 4.17.1 The junction boxes shall be 3 / 4 way dome cover type.
- 4.17.2 The minimum internal diameter of the box shall be 240 mm.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - JUNCTION BOX	PC288-TS-0818	0	 श्री एम आई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 5 of 7		

## 5.0 SPECIAL FEATURES FOR JUNCTION BOXES FOR HAZARDOUS AREA

- 5.1 For increased safety junction boxes, the terminals shall be provided with positive locking device against loosening.
- 5.2 The enclosure shall be in addition, of increased safety execution, Exe, as per relevant standard and shall be suitable for installation in classified hazardous area.
- 5.3 The junction boxes shall be liberally dimensioned in order to avoid temperature rise inside the enclosure which may damage the insulating materials or gaskets employed therein.
- 5.4 Cables shall enter the terminal box through increased safety compression type cable glands. From the terminal chamber to the main enclosure, the connections shall be made through proper bushings.
- 5.5 An additional earthing terminal inside the terminal chamber shall be provided.
- 5.6 The junction boxes shall be provided with Brass-Nickel plated shorted links. The terminal block shall be made of non-hygroscopic compound. Bakelite / Hylam shall not acceptable.
- 5.7 All screws / bolts and nuts shall be of stainless steel.
- 5.8 Junction boxes and cable glands must be certified by Statutory Authorities for use in the specified hazardous area. Equipments certified by overseas authorities shall obtain certificate of compliance / letter of opinion from respective statutory authorities.
- 5.9 Duly wired prototype samples for junction boxes shall be submitted for scrutiny as and when called for.
- 5.10 Type Test certificates for increased safety type junction boxes and cable glands along with blanking plugs shall be supplied.

## 6.0 PAINTING

- 6.1 Epoxy based electrostatic powder coating paint shall be provided on exterior surface while the interior of junction boxes shall be painted with anti-condensate paint. The painting shall be able to withstand corrosive atmosphere.
- 6.2 Unless otherwise specified, the finishing shade shall be grey having shade no. 632 as per IS-5.
- 6.3 The terminal block of junction boxes shall be painted with Red, Yellow, Blue & Black colour for phase indication.

## 7.0 TESTS AND INSPECTION

- 7.1 The junction boxes shall be routine tested as per relevant standards.
- 7.2 Additional tests, wherever specified, shall be carried out on one unit of each rating.
- 7.3 The procedure & extent of the physical checks, routine & type test shall be governed by Quality Assurance Plan mutually agreed and approved by Inspection Authority.
- 7.4 All the above mentioned tests shall be carried out in the presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection at works and inspection at site for final acceptance.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT TECHNICAL SPECIFICATION - JUNCTION BOX</b>	<b>PC288-TS-0818</b>	0	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 6 of 7		

7.5 These inspections shall, however, not absolve the vendor from their responsibility for making good any defect which may be noticed subsequently.

## 8.0 PACKING

Each junction box and cable gland shall be suitably packed and protected from damage due to transportation, loading and unloading. Threaded fittings shall have plastic caps to protect the threading.

## 9.0 DRAWINGS AND DOCUMENTS

9.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

9.2 All drawings and documents shall have the following descriptions written boldly:

- Name of client
- Name of consultant
- Enquiry / order number with plant / project name
- Motor Code No. and Description

## 10.0 SPARES

10.1 Commissioning Spares: Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval.

10.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.

10.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.

10.4 All spare parts shall be identical to the parts used in the equipment.

## 11.0 DEVIATIONS

11.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

**ANNEXURE - I**  
**DOCUMENTATION FOR JUNCTION BOXES**

Sl. No.	Document Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	Certified dimensional drawing, including mounting details	N	Y	Y
4.	Drawing showing constructional details	N	Y	Y
5.	Illustrative and Descriptive catalogues	N	N	Y
6.	Spare parts list	N	N	Y
7.	FLP/Exe certificates for junction boxes and terminals conforming to IEC/ISS (CMRI, CCE, DGFASLI and BARC for terminals)	N	N	Y
8.	Certificate for weather proof construction for junction boxes as per IPW-55	N	N	Y

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - ELECTRICALS FOR OVERHEAD CRANES &amp; HOISTS</b>	<b>PC288-TS-0819</b>	0	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 1 of 11		

# **TECHNICAL SPECIFICATION** **ELECTRICALS FOR OVERHEAD CRANES & HOISTS**



## CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	GENERAL DESIGN AND CONSTRUCTIONAL REQUIREMENTS
5.0	EQUIPMENT SPECIFICATION
6.0	CABLES, CABLE TERMINATION AND CONNECTIONS
7.0	EARTHING
8.0	CONTROL DESK / CONTROL STATION
9.0	PAINTING
10.0	MAKE OF ELECTRICAL ITEMS
11.0	TESTS AND INSPECTION
12.0	INSTALLATION, TESTING AND COMMISSIONING
13.0	DRAWINGS AND DOCUMENTS
14.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR ELECTRICALS FOR OVERHEAD CRANES & HOISTS

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - ELECTRICALS FOR OVERHEAD CRANES &amp; HOISTS</b>	<b>PC288-TS-0819</b>	<b>0</b>	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 3 of 11		

## 1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, engineering, manufacture, testing at works, supply at site, erection, site testing and commissioning of the complete electrical equipment and accessories as required for the overhead travelling crane and hoists.
- 1.2 This standard shall be read in conjunction with relevant mechanical specifications, other relevant standards / specifications.
- 1.3 The scope of work shall include but not limited to the following items:
- Drive motors
  - Starting resistors (in case of slip ring motors)
  - Power control panel
  - Control stations
  - Limit switches
  - Electromagnetic brakes
  - Power and control cables with accessories
  - Earthing of all equipment
  - All other items, not specified but, required for safe and proper operation
- 1.4 The owner shall provide one no. medium voltage feeder for each crane / hoist and terminate the feeder cable in an isolator located at one end of the bay at a height of 1.5 m from the operating floor. The vendor shall indicate the exact power requirement (running and peak) to enable the owner to size and provide the power supply feeder.
- 1.5 Further distribution of power from this isolator onwards shall be in the vendor's scope.

## 2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture, testing and installation of the equipment shall comply with the latest issue of IS-6547, IS-807 and other relevant Indian Standard specifications and codes of practices. Equipment complying with equivalent IEC standards shall also be acceptable.
- 2.2 The equipment and installation shall also comply with the provisions of latest issue of Indian Electricity rules and other statutory acts and regulations.
- 2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specification, the requirement specified here-in shall prevail.

## 3.0 SERVICE CONDITIONS

### 3.1 Ambient Conditions

These shall be as indicated in Design Philosophy - Electrical.

### 3.2 System Details

These shall be as indicated in Design Philosophy - Electrical.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - ELECTRICALS FOR OVERHEAD CRANES &amp; HOISTS</b>	<b>PC288-TS-0819</b>	<b>0</b>	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 4 of 11		

3.3 The owner shall provide only three phase power at the specified medium voltage. For lighting, control and plug supply the vendor shall provide necessary single phase step-down transformers.

3.4 All the electrical equipment shall be so designed that enable the crane / hoist to operate at its rated capacity and specified duty cycle with the system variation under the ambient conditions without exceeding the permissible temperature rise and without any detrimental effect on any part.

#### 4.0 GENERAL DESIGN AND CONSTRUCTIONAL REQUIREMENTS

4.1 The electrical system and installation shall be designed as per latest practice to provide maximum reliability, flexibility, safety to personnel and equipment and ease of operation and maintenance.

4.2 All equipment shall have adequate and standard ratings as per ISS.

4.3 All electrical equipment to be located in indoor plant area shall be enclosed in dust, damp and vermin proof enclosure equivalent to IP-54 as per IS/IEC:60529.

4.4 Equipment to be located outdoor shall be weather proof and have IPW-55 protection as per IS/IEC:60529 and shall also be provided with canopy as far as practicable.

4.5 The equipment to be located in hazardous area shall have additional protection as follows:

- a) Zone – I All the equipment shall be in flameproof execution.
- b) Zone – II The equipment producing sparks under normal operation shall be in flameproof execution and others shall be in increased safety execution.

The equipment shall be suitable for the enclosure group and temperature class as indicated in Design Philosophy - Electrical. The equipment selected shall conform to relevant Indian Standard Specification and must be certified by Central Mining Research Institute, Dhanbad or any other statutory authority for use in the specified hazardous area.

4.6 The pendant push button shall be light weight enclosure of aluminium/ polypropylene etc. In case of hazardous areas, the loop between the pendant push button and the crane control panel shall be made intrinsically safe by using suitable isolators. Alternatively certified flame proof components and increased safety terminals can be housed in the hose proof aluminium / polypropylene enclosure.

4.7 Special care shall be taken to ensure that the parts to be opened for inspection and maintenance retain their dust tightness even after repeated opening and closing operations.

4.8 All mating surfaces shall be properly machined. Neoprene gaskets shall be used for dust and weather proofing. The gaskets shall be without any discontinuity.

4.9 Only non-hygroscopic materials shall be used for insulation. All insulation shall be specially impregnated to withstand ambient conditions and atmospheric pollution.

4.10 All live parts shall be adequately protected to prevent inadvertent or accidental contact.

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - ELECTRICALS FOR OVERHEAD CRANES &amp; HOISTS</div>	PC288-TS-0819	0	<div><div>बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 5 of 11		

- 4.11 The minimum clearance and creepage distance of M.V. equipment shall be 20 and 28 mm respectively and shall be positively maintained after connections.
- 4.12 All external hardware of diameter less than 8 mm shall be of stainless steel and those of diameter 8 mm and above shall be of mild steel cadmium plated or zinc passivated.
- 4.13 Earthing terminals complete with sockets and identification marks shall be provided on the enclosure of all electrical equipment. The number of terminals shall be two for equipment rated above 240V and one for those rated 240V and below. Additional internal earthing arrangement shall be provided for flameproof equipment.
- 4.14 All equipment shall be provided with stainless steel name plates containing the particulars as per relevant IS along with the description and code nos. of equipment
- 4.15 All the electrical equipment shall be provided with separate terminal box, heavy duty double compression type rolled aluminium cable glands, proper crimping lugs and anti-vibration type terminals suitable for the cable sizes required.
- 4.16 Enclosure for limit switches, pendant push button, junction boxes and magnets etc. shall be of cast aluminium. Enclosure for control panel, transformer and resistors may be of sheet steel. The thickness of the sheet steel for the enclosure shall not be less than 2.5 mm. All enclosures shall be suitably painted to withstand atmospheric pollution as mentioned in the Design Philosophy - Electrical.
- 4.17 The doors or inspection covers shall be provided with threaded knobs or butterfly nuts made of plated carbon steel. Copper or copper alloys shall not be used outside the enclosures.
- 4.18 To facilitate maintenance and testing of all electrical equipment:
- Disconnecting links shall be provided where necessary.
  - All cable lugs and terminals shall be numbered in a permanent form corresponding to the wiring diagram.
  - Easy access and adequate working space shall be provided around all motors, panels, limit switches etc. safety railing shall be provided, where necessary.

## 5.0 EQUIPMENT SPECIFICATION

### 5.1 Power Connection

- 5.1.1 The main supply shall be obtained by flexible cable or otherwise as per requirement.
- 5.1.2 In case of overhead bare conductors, they shall be of copper and mounted on side of the crane bridge. Four number of gunmetal type current collector with renewable carbon inserts shall be used for power connection. One end of the bare conductor shall be connected to the owner's isolator by means of fixed cable.
- 5.1.3 In case of flexible cable arrangement, the cable shall be connected at one end of the crane and the other end to owner's isolator. The cable shall be hung at intervals by festooned type arrangement.
- 5.1.4 In either case the power fed to the trolley shall be by means of flexible cables fixed and supported by festooned arrangement.

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - ELECTRICALS FOR OVERHEAD CRANES &amp; HOISTS</div>	PC288-TS-0819	0	<div> बी एच ई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 6 of 11		

5.1.5 The arrangement of fixing and supporting the flexible cables shall be such that the cable is not damaged due to repeated travelling of the crane and trolley. Supporting G.I. wire shall be provided, wherever required.

5.1.6 The collector rollers and shoes shall be designed to avoid sparking.

## 5.2 Power Control Panel

5.2.1 The panel shall house all the necessary electrical equipment for distribution of power and control of individual equipment / circuit.

5.2.2 The panel shall be totally enclosed, floor mounting, dead front, free standing type in cubicle construction.

5.2.3 The panel shall house the following:

i) For incoming supply

- Triple pole switch fuse units
- Supply 'ON' signal lamps (LED Type)

The above switch shall cut off all power driven and associated equipment on the crane except lighting and plug supply circuits.

ii) For motors

- Reversing type starter with necessary contactors and timers.
- Other controlling relays and devices.

iii) For lighting, control and plug supply

- Single phase transformers
- Isolating switch fuse units on primary and secondary sides.

5.2.4 All switches shall be motor duty type (AC 23) and rated for 1.5 times of the full load current of the circuit. The incoming switch shall be interlocked with the panel door.

5.2.5 All contactors shall be air break type and of AC4 utilization categories. The thermal rating of the contactor shall be 1.5 times the full load current of the circuit.

5.2.6 The power contactors shall be interlocked electrically and mechanically so that there shall be no possibility of simultaneous operation of two contactors for the same motor.

5.2.7 Electrical interlock shall be provided between main hoist and micro hoist motors.

5.2.8 All thermal overload relays shall have in-built single phasing feature and ambient compensated, separately mounting and hand reset type. The reset push bottom for thermal overload relays shall be provided on the cover of the control panel so that it is possible to reset the relay from outside without opening the cover of the panel. Also indication shall be provided for hoisting/travel motors tripping on overload.

5.2.9 The panel shall be installed on properly levelled base frame fabricated out of channels of suitable size.

## 5.3 Motors

5.3.1 The design and specification of all motors shall comply with requirements stated elsewhere in the specifications.

5.3.2 The power rating of the motors shall be 25% higher than the design requirement of the driven equipment, under the specified service and duty conditions.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - ELECTRICALS FOR OVERHEAD CRANES &amp; HOISTS</b>	<b>PC288-TS-0819</b>	<b>0</b>	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 7 of 11		

5.3.3 All motors shall preferably be of squirrel cage type and so designed that smooth acceleration or deceleration of the load is possible without any jerks. Further a maximum displacement of 2 mm when starting and stopping the motor in quick succession shall be guaranteed.

5.3.4 The motors for main hoist and micro hoist shall be suitable for intermittent duty type S4 with 60% C.D.E. and 300 starts / stops per hour. The motors for long travel and cross travel shall be suitable for S2 duty for 60 minutes.

5.3.5 The motors shall be so located that all parts are accessible for inspection and maintenance without affecting normal ventilation.

#### 5.4 Brakes

5.4.1 The brakes for each motor shall be suitable for duties as specified below:

- a) Main / Micro hoist S4 duty
- b) Long / cross travel S2 duty

5.4.2 The coil of the brake shall be wound with fibre glass covered annealed copper conductor suitable for class H application. An additional covering with glass taps shall be provided over the coil. The maximum temperature of the coil for continuous operation shall be limited to 140° C. The coil shall be vacuum impregnated.

5.4.3 For other design details refer mechanical engineering standard.

#### 5.5 Limit Switches

5.5.1 Limit switches of both shunt and series type shall be used in control and power circuit.

5.5.2 These shall be heavy duty type and of sturdy construction in cast aluminium enclosure.

5.5.3 The mode of operation of these limit switches shall be positive and direct acting type.

5.5.4 The contacts shall be rated 50% more than the required current ratings.

5.5.5 The width of the roller of limit switches shall be sufficient to avoid slippage of contact with the striker.

5.5.6 The striker provided for operating these limit switches shall have rubber padding on surface which will make contact with roller to actuate it. The limit switches and its roller should be designed to withstand the frequent impact pressure.

5.5.7 Switches in which the contacts are operated by spring or gravity or both on the withdrawal of a chain or similar devices, shall not be used.

#### 5.6 Transformers

5.6.1 These shall be of dry type, class H insulated, air cooled, double wound and mounted inside the panel.

5.6.2 The transformers shall be provided with switch fuse unit on their primary side of suitable rating. One side of secondary windings of the transformers shall be earthed and other shall be provided with fuse of suitable rating.

5.7 The rating of the transformers shall be at least 2.5 times the continuous load.

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - ELECTRICALS FOR OVERHEAD CRANES &amp; HOISTS</div>	PC288-TS-0819	0	<div></div>
		Document No.	Rev	
		Sheet 8 of 11		

## 5.8 Junction Box

5.9 Junction boxes shall be of cast aluminium construction and adequately sized to enable easy termination of cables.

## 5.10 Hand Lamps

5.10.1 Provision shall be made in the crane for use of hand lamps by installing 2 nos. 24 volts, 2 pin metal clad switch sockets. One of the sockets shall be on the bridge (outside the panel) and the other on the trolley.

5.10.2 The transformer primary and secondary voltage shall be 250V and 25V respectively.

## 6.0 CABLES, CABLE TERMINATION AND CONNECTIONS

6.1 The cables used for fixed wiring shall be 1.1 KV grade PVC insulated armoured and PVC sheathed overall, and shall conform to IS: 1554 Part-I.

6.2 The flexible cable used for power supply to crane and also for interconnection of equipment mounted on moving and fixed part of the crane shall be 1.1 KV grade heavy duty type.

6.3 All cables shall be properly laid and supported with adequately sized aluminium clamps at 500 mm interval.

6.4 Cable entry on all electrical equipment e.g. panels, motors, limit switches, brakes, junction boxes etc. shall be through double compression type rolled aluminium cable glands.

6.5 The internal power wiring of panels shall be carried out by PVC insulated stranded copper flexible cable.

6.6 The wiring shall be arranged in a neat fashion and supported on PVC channel or PVC stand of screw support.

6.7 For equipment mounted on the doors, the wiring shall be carried out with flexible stranded copper cables in such a way that no strain is put on the wires and equipment when the door is opened for inspection and maintenance.

6.8 External looping of wires shall be done through separate dust tight junction boxes.

6.9 The sizes of power cables to be used shall be subject to owner's approval. The minimum size of power and control cables shall be 16 sq. mm (Al) & 2.5 sq. mm (Cu) respectively.

## 7.0 EARTHING

7.1 The earthing of all electrical equipment shall be carried out in accordance with IS: 3043.

7.2 The enclosures of electrical equipment shall be connected to an aluminium earth ring on the crane which in turn shall have effective electrical connection with the bridge.

7.3 The crane bridge shall be earthed through the bridge travel runway rails on both sides which in turn shall be earthed to owner's earth ring located on the ground floor.



<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - ELECTRICALS FOR OVERHEAD CRANES &amp; HOISTS</b></div>	<div>PC288-TS-0819</div>	<div>0</div>	<div><div>बी एच ई एल <b>BHEL</b></div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 9 of 11</div>		

7.4 Further the power supply cable for the crane shall have an additional conductor for earth connection. Both sides of this conductor shall be earthed.

7.5 All earth conductors shall be of aluminium.

7.6 This size of earth conductor shall be equal to half the size of the power conductor subject to a minimum size of 10 sq. mm.

## 8.0 CONTROL DESK / CONTROL STATION

8.1 The crane shall be controlled either from the floor by means of a pendant control station or from bridge mounted control desk as indicated in the mechanical data sheet.

8.2 In either case, the units shall have the following control devices:

- Main off push button with padlocking arrangement.
- Indication lamps for supply 'ON'
- Control push buttons, as specified in the mechanical data sheet.
- All other devices required for safe and proper operation of the crane / hoist.

8.3 All push buttons shall be momentary contact type, coloured as per IS: 6875 and have 1 NO and 1 NC contacts.

8.4 The bridge mounted control desk, where specified, shall be of totally enclosed and dust tight construction. All controlling equipment shall be mounted on the top. It shall be located at most convenient location to allow movement of the operator. The installation shall be equipped with adjustable chair, fan, light and main isolating switch.

8.5 The pendant control station, where specified, shall be in a single enclosure and in totally enclosed dust light execution. The unit shall be suspended and supported from the bridge platform by flexible steel wire rope. The connection shall be made with a multi core flexible copper conductor cable and shall have 20% spare cores. One core shall be provided for earth connection of the circuit.

## 9.0 PAINTING

Enclosures of all electrical equipment shall be painted with two coats of epoxy based primers after suitable pre-treatment. Two coats epoxy based paint of approved colour shall be provided.

## 10.0 TESTS AND INSPECTION

10.1 All equipment shall be routine tested as per relevant Indian Standard Specifications.

10.2 Additional tests, wherever specified, shall be carried out on one equipment of each rating.

10.3 All the above mentioned tests shall be carried out in presence of owner's representative.

10.4 The owner's inspection shall, however, not absolve the vendor from his responsibility for making good any defects which may be noticed subsequently.

10.5 Despatch of materials shall be subject to written consent of owner or his representative.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - ELECTRICALS FOR OVERHEAD CRANES &amp; HOISTS</b>	<b>PC288-TS-0819</b>	<b>0</b>	
		Document No.	Rev	
		Sheet 10 of 11		

## 11.0 INSTALLATION, TESTING AND COMMISSIONING

- 11.1 The vendor shall undertake installation of all electrical equipment in accordance with latest code of practices, in conformity with recommendation of the respective equipment manufacturer, drawings approved by the owner or owner's representative, direction of Engineer-in-charge, statutory regulations and to the entire satisfaction of the owner.
- 11.2 The vendor shall arrange all the necessary erection tools and tackles, testing and measuring instruments and shall supply the required erection materials including structural steel.
- 11.3 Following tests shall be specifically conducted before commissioning in presence of owner's representative. All the test results shall be recorded and submitted to the owner.
- Insulation test.
  - Continuity test.
  - High voltage test.
  - Simulation test.

## 12.0 DRAWINGS AND DOCUMENTS

- 12.1 Drawings and documents as per Annexure-I shall be supplied unless otherwise specified.
- 12.2 All drawings and documents shall have the following description written boldly :
- Name of client
  - Name of consultant
  - Enquiry / Order Number with plant / project name
  - Code No. and Description

## 13.0 SPARES

- 13.1 Commissioning Spares: Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval.
- 13.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 13.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 13.4 All spare parts shall be identical to the parts used in the equipment.

## 14.0 DEVIATIONS

- 14.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

## ANNEXURE - I

### DOCUMENTATION FOR ELECTRICALS FOR OVERHEAD CRANES & HOISTS

Sl. No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification sheet and technical particulars	N	Y	Y
2.	Composite schematic diagram	N	Y	Y
3.	Dimensional drawing showing the mounting details and general arrangement for the following equipment			
	a) Motors	N	Y	Y
	b) Power control panel	N	Y	Y
	c) Control station	N	Y	Y
	d) Limit switches etc.	N	Y	Y
4.	Down shop lead and power supply arrangement with civil scope.	N	Y	Y
5.	Inter-connection with terminal diagram and cable details	N	Y	Y
6.	Operating and maintenance instruction manual	N	N	Y
7.	Catalogues of bought out items	N	N	Y
8.	Test certificates	N	N	Y

**Note:**

- 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
- 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

- The tenderer shall also quote for any other spares as deemed necessary to be kept in stock for stipulated time.

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – HIGH VOLTAGE VARIABLE FREQUENCY DRIVES</b>		PC288-TS-0820A		0	 
			Document No.		Rev	
			Sheet 1 of 15			

# **TECHNICAL SPECIFICATION** **HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM**

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	GENERAL REQUIREMENTS
4.0	SITE CONDITIONS
5.0	TECHNICAL REQUIREMENTS
6.0	INSPECTION, TESTING AND ACCEPTANCE
7.0	SPARES
8.0	DOCUMENTS
9.0	CERTIFICATE
10.0	PACKING AND DESPATCH

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – HIGH VOLTAGE VARIABLE FREQUENCY DRIVES</b></div>	PC288-TS-0820A	0	<div><div>श्री एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 3 of 15		

## 1.0 SCOPE

- 1.1 The scope of this specification is to define the minimum technical requirements for the design, manufacture, testing and supply of High Voltage, AC Variable Frequency Drive system. The VFD system shall be complete with Squirrel Cage Induction Motor/ Synchronous Motor as specified in data sheet, Converter, Converter input transformer, drive output transformer, DC link reactor with associated auxiliaries, harmonic filters and field mounted local motor control panel.
- 1.2 The Vendor shall be responsible for engineering and functioning of the complete system, meeting the intent and requirement of this specification and data sheets. This shall include but not be limited to inverter sizing, transformer sizing, transformer impedance selection, vector group, input and output harmonic filter design and sizing, output dv/dt filter sizing, motor cable selection and motor sizing/selection.
- 1.3 This specification applies to drive systems having converter input voltage above 1000 V AC and up to and including 11000V AC.

## 2.0 CODES AND STANDARDS

- 2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS, unless otherwise specified:

IS:325	Three-phase Induction Motors
IS:3700	Essential Ratings and Characteristics of Semiconductor Devices
IS:3715	Letter symbols for semi-conducting devices
IS:4411	Code of designation of semi-conducting devices
IS:5001	Guide for preparation of drawings of semiconductor devices and Integrated Circuits
IS:5469	Code of practice for the use of semiconductor Junction Devices
IS:14901	Semi-conductor devices- Discrete devices & Integrated Circuits
IS:15880	Three Phase Cage Induction motors when fed from IGBT Converters Application Guide
IS:8789	Values of Performance characteristics for Three Phase induction motor
IS: 12615	Energy Efficient Induction Motors - Three Phase Squirrel Cage
IS:12729	Common specification for High-Voltage Switchgear and Control gear standards
IEC:60 146-1-3	Semiconductor Convertors general requirements and line commutated convertors- Transformer & reactors
IEC:61800	Adjustable speed electrical power drive systems
IEEE:519	Recommended Practices and requirements for Harmonics Control in Electrical power system

- 2.2 In case of imported equipment, standards of the country of origin shall be applicable, if these standards are equivalent or stringent than the applicable Indian standards.
- 2.3 The equipment shall also conform to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.
- 2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BSNDE/IEEE/NEMA or equivalent agency shall be applicable.
- 2.5 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations the following order of priority shall govern:

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – HIGH VOLTAGE VARIABLE FREQUENCY DRIVES</b>	PC288-TS-0820A	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 4 of 15		

- Statutory regulations
- Data sheets
- Job specification
- This specification
- Codes and standards

### 3.0 GENERAL REQUIREMENTS

- 3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.
- 3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply
- 3.3 Vendor shall give a notice of at least one year to the end user of equipment before phasing out the product/spares to enable the end user for placement of order for spares and services.
- 3.4 Vendor shall ensure proper co-ordination with the driven equipment supplier in selection/sizing of offered variable frequency drive system.

### 4.0 SITE CONDITIONS

- 4.1 The drive system shall be designed to operate under specified site conditions as specified in the data sheets. If not specifically mentioned therein, a design ambient temperature of 50°C and an altitude not exceeding 1000 metres above mean sea level shall be considered.
- 4.2 The AC drive shall be installed indoors in a non-hazardous, air-conditioned or pressurized room, as specified in data sheet. Transformer installation (outdoor/ indoor) shall be as indicated in datasheet. Motor shall be installed outdoors in safe or hazardous area as specified in datasheet.
- 4.3 All the equipment shall be designed for continuous duty as per nameplate rating under the specified ambient conditions.

### 5.0 DESIGN AND FABRICATION REQUIREMENTS

#### 5.1 Performance Requirement

- 5.1.1 The system shall be energy efficient, designed as standard product and shall provide very high reliability, high power factor, low harmonic distortion and low vibration/ wear / noise. It shall be easy to install in minimum time and expense and no special tools shall be required for routine maintenance.
- 5.1.2 The system shall be designed to deliver the motor input current and torque for the complete speed torque characteristics of the driven equipment, with input supply variation of  $\pm 10\%$  and frequency variation of  $\pm 3\%$ . The system shall be suitable for the load characteristics and the operational duty of the driven equipment. It shall be capable of withstanding the thermal and dynamic stresses and the transient mechanical torque, resulting from short-circuit.
- 5.1.3 The drive system shall be designed to operate in one or more of the following operating modes as to suit characteristics of the driven equipment or specified in the data sheet:
- a. Variable torque changing as a function of speed i.e. Speed squared
  - b. Constant torque over a specific speed range

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – HIGH VOLTAGE VARIABLE FREQUENCY DRIVES</b></div>	PC288-TS-0820A	0	<div><div>श्री एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 5 of 15		

- c. Constant power over a specific speed range where the torque decreases when speed Increases
- d. Any other as specified in data sheet
- 5.1.4 The drive controller shall be equipped with microprocessor based digital regulator with programmable functions. The power control regulator logic shall provide for an acceleration/deceleration current limit curve and shall be capable of field adjustments without shutting the system down. Linear acceleration and deceleration shall be separately programmable from 0.1 to 20 seconds.
- 5.1.5 The System shall be suitable for single quadrant operation and the speed variation shall be with range 10-100 % unless otherwise specified in data sheet with speed set accuracy of  $\pm 1\%$  of rated maximum speed and steady state regulation of  $\pm 0.5\%$  of rated speed.
- 5.1.6 The total harmonic distortion (THD) of the voltage and current at inverter output shall be as per IEC 61800 and same shall be considered in the design of the motor. The dv/dt limits & Vpeak shall also be as per IEC-61800-2.
- 5.1.7 Harmonics at the supply side of the drive system at primary of the main input transformer shall be restricted within the maximum allowable levels of current and voltage distortion as per recommendations in the latest edition of IEEE-519. The vendor shall perform design calculation for harmonic filter system considering VFD connected to the power system and including the supply of harmonic filters along with all accessories which shall be installed at owner's power system unless otherwise specified. These harmonic studies shall be conducted with maximum and minimum system fault level, cable capacitance, system equipment reactance etc. The studies shall highlight but not be limited to maximum load current, expected resonant frequencies, need of harmonic filters, sequence of switching of filters, voltage wave form, rating of equipments/ feeder for feeding filters from owner's switchgear etc.
- 5.1.8 Unless otherwise specified, the overload capacity of the controller shall be 150% of rated current of motor for one minute for constant torque applications, and 110% of rated current for one minute for variable torque applications at rated voltage. If the motor load exceeds the limit, the drive shall automatically reduce the frequency and voltage to the motor to guard against overload. If load demands exceed the current limit for more than 1 minute, the drive shall shutdown to prevent over heating of the motor and damage to the drive.
- 5.1.9 During operation, the system shall be capable of developing sufficient torque under all load conditions to respond to a 20% alteration in speed set point within a time limit upto 60 seconds.
- 5.1.10 The integrator action of the speed set point alteration shall be independently adjustable for both an upward and a downward alteration. The minimum time interval between set point adjustments by the distributed control system shall be considered as 10 seconds.
- 5.1.11 The drive shall trip in case the speed exceeds 105% of the maximum operational speed or reduces to 95% of the minimum operational speed for more than 10 seconds.
- 5.1.12 Maximum noise level from the drive at 1-meter distance, under rated load with all normal cooling fans operating shall not exceed 85 dBA.
- 5.1.13 Variable frequency drive shall be arranged so that it can be operated in an open circuit mode, disconnected from the motor for start up adjustments and troubleshooting/ maintenance.

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – HIGH VOLTAGE VARIABLE FREQUENCY DRIVES</b></div>	PC288-TS-0820A	0	<div> श्री एच ई एल </div>
		Document No.	Rev	
		Sheet 6 of 15		

5.1.14 Voltage at motor neutral shall be maintained at ground potential for the total operating condition.

## 5.2 Control Requirement

5.2.1 The system shall operate on constant V/f supply with required voltage boost capability in low frequency mode of operation.

5.2.2 Short time voltage dips up to 20% of nominal voltage (e.g. in case of a large motor start up connected to the same bus as VFD) shall not cause the control system to stop functioning and shall not trip the drive system.

5.2.3 The system shall also be equipped with a momentary powerloss ride through feature which will restart the system in case of voltage dip over 20% or power interruptions for less than 2 seconds, with recovery of the voltage to its nominal value .. The drive shall have the facility to block this feature, if required by the operator. Upon restart, the converter shall be capable of synchronizing onto a rotating motor and develop full acceleration torque within 10 seconds.

5.2.4 The system shall be suitable for number of starts as per attached specification for High Voltage Motors.

5.2.5 The power controller shall be controlled to always start the motor in the forward direction. Logic shall be provided to prevent the motor from being started in the reverse direction.

5.2.6 The drive motor shall be speed controlled corresponding to 4-20mA or 0-10 V reference input signal. Unless otherwise specified, upon complete loss of the user's speed reference signal, the drive shall automatically run at constant speed as at 80-100% of the last speed reference available prior to the loss of signal.

5.2.7 It shall be possible to vary the speed of the drive in either manual or auto mode. Auto/Manual selection shall be from VFD panel unless otherwise specified.

- With the selector switch in "manual" mode, the operator shall be able to set the speed through key pad (mounted on front of the drive panel) or from speed increase/decrease push buttons (from the field). Motor operated potentiometer shall be provided as a speed set point device.
- With the selector switch in "auto" mode, speed of the motor shall be controlled from a 4-20 mA signal, from owner's PLC/DCS (Process Control) system. Necessary equipment required for interfacing with PLC/DCS shall also be provided in the VFD panel.
- Local/Remote selector switch shall be provided in local control station (in Field). With the selector switch in "Local" mode, the operator shall be able to start and set the speed through local control station (in Field). With the selector switch in "Remote" mode, speed of the motor shall be controlled either from VFD panel or from Owner's PLC/DCS as explained in a) and b) above.

5.2.8 The required provision for the interface with remote PLC/DCS located at control room shall be either through hardwired connection (with potential free contacts and transducers as described elsewhere in this specification) or through serial communication link as defined in the datasheet.

5.2.9 Drive system shall have provision for interface with upper level automation such as Substation monitoring system or electrical control system in case specified in the data sheet/job specification.



<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – HIGH VOLTAGE VARIABLE FREQUENCY DRIVES</b></div>	PC288-TS-0820A	0	<div><div>श्री एच ई एल</div></div>
		Document No.	Rev	
		Sheet 7 of 15		

- 5.2.10 The closed loop control feed back for the drive system having out put transformer shall be tapped from the secondary side of the output transformer.

### 5.3 Panel Construction

- 5.3.1 The panel shall include suitable semi conducting power devices (Diodes/IGBT/IGCT/ IEGT/SGCT) modules with protective devices, reactors (if required) , filters, control circuit, control accessories, indication and annunciation etc. The construction of the panel shall provide effective protection against electromagnetic emissions and shall meet the design requirement of relevant standards.
- 5.3.2 Upstream breaker 'ON/OFF/TRIP' indications and remote breaker closing and trip push buttons shall be provided on the front door.
- 5.3.3 Safety Interlock shall be provided so that power cabinet can't be opened unless the upstream breaker is disconnected, safety-grounding switch is closed and DC link capacitor is discharged. Power source breaker can only be closed once the earthing switch is open and panel door is closed with lock defeat facility.
- 5.3.4 The drive shall be suitably housed in sheet steel panels and shall be fabricated using cold rolled sheet steel. The sheet steel used for the panel shall be of minimum 2 mm CRCA. The panel shall be suitable for indoor installation, if not otherwise specified. The panel shall be free standing with degree of enclosure protection as IP-31. Maximum and minimum operating height shall be 1900 mm and 300 mm respectively.
- 5.3.5 Bolted un-drilled gland plate shall be provided at bottom. Clamp type terminals shall be used for connection of all wires up to 10 mm<sup>2</sup>, and terminal for higher sizes shall be bolted type suitable for cable lugs. Minimum space for power cable termination shall be 600mm clear from bottom of the cable gland plate.
- 5.3.6 Bus bars shall be of electrolytic copper/aluminium, sleeved, color coded separately for AC and DC system. All the live parts shall be sleeved / shrouded to ensure complete safety to personnel intending to carry out routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall be provided with suitable nameplate.
- 5.3.7 All the switches, component and accessories which are essential for normal and emergency operation shall preferably be mounted on the door and shall be operable externally. All the analogue instruments, where provided, shall be switchboard type, back connected & of size 96x96mm. Scale shall have red mark indicating maximum permissible operating rating.
- 5.3.8 Each panel shall be provided with illuminating lamp/11 W CFL with switch and fuse. 5/15A, 240V power socket with switch and fuse shall be provided. Each panel shall have space heater with switch fuse and variable setting thermostat.
- 5.3.9 Copper earth bus of min. 30x6 sq.mm. upto short circuit withstand capacity of 31.5kA and 50x6 sq.mm. for a short circuit withstand capacity above 31.5kA shall be provided in the panel with provision for connection to owner's plant earth grid. All the non-metallic components/parts shall be connected to the main earth bus bar. Separate earth bus bar and stud for electronic control system if required shall be provided.
- 5.3.10 All panels shall be of same height so as to form a uniform line-up, to give good aesthetic appearance.
- 5.3.11 All the control wiring shall be enclosed in plastic/ metal channel. Each wire shall be identified at both ends by self-sticking wire marker tapes or PVC ferrules. Power and control wiring

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – HIGH VOLTAGE VARIABLE FREQUENCY DRIVES</b></div>	PC288-TS-0820A	0	<div> श्री एच ई एल </div>
		Document No.	Rev	
		Sheet 8 of 15		

inside the panel shall be done with BIS approved, PVC insulated, fire retardant, low smoke, copper conductor wire 1.5mm<sup>2</sup> size wire shall normally be used provided the control fuse rating is 10 Amps or less and 2.5 mm<sup>2</sup> size for control fuse rating above 16 A for electrical circuits and 0.5mm<sup>2</sup> for electronic circuits. All wires shall be ferruled and terminals shall be properly numbered, minimum 20% spare terminals shall be provided.

- 5.3.12 All electronic modules and components shall be accessible from front of panel only. Modular assemblies for both the system control electronic equipments and power electronic equipments shall be used.
- 5.3.13 Low voltage compartment and cabling shall be electrically and physically separated from the high voltage compartment.
- 5.3.14 DC link capacitor and pre-charging & discharging circuit shall be preferably mounted in the rear of the panel.
- 5.3.15 Suitable eyebolts/ lifting clamps/ strap & cradle arrangement shall be provided for lifting of the panel/shipping section. The bolts, when removed shall not leave any opening in the panel.
- 5.3.16 Acrylic type transparent insulating material shall be used for covering live components.
- 5.3.17 Drive keypad, operator control panel required for control, monitoring and measurements shall be supplied and installed outside the panel on the front door. It shall be accessible for operation without opening the front door and shall be non-removable type.
- 5.3.18 All equipment shall be complete with cable glands, lugs etc. and cable glands shall be single or double compression type for indoor and outdoor equipment respectively. Cable glands shall also be suitable for the hazardous area application if specified in data sheet.

## 5.4 Cooling

- 5.4.1 The drive panel shall be naturally cooled or water cooled type as per manufacturer's standards. However, it is preferred to have natural air cooled system. If unavoidable, forced type-cooling system shall be provided. Cooling system shall include well-dimensioned panel, adequate cooling airflow path, modular cooling fan and if necessary, panel cooling fan or water-cooling system shall be considered. Vendor shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. For fan cooled drives, redundant ventilating fans (N+ 1) shall be provided. In case redundant cooling fan is not possible to be mounted in the panel, same shall be supplied loose.
- 5.4.2 For water-cooled drives, entire cooling system including but not limited to heat exchanger, flow and pressure meters and pumps shall be in vendor's scope. The system shall be provided with closed circuit water cooling system, requiring only make up water required for topping up. The cooling water pumps, in case provided, shall have 100% redundancy. Water quality/characteristics shall be as defined in the data sheet and selected cooling water system components/material shall be suitable for the same. Adequate safety measures shall be incorporated in water cooled drives such that no leakage is there which results in malfunctioning of electronic devices. Proper segregation between water cooling system and other equipment shall be provided. It is preferred that cooling cabinet panel shall be separated from the main panels.
- 5.4.3 Necessary starters shall be provided within the VFD panels for the Ventilation fans, Cooling Water circulation pumps, any other auxiliary motor etc. The system provided shall be interfaced with drive starting and shutdown so that safety interlocks such as start permit from

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – HIGH VOLTAGE VARIABLE FREQUENCY DRIVES</b></div>	PC288-TS-0820A	0	<div><div>श्री एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 9 of 15		

cooling system to drive and trip signal from cooling system to drive in case of cooling system failure etc., are incorporated in the overall sequence logic.

- 5.4.4 MCB for motor space heater, auxiliary power supply if required for local panel, drive panel space heater etc. shall be included and mounted in easy accessible location.

## 5.5 Equipment/ Component Specification

### 5.5.1 Motor

The motor shall be designed, constructed and tested in accordance with the latest revision of Specification /data sheet for High Voltage Induction / Synchronous Motor, in addition to the following requirements:

- The motor shall be suitable for operation with a solid-state power supply consisting of an adjustable frequency inverter for speed control.
- The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive.
- The motor shall be designed to operate continuously at any speed over the range (10-100%) of rated speed unless otherwise specified in data sheet.
- The permitted voltage variation should take into account the steady state voltage drop across the AC drive and all other system components upstream of the motor.
- Motors required to be transferred to DOL by-pass mode shall be rated for specified variations in system line voltage and frequency. Starting current of motor in DOL bypass mode shall be limited to value specified in motor specifications, unless otherwise specified in datasheets.
- The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid-state power supply.
- The motor insulation shall be designed to accept the applied voltage waveform, within the Vpeak and dv/dt limits as per IEC-61800-4 and necessary co-ordination between the VPD manufacturer & motor manufacturer W.r.t. incorporation of VPD output parameter in the design of motor shall be carried out.
- The drive manufacturer shall be solely responsible for proper selection of the motor for the given load application and the output characteristics of the drive.
- Motors shall be provided with Resistance Temperature Detectors (RTDs).

### 5.5.2 Converter Transformer/ Output transformer

- The converter transformer shall be dry type or oil filled type as specified in the data sheet. In case of the dry type transformer, it shall be mounted in the drive system panel unless specified otherwise in the datasheet. Offered transformer shall be as per enclosed Specifications/data sheet.
- The impedances of converter input transformers with more than one secondary windings for 12/18/24/36 pulse systems shall be selected to ensure equal load/current sharing between the secondary windings, the converters and the motor windings under all operational conditions including starting and restarting.

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – HIGH VOLTAGE VARIABLE FREQUENCY DRIVES</b></div>	<div>PC288-TS-0820A</div>	<div>0</div>	<div><div>कोयला इंडिया <b>BHEL</b></div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 10 of 15</div>		

- c. Drive out put transformer considered only for the purpose of meeting standard rated motor voltage i.e. 3300, 6600V, 11000V shall not be provided unless otherwise agreed between purchaser and the manufacturer.

#### 5.5.3 Power Converter

- The static power converter shall consist of a line side power converter for operation as a rectifier and a load side power converter for operation as a fully controlled inverter. Power converter shall be fast switching, most efficient and low loss type.
- Adequate short circuit and over voltage protection shall be provided for the converter and inverter system.
- All power converter devices shall include protective devices, snubber networks and dv/dt networks as required.
- The current rating of the converter's semi-conductor components shall not be less than 120% of the nominal current flowing through the elements at full load of the VFD through the entire speed range.
- All power diodes shall be of silicon type with minimum  $V_{BO}$  rating as 2.5 times the rated operating voltage.
- The power converter circuit shall be designed so that motor can be powered at its full nameplate rating continuously without exceeding its rated temperature rise due to harmonic currents generated by the inverter operation.
- The conversion devices and associated heat sinks shall be assembled such that individual devices can be replaced without requiring the use of any special precautions/tools.
- The cooling system of the electronic components, if provided, shall be monitored and necessary alarms shall be provided to prevent any consequential damage to the power control devices.
- Offered system shall also take into account the distance between Drive panel and motor and system shall include all material and accessories to make system suitable for a distance of 350m unless otherwise specified in the data sheet.

#### 5.5.4 DC Link Reactor

- Smoothing reactors for the DC link shall be designed to sufficiently decouple the rectifier and inverter portion of the converter and to limit fault currents in this circuit.
- Unless otherwise specified, the reactor shall be air-cooled or fan cooled type located within the panel.
- Reactor shall be suitable for operation with the non-sinusoidal current wave shapes and DC components under all operational conditions of the system without exceeding its temperature limits.

#### 5.5.5 Output Filter

VFD output current waveform should be inherently sinusoidal at all speeds, with harmonic limits as specified in this specification. Output filter shall be provided, if required. Output filter capacitors shall be provided with discharge circuits to ensure that all residual stored charge is

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – HIGH VOLTAGE VARIABLE FREQUENCY DRIVES</b>	PC288-TS-0820A	0	 श्री एम आई एल 
		Document No.	Rev	
		Sheet 11 of 15		

reduced to less than 50 V DC within 300 seconds after a loss of AC voltage. All capacitor shall be maintenance-free and self-healing type.

The VFD system shall inherently protect motor from high voltage dv/dt stress, independent of cable length to motor. Output filter shall be an integral part of the VFD system and included within the VFD enclosure.

#### 5.5.6 Bypass Feature

- Bypass feature along with motor protection relay and output side isolator/breaker shall be provided by purchaser unless otherwise specified in the datasheet. All necessary interlocks as required for safe and reliable operation of VFD system along with bypass feeder and output side isolator/breaker provided by Purchaser shall be provided in VFD system.
- Bypass starter shall be in separate compartment and switching scheme shall be such that in case of drive mal-operation, the motor could be taken on bypass control manually, while the drive could be attended independently. Suitable interlock shall be provided such that bypass mode and VFD mode shall not operate simultaneously.

#### 5.5.7 Local Motor Control Station

- The local motor control station, to be installed in the field near the motor shall conform to the attached specifications. Components and accessories that are required in the local motor control station may be mounted on the local field mounted panel envisaged for the driven equipment.
- Meters in the local control station shall be suitable for 4-20mA transducer outputs and shall be calibrated for the actual motor current. Further, for drives with bypass facility, the meters shall be capable of reading bypass mode full load and starting currents as well as the VFD mode drive current.

### 5.6 Protection, Control, Metering, Indication and Annunciation

5.6.1 The system vendor shall provide all the necessary system control, protection, alarm and metering equipment for the entire drive system and its auxiliary equipment.

5.6.2 Automatic sequence control shall include start-up of cooling system, auxiliary system of the motor, interlock checking, automatic start and run-up of drive, planned and emergency shutdown. The same shall be processed through microprocessor-based system.

#### 5.6.3 Operator Control Panel

- Each drive shall be equipped with a front mounted operator control console consisting of a backlit alphanumeric display and a keypad with keys for parameterization and adjusting parameter which shall not be limited to Start/Stop, Local/Remote, Auto/Manual, Increase/Decrease, menu navigation and protection and measurement parameter selection, etc.
- All parameter names, fault messages, warnings and other information shall be displayed in complete English words or standard English abbreviations to allow the user to understand the display without the use of a manual or cross-reference table. This shall also be used for the modification of all electrical values, configuration parameters, drive menu parameters, application and activity function access, faults, local control, adjustment storage, self test and diagnostics. Keypad shall be operable with password for changing the protection setting, safety interlock etc. However, the parameters such as measurements, setting, mode of drive etc. shall be allowed to be viewed without any password.

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – HIGH VOLTAGE VARIABLE FREQUENCY DRIVES</b></div>	PC288-TS-0820A	0	<div><div>श्री एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 12 of 15		

- c. Operator console shall have facility/ port to connect external hardware such as Laptop etc. Console shall have facility to upload and download all parameter settings from one drive to another identical drive for start-up and operation.
- d. Drive system control shall also have facility to receive tripping signal from upstream breaker for tripping and also provision for closing upstream breaker after all required process parameters are achieved.
- e. User-friendly software for operation and fault diagnostic shall be loaded in the drive system panel before commissioning.

#### 5.6.4 Protective Features

The system shall incorporate adequate protective features, properly coordinated for the drive control and for the motor but not limited to the following:

- I. Incoming line surge protection
- II. Under / Over voltage protection
- III. Phase loss protection.
- IV. Programmable over current protection and under load protection.
- V. Inverter Fault.
- VI. Over frequency/Over speed of motor
- VII. Ventilation loss (In case same is not provided, drive shall generate an over temperature fault alarm and suitable sensors, as required for same, shall be provided).
- VIII. Over temperature of equipment.
- IX. Specific motor protection, including motor winding, bearing temperatures, over current, overload, negative phase sequence and earth fault protections etc.
- X. System earth fault protection.
- XI. Excitation system protection for synchronous motor
- XII. Over and under frequency, rotor earth fault (if applicable), field failure protection for synchronous motor
- XIII. Additional protection, if any for the drive system

#### 5.6.5 Control

The following controls shall be provided as a part of the Operator Control Panel or through separate switches.

- I. Start/Stop
- II. Speed control (Raise/Lower)
- III. Forward/Reverse (if specified)
- IV. Auto/Manual /Test mode
- V. Local/Remote
- VI. Emergency stop
- VII. Start/Stop for bypass starter (where specified)
- VIII. Trip-Remote Breaker
- IX. Excitation control system for synchronous motors
- X. Sequential switching of filters

#### 5.6.6 Indications

Vendor shall provide indications as required for normal operation and for ease of maintenance, which shall not be limited to the following indications.

- I. Motor running
- II. Motor stopped



<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – HIGH VOLTAGE VARIABLE FREQUENCY DRIVES</b></div>	PC288-TS-0820A	0	<div><div>श्री एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 13 of 15		

- III. VFD System Fault
- IV. System ready to start
- V. AC mains ON
- VI. Motor over speed
- VII. Rectifier output 'ON'
- VIII. Motor zero speed
- IX. Remote breaker trip
- X. Excitation system healthy for synchronous motors

Above indications may be provided as a part of the operator control panel, i.e. door mounted keypad or through hardwired LEDs. LEDs provided for indication shall be cluster type with adequate brightness and minimum 2 Nos LEDs chips per light. LEDs shall be connected in parallel and each LED chip having diameter not less than 3mm.

Potential free contacts for items i to iv shall be wired separately for remote indications in DCS system.

#### 5.6.7 Metering

Digital display of the following parameters shall be as a part of the Operator Control Panel, selectable by the operator.

- I. Output voltage
- II. Output current-VFD model Bypass mode
- III. Output frequency
- IV. Drive thermal state
- V. Motor speed
- VI. Motor energy meter
- VII. Hour Run
- VIII. Voltage and current meter for excitation system of synchronous motor
- IX. KVAR, power factor meter for synchronous motors
- X. Necessary transducer shall be provided with 4-20mA output for indicating motor speed and motor current in DCS unless otherwise specified for other parameters.
- XI.

#### 5.7 Fault Diagnostic

Fault diagnostic shall be built into the system to supervise the operation and failure of the system. The information regarding failure of any of the system including, shutdown of the system, shall be available for a period of minimum 4 days (96 hours) after a shutdown, even though no supply would be available to the system. The system may be totally de-energized for maintenance or otherwise. It shall be possible to retrieve the record of events prior to tripping of the system or de-energisation. Auxiliary supply to the system components or to the electronics (firmware) for the diagnostics / display shall be taken care by the manufacturer for this purpose.

#### 5.8 External Power supply for auxiliary and Control Circuit

Auxiliary power supply for devices external to VFD module, space heater supply for Motor, VFD panel space heater, auxiliary power supply for transformers, cubicle 11W CFL lamps, indicating lamps, digital meters (Ammeter, Speedometer) etc. shall operate on 240 volts single phase AC supply provided by purchaser.

All control circuit shall operate at maximum voltage of 240V AC or 220V DC unless otherwise specified in the datasheet.

Vendor shall include supply of all control transformers, protective devices, associated

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – HIGH VOLTAGE VARIABLE FREQUENCY DRIVES</b></div>	PC288-TS-0820A	0	<div><div>श्री एच ई एल</div></div>
		Document No.	Rev	
		Sheet 14 of 15		

accessories etc. and any other control supply voltage required for the system shall be derived by the vendor from the power supply made available by purchaser.

## 5.9 Reliability Features

The expected lifetime of the drive system shall be min. 20 years. The system including all individual components forming part of the system shall have an availability of minimum 0.997 and a minimum MTBF of 4 years.

## 5.10 Maintenance features

The controller design shall incorporate the following maintenance features:

Modular construction

All components shall be easily accessible.

Standard diagnostics to aid maintenance personnel. These shall include LED or alphanumeric displays, test or measurement points.

## 5.11 Painting

5.11.1 After preparation of the under surface, the panel shall be spray painted with two coats of epoxy based final paint or shall be powder coated. The colour shade of final paint shall be as RAL 7032, unless specified otherwise. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

5.11.2 All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

## 6.0 INSPECTION, TESTING AND ACCEPTANCE

6.1 During fabrication, the drive shall be subject to inspection by PDIL / Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used.

6.2 All tests shall be carried out at the manufacturer's works under his care and expense. The tests shall be witnessed by an inspector of PDIL/Owner or of an agency authorized by the owner. Prior notice of minimum 4 weeks shall be given to the inspector for witnessing the tests.

6.3 All Routine & Type Tests shall be conducted as per the NIT for HV variable frequency drive as per IEC 61800-4. Moreover, combined test for VFD and motor at vendor's works shall be carried out.

6.4 String Test with driven equipment

If a string test with driven equipment is specified in the data sheet of the driven equipment, it shall be carried out with the job equipment.

## 7.0 SPARES

7.1 Commissioning Spares: Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval.

7.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.

7.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – HIGH VOLTAGE VARIABLE FREQUENCY DRIVES</b>	PC288-TS-0820A	0	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 15 of 15		

7.4 All spare parts shall be identical to the parts used in the equipment

## 8.0 DRAWINGS

8.1 Vendor shall submit to Purchaser, for approval, before completion of manufacturing and assembly of equipment following drawings and literature.

- (i) Installation and maintenance manual including trouble-shooting chart.
- (ii) Panel drawings and cable schedule
- (iii) Block diagram and control logic.

## 9.0 CERTIFICATION

The motors and associated Variable frequency drive system equipment shall have test certificates issued by recognized independent test house (CIMFRI BASEEFA/ LCIE/UL/FM or equivalent). All indigenous motors shall conform to Indian Standards and shall be certified by Indian testing agencies. All motors (indigenous and imported) shall also have valid statutory approvals as applicable for the specified hazardous location. All indigenous flameproof motors shall have valid BIS license and marking as required by statutory authorities.

Also the motor nameplate shall clearly indicate that the motor is suitable for operation with variable frequency drive along with VFD make and model number.

## 10.0 PACKING AND DESPATCH

All the equipment shall be divided in to several shipping sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation i.e. ship/rail or trailer. The equipment shall be wrapped in polyethylene sheets before being placed in wooden crates/cases to prevent damage to the finish. Crates/cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Weight', 'Owner's particulars', 'PO nos.' etc., shall be clearly marked on the package together with other details as per purchaser for scrutiny. The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage, in areas with heavy rains/high ambient temperature.

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVES</b>		PC288-TS-0820B		0	 
			Document No.		Rev	
			Sheet 1 of 15			

# **TECHNICAL SPECIFICATION** **MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM**

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVES</b>		PC288-TS-0820B		0	
			Document No.		Rev	
			Sheet 2 of 15			

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	GENERAL REQUIREMENTS
4.0	SITE CONDITIONS
5.0	TECHNICAL REQUIREMENTS
6.0	INSPECTION, TESTING AND ACCEPTANCE
7.0	SPARES
8.0	DOCUMENTS
9.0	CERTIFICATE
10.0	PACKING AND DESPATCH

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVES</b></div>	PC288-TS-0820B	0	<div><div>श्री एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 3 of 15		

## 1.0 SCOPE

- 1.1 The scope of this specification is to define the minimum technical requirements for the design, manufacture, testing and supply of Medium Voltage, AC Variable Frequency Drive system. The VFD system shall be complete with Squirrel Cage Induction Motor/ Synchronous Motor as specified in data sheet, Converter, Converter input transformer, drive output transformer, DC link reactor with associated auxiliaries, harmonic filters and field mounted local motor control panel.
- 1.2 The Vendor shall be responsible for engineering and functioning of the complete system, meeting the intent and requirement of this specification and data sheets. This shall include but not be limited to inverter sizing, transformer sizing, transformer impedance selection, vector group, input and output harmonic filter design and sizing, output dv/dt filter sizing, motor cable selection and motor sizing/selection.
- 1.3 This specification applies to drives connected to line voltage up to 1000 V, AC.

## 2.0 CODES AND STANDARDS

- 2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS, unless otherwise specified:

- |                |  |
|----------------|--|
| IS:325         | Three-phase Induction Motors   |
| IS:3700        | Essential Ratings and Characteristics of Semiconductor Devices                                       |
| IS:3715        | Letter symbols for semi-conducting devices   |
| IS:4411        | Code of designation of semi-conducting devices   |
| IS:5001        | Guide for preparation of drawings of semiconductor devices and Integrated Circuits                   |
| IS:5469        | Code of practice for the use of semiconductor Junction Devices                                       |
| IS:14901       | Semi-conductor devices- Discrete devices & Integrated Circuits                                       |
| IS:15880       | Three Phase Cage Induction motors when fed from IGBT Converters Application Guide                    |
| IS:8789        | Values of Performance characteristics for Three Phase induction motor                                |
| IS: 12615      | Energy Efficient Induction Motors - Three Phase Squirrel Cage  |
| IS/IEC:60947   | Low Voltage Switchgear and Control gear  |
| IEC:60 146-1-3 | Semiconductor Convertors general requirements and line commutated convertors- Transformer & reactors |
| IEC:61800      | Adjustable speed electrical power drive systems  |
| IEEE:519       | Recommended Practices and requirements for Harmonics Control in Electrical power system              |
- 2.2 In case of imported equipment, standards of the country of origin shall be applicable, if these standards are equivalent or stringent than the applicable Indian standards.
  - 2.3 The equipment shall also conform to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.
  - 2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BSNDE/IEEE/NEMA or equivalent agency shall be applicable.
  - 2.5 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations the following order of priority shall govern:

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVES</b>	<b>PC288-TS-0820B</b>	<b>0</b>	 कोयला इण्डिया  बी एच ई एल
		Document No.	Rev	
		Sheet 4 of 15		

- Statutory regulations
- Data sheets
- Job specification
- This specification
- Codes and standards

### 3.0 GENERAL REQUIREMENTS

- 3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.
- 3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply
- 3.3 Vendor shall give a notice of at least one year to the end user of equipment before phasing out the product/spares to enable the end user for placement of order for spares and services.
- 3.4 The vendor shall be responsible for design, engineering and manufacturing of the complete VFD system to fully meet the intent and requirements of this specification and attached data sheets.

### 4.0 SITE CONDITIONS

- 4.1 The AC drive system shall be designed to operate under specified site conditions as specified in the data sheets. If not specifically mentioned therein, a design ambient temperature of 50°C. and an altitude not exceeding 1000 metres above mean sea level shall be considered.
- 4.2 The AC drive shall be installed indoors in a non-hazardous, air-conditioned or pressurized room, as specified in data sheet.
- 4.3 All the equipment shall be designed for continuous duty as per nameplate rating under the specified ambient conditions.

### 5.0 DESIGN AND FABRICATION REQUIREMENTS

#### 5.1 Performance Requirement

- 5.1.1 The system shall be energy efficient, designed as standard product and shall provide very high reliability, high power factor, low harmonic distortion and low vibration/ wear/noise. It shall be easy to install in minimum time and expense and no special tools shall be required for routine maintenance.
- 5.1.2 The system shall be designed to deliver the motor input current and torque for the complete speed torque characteristics of the driven equipment, with input supply variation of  $\pm 10\%$  and frequency variation of  $\pm 3\%$ . The system shall be suitable for the load characteristics and the operational duty of the driven equipment. It shall be capable of withstanding the thermal and dynamic stresses and the transient mechanical torque, resulting from short-circuit.
- 5.1.3 The drive system shall be designed to operate in one or more of the following operating modes as to suit characteristics of the driven equipment or specified in the data sheet:
- a. Variable torque changing as a function of speed i.e. Speed squared
  - b. Constant torque over a specific speed range
  - c. Constant power over a specific speed range where the torque decreases when speed increases
  - d. Any other as specified in data sheet

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVES</b>	<b>PC288-TS-0820B</b>	<b>0</b>	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 5 of 15		

- 5.1.4 The drive controller shall be equipped with microprocessor based digital regulator with programmable functions. The power control regulator logic shall provide for an acceleration/deceleration current limit curve and shall be capable of field adjustments without shutting the system down. Linear acceleration and deceleration shall be separately programmable from 0.1 to 20 seconds.
- 5.1.5 The System shall be suitable for single quadrant operation and the speed variation shall be with range 1:100 unless otherwise specified in data sheet with speed set accuracy of  $\pm 1\%$  of rated maximum speed and steady state regulation of  $\pm 0.5\%$  of rated speed.
- 5.1.6 The total harmonic distortion (THD) of the voltage and current at inverter output shall be as per IEC 61800 and same shall be considered in the design of the motor. The dv/dt limits & Vpeak shall also be as per IEC-61800-2.
- 5.1.7 Harmonics at the supply side of the drive system at primary of the main input transformer shall be restricted within the maximum allowable levels of current and voltage distortion as per recommendations in the latest edition of IEEE-519. The vendor shall perform design calculation for harmonic filter system considering VFD connected to the power system and including the supply of harmonic filters along with all accessories which shall be installed at owner's power system unless otherwise specified. These harmonic studies shall be conducted with maximum and minimum system fault level, cable capacitance, system equipment reactance etc.
- 5.1.8 The controller output overload capacity shall be 150% of rated current of motor for one minute for constant torque applications, and 110% of rated current for one minute for variable torque applications at rated voltage. If the motor load exceeds the limit, the drive shall automatically reduce the frequency and voltage to the motor to guard against overload. If load demand exceeds the current limit for more than 1 minute, the drive shall shut down to prevent over heating of the motor and damage to the drive.
- 5.1.9 During operation, the system shall be capable of developing sufficient torque under all load conditions to respond to a 20% alteration in speed set point within a time limit upto 60 seconds.
- 5.1.10 The integrator action of the speed set point alteration shall be independently adjustable for both an upward and a downward alteration. The minimum time interval between set point adjustments by the distributed control system shall be considered as 10 seconds.
- 5.1.11 The drive shall trip in case the speed exceeds 105% of the maximum operational speed or reduces to 95% of the minimum operational speed for more than 10 seconds.
- 5.1.12 Maximum noise level from the drive at 1-meter distance, under rated load with all normal cooling fans operating shall not exceed 85 dBA.
- 5.1.13 Variable frequency drive shall be arranged so that it can be operated in an open circuit mode, disconnected from the motor for start up adjustments and troubleshooting/ maintenance.

## 5.2 Control Requirement

- 5.2.1 The system shall operate on constant V/f supply with required voltage boost capability in low frequency mode of operation.
- 5.2.2 Short time voltage dips up to 20% of nominal voltage (e.g. in case of a large motor start up connected to the same bus as VFD) shall not cause the control system to stop functioning and shall not trip the drive system.

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVES</b></div>	<div>PC288-TS-0820B</div>	<div>0</div>	<div><div>श्री एच ई एल <b>BHEL</b></div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 6 of 15</div>		

- 5.2.3 The system shall also be equipped with a momentary powerloss ride through feature which will restart the system in case of voltage dip over 20% or power interruptions for less than 2 seconds, with recovery of the voltage to its nominal value .. The drive shall have the facility to block this feature, if required by the operator. Upon restart, the converter shall be capable of synchronizing onto a rotating motor and develop full acceleration torque within 10 seconds.
- 5.2.4 The system shall be suitable for number of starts as per attached specification for Medium Voltage Motors.
- 5.2.5 The power controller shall be regulated to always start the motor in the forward direction. Logic shall be provided to prevent the motor from being started in the reverse direction.
- 5.2.6 The drive motor shall be speed controlled corresponding to 4-20mA or 0-10 V reference input signal. Upon complete loss of the user's speed reference signal, the drive shall automatically run at constant speed as at 80-100% of the last speed reference available prior to the loss of signal.
- 5.2.7 It shall be possible to vary the speed of the drive in either manual or auto mode. Auto/Manual selection shall be from VFD panel unless otherwise specified.
- With the selector switch in "manual" mode, the operator shall be able to set the speed through key pad (mounted on front of the drive panel) or from speed increase/decrease push buttons (from the field). Motor operated potentiometer shall be provided as a speed set point device.
  - With the selector switch in "auto" mode, speed of the motor shall be controlled from a 4-20 mA signal, from owner's PLC/DCS (Process Control) system. Necessary equipment required for interfacing with PLC/DCS shall also be provided in the VFD panel.
  - Local/Remote selector switch shall be provided in local control station (in Field). With the selector switch in "Local" mode, the operator shall be able to start and set the speed through local control station (in Field). With the selector switch in "Remote" mode, speed of the motor shall be controlled either from VFD panel or from Owner's PLC/DCS as explained in a) and b) above.
- 5.2.8 The required provision for the interface with PLC/DCS (located at remote control room) including the details of communication module and data transfer facility, I/O details shall be furnished. The communication interface shall be via serial communication link with industry standard open protocol i.e. MODBUS/IEC-61850/ RS-485 etc. and same shall be coordinated with the interfacing equipment. In case the vendor is using their proprietary software, the interface software for use with owner's system (software) shall be provided.
- 5.2.9 Drive system shall have provision for interface with upper level automation such as Substation monitoring system or electrical control system in case specified in the data sheet/job specification.
- 5.2.10 The closed loop control feed back for the drive system having output transformer shall be tapped from the secondary side of the output transformer.
- 5.3 Panel Construction**
- 5.3.1 The panel shall include suitable isolating device (i.e. Circuit breaker/MCCB/ Switch fuse) for main supply, contactors, semi conducting power devices (Diodes / IGBT) modules with



<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVES</b></div>	PC288-TS-0820B	0	<div><div>श्री एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 7 of 15		

protective devices, reactors, filters, output isolating device, control circuit, control accessories, indication and annunciation etc.

- 5.3.2 Main isolating device shall function as a manual disconnect and shall be an AC thermal magnetic circuit breaker or a fused switch with dual element fuse to trip automatically on fault currents, as specified in data sheet. Devices shall be lockable in the open position and shall have a minimum interrupting capacity as specified in data sheet. Interlock shall be provided between the door, so that door cannot be opened unless the breaker/switch is open.
- 5.3.3 Safety Interlock shall be provided so that power cabinet can't be opened unless the upstream breaker is disconnected, safety-grounding switch is closed and DC link capacitor is discharged. Power source breaker can only be closed once the earthing switch is open and panel door is closed with lock defeat facility.
- 5.3.4 The drive shall be suitably housed in sheet steel panels and shall be fabricated using cold rolled sheet steel. The sheet steel used for the panel shall be of minimum 2 mm CRCA except the doors & covers that may be made of 2mm CRCA. The panel shall be suitable for indoor installation, if not otherwise specified. The panel shall be free standing with degree of enclosure protection as IP-31. Maximum and minimum operating height shall be 1900 mm and 300 mm respectively.
- 5.3.5 Bolted un-drilled gland plate shall be provided at bottom. Clamp type terminals shall be used for connection of all wires up to 10 mm<sup>2</sup> and terminal for higher sizes shall be bolted type suitable for cable lugs. Minimum space for power cable termination shall be 300mm clear.
- 5.3.6 Bus bars shall be of electrolytic copper/aluminium, sleeved, color coded separately for AC and DC system. All the live parts shall be sleeved / shrouded to ensure complete safety to personnel intending to carry out routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall be provided with suitable nameplate. All wires shall be ferruled and terminals shall be properly numbered, minimum 20% spare terminals shall be provided.
- 5.3.7 All the power and control switches shall preferably be mounted on the door and shall be operable externally. All the analogue instruments, wherever provided, shall be switch board type, back connected, 96x96mm size. Scale shall have red mark indicating maximum permissible operating rating.
- 5.3.8 Each panel shall be provided with illuminating lamp/II W CFL with switch and fuse. 5/15A, 240V power socket with switch and fuse shall be provided. Each panel shall have space heater with switch fuse and variable setting thermostat.
- 5.3.9 Copper earth bus of min. 30X6 mm size shall be provided at the bottom of the panel extending outside the panel on both sides. All the non-metallic components/parts shall be connected to the main earth bus bar. In case a separate earth bus for electronic control system is required, the same shall be indicated in the drawings.
- 5.3.10 All panels shall be of same height so as to form a uniform line-up, to give good aesthetic appearance.
- 5.3.11 All the control wiring shall be enclosed in plastic/ metal channel. Each wire shall be identified at both ends by self-sticking wire marker tapes or PVC ferrules. Power and control wiring inside the panel shall be done with BIS approved, PVC insulated, fire retardant, low smoke, copper conductor wire 1.5mm<sup>2</sup> size wire shall normally be used provided the control fuse rating is 10 Amps or less and 2.5 mm<sup>2</sup> size for control fuse rating above 16 A for electrical circuits and 0.5mm<sup>2</sup> for electronic circuits. All wires shall be ferruled and terminals shall be properly numbered, minimum 20% spare terminals shall be provided.



<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVES</b></div>	PC288-TS-0820B	0	<div><div>श्री एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 8 of 15		

- 5.3.12 All electronic modules and components shall be accessible from front of panel only. Modular assemblies for both the system control electronic equipments and power electronic equipments shall be used.
- 5.3.13 DC link capacitor and pre-charging & discharging circuit shall be preferably mounted in the rear of the panel.
- 5.3.14 Suitable eyebolts/ lifting clamps/ strap & cradle arrangement shall be provided for lifting of the panel/shipping section. The bolts, when removed shall not leave any opening in the panel.
- 5.3.15 Acrylic type transparent insulating material shall be used for covering live components.
- 5.3.16 All equipment shall be complete with cable glands, lugs etc. and cable glands shall be single or double compression type for indoor and outdoor equipment respectively. Cable glands shall also be suitable for the hazardous area application if specified in data sheet.

## 5.4 Cooling

- 5.4.1 Cooling system shall include well-dimensioned panel, adequate cooling airflow path, module cooling fan and if necessary, panel cooling fan. Vendor shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. For fan cooled drives, redundant ventilating fans (N+1) shall be provided. Necessary starters shall be provided within the VFD panels for these fans. In case redundant cooling fan is not possible to be mounted, same shall be supplied loose.
- 5.4.2 MCB for motor space heater, auxiliary power supply if required for local panel, drive panel space heater etc. shall be included and mounted in easy accessible location.

## 5.5 Equipment/ Component Specification

### 5.5.1 Motor

The motor shall be designed, constructed and tested in accordance with the attached standard specification for Medium Voltage Induction Motor, in addition to the following requirements:

- The motor shall be suitable for operation with a solid-state power supply consisting of an adjustable frequency inverter for speed control.
- The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive.
- The motor shall be designed to operate continuously at any speed over the range (10-100%) of rated speed unless otherwise specified in data sheet.
- Motor shall be provided with thermistor type temperature detector
- The motors shall be provided with Class 'F' insulation with temperature rise limited to Class 'B'.
- The permitted voltage variation should take into account the steady state voltage drop across the AC drive and all other system components upstream of the motor.
- Motors required to be transferred to DOL by-pass mode shall be rated for specified variations in system line voltage and frequency. Starting current of motor in DOL bypass mode shall be limited to value specified in motor specifications, unless otherwise specified in datasheets.

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVES</b></div>	<div>PC288-TS-0820B</div>	<div>0</div>	<div><div>बी एच ई एल <b>BHEL</b></div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 9 of 15</div>		

- h. The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid-state power supply.
- i. The motor insulation shall be designed to accept the applied voltage waveform, within the  $V_{peak}$  and  $dv/dt$  limits as per IEC-61800-2.
- j. The drive manufacturer shall be solely responsible for proper selection of the motor for the given load application and the output characteristics of the drive.
- k. Motors shall be provided with Resistance Temperature Detectors (RTDs).
- l. Induced voltage at the shaft end of the motor at no load shall not exceed 250 mV rms for roller and ball bearings and 400 mV for sleeve bearings. The non driving end bearing shall be insulated from the motor frame to avoid circulating current. The insulated bearing end shield or pedestal shall bear a prominent warning.

### 5.5.2 Converter Transformer/ Output transformer

The converter transformer shall be suitable for use with the variable frequency drive system. The impedances of transformers with two secondary windings for 12 pulse systems shall be selected to ensure equal load/current sharing between the two secondary windings, the converters and the motor windings under all operational conditions including starting and restarting. The transformer shall be provided with  $\pm 5\%$  off circuit taps in steps of  $\pm 2.5\%$ .

### 5.5.3 Power Converter

- a. The static power converter shall consist of a line side power converter for operation as a rectifier and a load side power converter for operation as a fully controlled inverter. Power converter shall be fast switching, most efficient and low loss type.
  - a. Normally, for all output short circuits, the inverter shall interrupt the current before any semi-conductor fuse blows. For internal short circuits, semi-conductor fuse protection shall be provided, and for faults upstream of semi-conductor fuses, the converter shall be able to withstand a three-phase short circuit current until interrupted by normal breaker operation. In case of fuseless design, the failure shall be limited to the particular device, without causing any damage to other parts of the power module. There must be clear annunciation of the failure of the device.
  - b. All power converter devices shall include protective devices, snubber networks and  $dv/dt$  networks as required.
  - c. The current rating of the converter's semi-conductor components shall not be less than 120% of the nominal current flowing through the elements at full load of the VFD through the entire speed range.
  - d. All power diodes shall be of silicon type with minimum  $V_{BO}$  rating as 2.5 times the rated operating voltage.
  - e. The power converter circuit shall be designed so that motor can be powered at its full nameplate rating continuously without exceeding its rated temperature rise due to harmonic currents generated by the inverter operation.
  - f. The conversion devices and associated heat sinks shall be assembled such that individual devices can be replaced without requiring the use of any special precautions/tools.

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVES</b></div>	<div>PC288-TS-0820B</div>	<div>0</div>	<div><div>श्री एच ई एल <b>BHEL</b></div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 10 of 15</div>		

- g. The cooling system of the electronic components, if provided, shall be monitored and necessary alarms shall be provided to prevent any consequential damage to the power control devices.
- h. All the power transistors, thyristors and diodes shall be protected with high-speed semiconductor grade fuse. I2t particulars of the power controller devices and the fuses shall be properly co-ordinated for the selection of fuses.

#### 5.5.4 DC Link Reactor

- a. Smoothing reactors for the DC link shall be designed to sufficiently decouple the rectifier and inverter portion of the converter and to limit fault currents in this circuit. AC line reactors, if provided as per standard vendor design, shall be suitable for harmonic suppression and fault current limitation.
- b. The reactor shall be dry type, air cooled or fan cooled type located within the panel. In case of fan cooled type, operation of fans shall be monitored.
- c. Reactor shall be suitable for operation with the non-sinusoidal current wave shapes and DC components under all operational conditions of the system without exceeding its temperature limits.

#### 5.5.5 Output Filter

VFD output current waveform shall be inherently sinusoidal at all speeds, with harmonic limits as per C1.5.1.6. Output filter capacitors shall be provided with discharge circuits to ensure that all residual stored charge is reduced to less than 50 V DC within 60 seconds after a loss of AC voltage. The VFD system shall inherently protect motor from high voltage dv/dt stress, independent of cable length to motor. Output filter shall be an integral part of the VFD system and included within the VFD enclosure.

#### 5.5.6 Bypass Feature

- 5.5.6.1 Output contactor/Load Break Switch shall be provided for isolation between the output of the controller and the motor for VFD systems with Bypass feature.

- 5.5.6.2 Bypass feature shall be provided, if specified in the data sheet. Accordingly Bypass feature with Bypass starter shall meet the following requirements, unless otherwise specified in the data sheet:-

Bypass starter shall comprise of switch-fuse, contactor, bimetal relay meeting the requirements of Type-2 coordination as per IS/IEC-60947. CBCT and ELR shall be provided for motors rated above 22kW & upto 55kW unless otherwise specified in the data sheet. Heavy duty starters shall be provided with saturable type current transformer operated overload relay only, which shall be suitable for motor starting time of 15-60 seconds. For motors rated above 55kW, ACB/MCCB and motor protection relay along with necessary metering shall be provided.

Bypass starter shall be in separate compartment and it shall be possible to isolate and maintain the VFD while drive motor runs in Bypass mode. Three contactors/ breakers shall be used for this purpose, one contactor in the bypass and two contactors across the drive, such that in case of drive mal-operation, the motor could be taken on bypass control, while the drive could be attended by opening its contactors. Suitable interlock shall be provided such that bypass mode and VFD mode shall not operate simultaneously.

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVES</b></div>	PC288-TS-0820B	0	<div><div>श्री एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 11 of 15		

### 5.5.7 Local Motor Control Station

- a. The local motor control station, to be installed in the field near the motor shall conform to the attached specifications. Components and accessories that are required in the local motor control station may be mounted on the local field mounted panel envisaged for the driven equipment.
- b. Meters in the local control station for motors rated above 5.5kW shall be suitable for 4-20mA transducer outputs and shall be calibrated for the actual motor current unless specified otherwise. Further, for drives with bypass facility, the meters shall be capable of reading bypass full load and starting currents, as well as the drive current. Local-off-Remote selector switch shall be provided in the LCS for selection of control from Local (i.e. LCS in Field) and Remote (i.e. from VFD panel / DCS / PLC).

### 5.6 Protection, Control, Metering, Indication and Annunciation

- 5.6.1 The system vendor shall provide all the necessary system control, protection, alarm and metering equipment for the entire drive system and its auxiliary equipment.
- 5.6.2 Automatic sequence control shall include start-up of cooling system, auxiliary system of the motor, interlock checking, automatic start and run-up of drive, planned and emergency shutdown. The same shall be processed through microprocessor-based system.

### 5.6.3 Operator Control Panel

- a. Each drive shall be equipped with a front mounted operator control console consisting of a backlit alphanumeric display and a keypad with keys for parameterization and adjusting parameter which shall not be limited to Start/Stop, Local/Remote, Auto/Manual, Increase/Decrease, menu navigation and protection and measurement parameter selection, etc.
- b. All parameter names, fault messages, warnings and other information shall be displayed in complete English words or standard English abbreviations to allow the user to understand the display without the use of a manual or cross-reference table. This shall also be used for the modification of all electrical values, configuration parameters, drive menu parameters, application and activity function access, faults, local control, adjustment storage, self test and diagnostics. Keypad shall be operable with password for changing the protection setting, safety interlock etc. However, the parameters such as measurements, setting, mode of drive etc. shall be allowed to be viewed without any password.
- c. Operator console shall have facility/ port to connect external hardware such as Laptop etc. Console shall have facility to upload and download all parameter settings from one drive to another identical drive for start-up and operation.
- d. Drive system control shall also have facility to receive tripping signal from upstream breaker for tripping and also provision for closing upstream breaker after all required process parameters are achieved.

- 5.6.4 User-friendly software for operation and fault diagnostic shall be loaded in the drive system panel before commissioning.

### 5.6.5 Protective Features

The system shall incorporate adequate protective features, properly coordinated for the drive control and for the motor but not limited to the following:

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVES</b></div>	<div>PC288-TS-0820B</div>	<div>0</div>	<div><div>बी एच ई एल <b>BHEL</b></div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 12 of 15</div>		

- I. Incoming line surge protection
- II. Under / Over voltage protection
- III. Phase loss protection.
- IV. Programmable over current protection and under load protection.
- V. Inverter Fault.
- VI. Over frequency/Over speed of motor
- VII. Ventilation loss (In case same is not provided, drive shall generate an over temperature fault alarm and suitable sensors, as required for same, shall be provided).
- VIII. Over temperature of equipment.
- IX. Specific motor protection, including motor winding, bearing temperatures, over current, overload, negative phase sequence and earth fault protections etc.
- X. System earth fault protection.
- XI. Excitation system protection for synchronous motor
- XII. Over and under frequency, rotor earth fault (if applicable), field failure protection for synchronous motor
- XIII. Additional protection, if any for the drive system

#### 5.6.6 Alarms

The system shall incorporate protection alarms, required for various fault conditions, for the Drive motor, Supply cables, Converter Transformer, DC Reactor and the Converter. Alarms shall also be included for the failure of various auxiliaries together with identification of the failing unit, loss of cooling system, various protection devices provided for converter transformer etc.

#### 5.6.7 Control

The following controls shall be provided as a part of the Operator Control Panel or through separate switches.

- I. Start/Stop
- II. Speed control (Raise/Lower)
- III. Forward/Reverse (if specified)
- IV. Auto/Manual /Test mode
- V. Local/Remote
- VI. Emergency stop
- VII. Start/Stop for bypass starter (where specified)
- VIII. Trip-Remote Breaker
- IX. Excitation control system for synchronous motors
- X. Sequential switching of filters

#### 5.6.8 Indications

Vendor shall provide indications as required for normal operation and for ease of maintenance, which shall not be limited to the following indications. Motor running

- I. Motor stopped
- II. VFD System Fault
- III. System ready to start
- IV. AC mains ON
- V. Motor over speed
- VI. Rectifier output 'ON'
- VII. Motor zero speed

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVES</b></div>	<div>PC288-TS-0820B</div>	<div>0</div>	<div><div>श्री एच ई एल <b>BHEL</b></div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 13 of 15</div>		

- VIII. Remote breaker trip
- IX. Excitation system healthy for synchronous motors

Above indications may be provided as a part of the operator control panel, i.e. door mounted keypad or through hardwired LEDs. LEDs provided for indication shall be cluster type with adequate brightness and minimum 2 Nos LEDs chips per light. LEDs shall be connected in parallel and each LED chip having diameter not less than 3mm. Potential free contacts for items i to iv shall be wired separately for remote indications in DCS system.

### 5.6.9 Metering

Digital display of the following parameters shall be as a part of the Operator Control Panel, selectable by the operator.

- I. Output voltage
- II. Output current-VFD model Bypass mode
- III. Output frequency
- IV. Drive thermal state
- V. Motor speed
- VI. Motor energy meter
- VII. Hour Run
- VIII. Voltage and current meter for excitation system of synchronous motor
- IX. KVAR, power factor meter for synchronous motors
- X. Necessary transducer shall be provided with 4-20mA output for indicating motor speed and motor current in DCS unless otherwise specified for other parameters.
- XI.

### 5.6.10 Annunciations

Potential free contacts shall be provided for following annunciations and shall be wired up to terminal block for owner's use for remote monitoring:

- I. Rectifier fuse failure/Drive fault
- II. Main AC failure
- III. Inverter fuse failure/Drive fault
- IV. Inverter overload
- V. Inverter high temperature/Drive fault
- VI. Failure of panel cooling system
- VII. Motor failed to start/Drive fault

All drive internal faults will be annunciated as drive fault.

### 5.7 Fault Diagnostic

Fault diagnostic shall be built into the system to supervise the operation and failure of the system. The information regarding failure of any of the system including, shutdown of the system, shall be available for a period of minimum 4 days (96 hours) after a shutdown, even though no supply would be available to the system. The system may be totally de-energized for maintenance or otherwise. It shall be possible to retrieve the record of events prior to tripping of the system or de-energisation. Auxiliary supply to the system components or to the electronics (firmware) for the diagnostics / display shall be taken care by the manufacturer for this purpose.

### 5.8 External Power supply for auxiliary and Control Circuit



<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVES</b></div>	<div>PC288-TS-0820B</div>	<div>0</div>	<div><div>श्री एच ई एल <b>BHEL</b></div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 14 of 15</div>		

Control supply for devices external to VFD module i.e contactors control, space heater supply for Motor / VFD, indicating lamps digital meters (Ammeter, Speedometer) etc. shall operate on 240 V control supply derived from single-phase control supply transformer, with switchfuse provided in primary and MCB in secondary, located inside the drive controller.

## 5.9 Reliability Features

The expected life time of the VFD shall be minimum 20 years. The VFD including all individual components forming part of the system shall have an availability of minimum 0.997 and a minimum MTBF of 4 years.

The controller design shall incorporate the following reliability features:

- Pre-tested components with power components to be 100% tested under dynamic conditions.
- Printed circuit boards shall be computer tested and adjusted.
- Printed circuit boards shall be temperature cycled for a minimum of 40 hours.
- Printed circuit boards shall be treated for tropical, humid and corrosive environment.

## 5.10 Maintenance features

The controller design shall incorporate the following maintenance features:

Modular construction

Printed circuit boards shall be plug connected.

All components shall be easily accessible.

Standard diagnostics to aid maintenance personnel. These shall include LED or alphanumeric displays, test or measurement points.

## 5.11 Painting

- 5.11.1 After preparation of the under surface, the panel shall be spray painted with two coats of epoxy based final paint or shall be powder coated. The color shade of final paint shall be as RAL 7032, unless specified otherwise. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.
- 5.11.2 All metal surfaces shall be thoroughly cleaned and de-greased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under-surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under-surface shall be made free from all imperfections before undertaking the finishing coat.
- 5.11.3 All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

## 6.0 INSPECTION, TESTING AND ACCEPTANCE

- 6.1 All tests shall be carried out at the manufacturer's works under his care and expense. The tests shall be witnessed by an inspector of PDIL/ Owner or of an agency authorized by the owner. Prior notice of minimum 4 weeks shall be given to the inspector for witnessing the tests.
- 6.2 During fabrication, the drive shall be subject to inspection by PDIL / Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVES</b>	<b>PC288-TS-0820B</b>	<b>0</b>	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 15 of 15		

**6.3** All Routine & Type Tests shall be conducted as per the NIT for MV variable frequency drive as per IEC 61800-2. Moreover, combined test for VFD and motor at vendor's works shall be carried out.

**6.4** String Test with driven equipment

If a string test with driven equipment is specified in the data sheet of the driven equipment, it shall be carried out with the job equipment.

## **7.0 SPARES**

**7.1** Commissioning Spares: Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval.

**7.2** Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.

**7.3** Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.

**7.4** All spare parts shall be identical to the parts used in the equipment.

## **8.0 DRAWINGS**

Vendor shall submit to Purchaser, for approval, before completion of manufacturing and assembly of equipment following drawings and literature.

- (i) Installation and maintenance manual including trouble-shooting chart.
- (ii) Panel drawings and cable schedule
- (iii) Block diagram and control logic.

## **9.0 CERTIFICATION**


The motors and associated Variable frequency drive system equipment shall have test certificates issued by recognized independent test house (CIMFRI BASEEFA/ LCIE/UL/FM or equivalent). All indigenous motors shall conform to Indian Standards and shall be certified by Indian testing agencies. All motors (indigenous and imported) shall also have valid statutory approvals as applicable for the specified hazardous location. All indigenous flameproof motors shall have valid BIS license and marking as required by statutory authorities.

Also the motor nameplate shall clearly indicate that the motor is suitable for operation with variable frequency drive along with VFD make and model number.

## **10.0 PACKING AND DESPATCH**

All the equipment shall be divided in to several shipping sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation i.e. ship/rail or trailer. The equipment shall be wrapped in polyethylene sheets before being placed in wooden crates/cases to prevent damage to the finish. Crates/cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Weight', 'Owner's particulars', 'PO nos. etc., shall be clearly marked on the package together with other details as per purchaser for scrutiny. The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage, in areas with heavy rains/high ambient temperature.




<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - COMMUNICATION AND FIRE ALARM CABLES (PC288-TS-0821)</div>	PC288-TS-0821	0	<div></div>
		Document No.	Rev	
		Sheet 1 of 10		

## TECHNICAL SPECIFICATION COMMUNICATION AND FIRE ALARM CABLES

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - COMMUNICATION AND FIRE ALARM CABLES (PC288-TS-0821)</b>	PC288-TS-0821	0	 
		Document No.	Rev	
		Sheet 2 of 10		

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	SITE CONDITIONS
4.0	TECHNICAL REQUIREMENTS -NON JELLY FILLED CABLES
5.0	TECHNICAL REQUIREMENTS FOR JELLY FILLED CABLES
6.0	INSPECTION, TESTING AND ACCEPTANCE
7.0	PACKING AND DESPATCH

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - COMMUNICATION AND FIRE ALARM CABLES (PC288-TS-0821)</b></div>	PC288-TS-0821	0	<div> भारतीय वैद्युत महामंडल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 3 of 10		

## 1.0 SCOPE

The intent of this specification is to define the requirements for design, manufacture and supply of Flame Retardant type PVC sheathed cables for use in plant communication and fire alarm systems and Jelly filled telecommunication cables.

## 2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of the latest revision of the following standards issued by BIS and DOT, unless otherwise specified:

### 2.1.1 BIS standards:

IS-694	PVC insulated cables for working voltages upto and including 1100V.
IS-1554 (Part-I)	PVC insulated (heavy duty) electric cables-(Part-I for working voltages up to and including 1100V).
IS-5831	PVC insulation and sheath of electric cable.
IS-8130	Conductors for insulated cables and flexible cords.
IS-9938	Recommended Colours for PVC insulation for LF wires and cables.
IS-10418	Drums for electric cables.
IS-10462 (Part-1)	Fictitious calculation method for determination of dimensions of protective coverings of cables:(Part-I Elastomeric and thermoplastic insulated cables).
IS-10810 (Part-58)	Methods of test for cables (Part 58. Oxygen Index test).
IS-10810 (Part- 61)	Methods of test for cables (Part 61. Flame retardant test)
IS-10810 (Part-62)	Methods of test for cables (Part 62. Fire resistance test for bunched cables).
IS-12444	Continuously cast and rolled electrolytic copper wire rods for electrical conductors.

### 2.2 DOT Standards:

GRJWIR-06/03	Specification for cable - switchboard (Screened and Unscreened) Generic Requirements.
G/CUG-O1/02	Specification for solid polythene insulated fully filled, Polythene sheathed underground telecom cables.

2.3 In case of imported cables, standards of the country of origin shall be applicable, if these standards are equivalent to or stringent than the applicable Indian standards.

2.4 The cables shall also conform to the provisions of the Indian Electricity rules and other statutory regulations currently in force in the country.

2.5 In case Indian standards are not available for any material, standards issued by IEC / BS / VDE / IEEE / NEMA or equivalent agency shall be applicable.

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - COMMUNICATION AND FIRE ALARM CABLES (PC288-TS-0821)</b></div>	PC288-TS-0821	0	<div></div>
		Document No.	Rev	
		Sheet 4 of 10		

2.6 In case of any contradiction between various referred standards/ specifications/ datasheets and statutory regulations the following order of priority shall govern:

- Statutory regulations.
- This specification.
- Codes and standards.

### 3.0 SITE CONDITIONS

Cables shall be suitable for installation in following conditions:

- i. Above ground in open-air locations (trays / ducts) in tropical, humid and corrosive atmosphere prevalent in refineries/petrochemical plants with severe weathering and exposure to solar radiation.
- ii. Directly buried in underground trenches, conduits with uncontrolled back-fill and possibility of flooding by water and chemicals.
- iii. Unless otherwise specified, the design ambient air temperature of 45° C / ground temperature of 30° C.
- iv. Cables shall be operating near electromagnetic radiations due to high voltage installation and other wireless equipments. Adequate screening shall be provided to make build the electromagnetic immunity.

### 4.0 TECHNICAL REQUIREMENTS -NON JELLY FILLED CABLES

#### 4.1 Conductors

4.1.1 The size of conductor shall be as per job requirement.

4.1.2 The conductors shall consist of annealed, high conductivity solid copper wire, smoothly drawn, circular in cross-section, uniform in quality, free from defects and uniformly coated with pure tin and shall conform to Cl. 3.0 of DOT specification GR/WIR-06/03. For telecommunication cables conductor shall be 0.5 mm and for PA system conductot dia shall be 0.6 mm as minimum. For fire larm cables size of conductor shall be chosen based on sum of the current drain of all field points in that circuit.

#### 4.2 Insulation

4.2.1 The core insulation shall be with PVC compound applied over the conductor by extrusion.

4.2.2 PVC insulation, when used shall meet the following requirements:

Conductor Diameter (Area)	Type of Insulation	Thickness of Insulation
Upto 0.63 mm (0.3mm <sup>2</sup> )	Type-2 of Table-3 as per IS-13176	As per Table-I of DOT Specs. GR/WIR-09/02
Above 0.63mm (Above 3.0 MM <sup>2</sup> )	Type-A as per IS-5831	Table-2 as per IS-1554 (Part-I)

4.2.3 The colours used for insulation shall conform as nearly as practicable to the standard colours as per 18-9938. The wire insulation shall have colours in accordance with Table-2 of DOT specification GR/WIR-06/03. The applied colour shall neither have deleterious

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - COMMUNICATION AND FIRE ALARM CABLES (PC288-TS-0821)</b></div>	PC288-TS-0821	0	<div></div>
		Document No.	Rev	
		Sheet 5 of 10		

effect on the electrical, mechanical or ageing properties of basic insulation nor shall get damaged by any friction etc.

- 4.2.4 For single pair cables, the colour shall be incorporated in the insulation.
- 4.2.5 For multi pair cables, cores shall have uniform pattern of continuous spiral (Pitch not exceeding 25mm) to facilitate easy identification. This may be done by the application of one or more coloured strips on a base colour or by direct extrusion.
- 4.2.6 Alternately, colouring may consist of concentric coloured rings or dots or dashes on the base colour. The coloured rings, dots or dashes shall have a width of not less than 1.0mm and shall be repeated along the length of the insulation at an interval not less than 15mm and not more than 25mm.
- 4.2.7 The dots or dashes shall be applied on diametrically opposite sides of the insulation, so that all colours are visible when the insulation is viewed from any side.
- 4.3 **Twisting**
- The two insulated conductors of a pair shall be uniformly twisted with a suitable right hand lay, which shall not exceed 80mm.
- 4.4 **Core Formation**
- The core formation shall conform to C1.6.0 of DOT specification no. GR/WIR-06/03.
- 4.5 **Screen**
- 4.5.1 Unless otherwise specified the cables used for fire alarm and detection shall be provided with overall screen. The screen shall be of aluminium tape with minimum thickness of 0.04mm. The overlap shall be minimum 3mm for cables up to 50 pair & minimum 6mm for cables above 50 Pair. The screen shall be backed by an outer protective layer of 0.13mm PVC tape or other non hygroscopic material lapped applied longitudinally or helically with overlap.
- 4.5.2 The cables shall be provided with a drain wire. Drain wire shall have a minimum cross-section of 0.5mm<sup>2</sup>, shall be composed of multistrand bare tinned annealed copper conductor. The drain wire shall be in continuous contact with the aluminium side of the overall screen. The drain wire resistance including screen shall not exceed 30 ohm/km.
- 4.6 **Ripcord**
- A non-metallic ripcord of suitable quality shall be laid longitudinally under the inner sheath & screen. The ripcord when pulled shall cut through the sheath and strip the core.
- 4.7 **Inner Sheath**
- 4.7.1 An extruded inner sheath of type ST1 PVC, as per IS-5831, with minimum thickness as per Table-4 of IS-1554 (Part-1) shall be applied over the laid up core, by extrusion to fit closely on it.
- 4.7.2 The inner sheath shall be as circular as possible. It shall be possible to remove the inner sheath without damage to the insulation.
- 4.7.3 When one or more layers of non-hygroscopic tape is helically applied over the laid up cores, as a binder, the thickness of such tape(s) shall not be construed as a part of the inner sheath.

<div><div>पी डी आई एल</div><div>PDIL</div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - COMMUNICATION AND FIRE ALARM CABLES (PC288-TS-0821)</b></div>	PC288-TS-0821	0	<div></div>
		Document No.	Rev	
		Sheet 6 of 10		

#### 4.8 **Armour**

- 4.8.1 The cables shall be provided with armouring, made of hot dip galvanised steel wire /strip over the inner sheath.
- 4.8.2 The armour shall be by means of 104mm thick round wires for cables with under armour diameter upto 13mm. For cables with an under armour diameter above 13mm, the armour shall either be of steel strip or round wire with thickness as per IS-1554 (Part-1).

#### 4.9 **Outer Sheath**

- 4.9.1 The cables shall be provided with an extruded PVC sheath for external protection. The PVC shall be type ST1 PVC, as per IS-5831.
- 4.9.2 The other sheath shall be with oxygen index 29 at 27±2°C and possess flame retardant properties meeting the requirements of IS 10810 Part-62 category - AF. In addition, suitable chemicals shall be added to the PVC compound of the outer sheath to protect the cable against rodent and termite attack.
- 4.9.3 The thickness of outer sheath shall be as per IS-1554 (Part 1).
- 4.9.4 The outer sheath shall fit tightly on the armour and shall be applied in such a manner that no undue residual strain is left in the material.
- 4.9.5 The outer sheath shall be grey in colour except for cables to be used for fire alarm system where it shall be red.
- 4.9.6 Sequential marking of the length of the cable, in meters, shall be provided on the outer sheath at every one meter. The marking shall be legible and indelible by suitable method.
- 4.9.7 The overall diameter of the cables shall be strictly as per the values declared in the technical information furnished along with the bids, subject to a maximum tolerance of ±2 mm.
- 4.10 **Cable Capacitance**
- 4.10.1 The core to core capacitance of the cables shall not exceed 100nF/Km at 1KHz.
- 4.10.2 The core to screen capacitance for the screened cables shall not exceed 250nF/Km at 1KHz.

### 5.0 **TECHNICAL REQUIREMENTS FOR JELLY FILLED CABLES**

- 5.1 Jelly filled telecom cables shall in general conform to the requirements of DOT specification G/CUG-01/02, unless otherwise specified in this specification.

#### 5.2 **Conductors**

- 5.2.1 The conductors shall consist of annealed, high conductivity solid copper wire, smoothly drawn, circular in cross-section, uniform in quality, free from defects and uniformly coated with pure tin and shall conform to cl. 3.0 of DOT specification G/CUG-01/02.

#### 5.3 **Insulation**

- 5.3.1 Each conductor shall be insulated with insulating grade PE conforming to C1.4.0 of DOT specification G/CUG-01/02.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - COMMUNICATION AND FIRE ALARM CABLES (PC288-TS-0821)</b>	PC288-TS-0821	0	
		Document No.	Rev	
		Sheet 7 of 10		

#### 5.4 Twisting

The two insulated conductors of a pair shall be uniformly twisted with a suitable right hand lay, which shall not exceed 150mm.

#### 5.5 Core Formation

The core formation shall conform to C1.6.0 of DOT specification G/CUG-01/02.

#### 5.6 Filling Compound

5.6.1 The cable shall be filled with a suitable stable water resistant compound, which shall be compatible with the insulation, binders and tapes used in the cable.

5.6.2 It shall be homogeneous and uniformly mixed material containing an anti-oxidant.

5.6.3 The compound shall not obscure the identification of the colour of the insulation of the conductors.

5.6.4 It shall not contain dirt, metallic particles or other foreign matter.

5.6.5 The compound shall be readily removable from the insulated conductors by wiping.

5.6.6 It shall be free from any unpleasant odour and shall have no toxic or dermatic hazards.

5.6.7 The flash point of the compound shall not be less than 200°C.

5.6.8 The volume Resistivity measured at 100°C shall not be less than 1010 ohm-ern.

5.6.9 The permittivity at 1 MHz tested as per ASTM 0-924 shall not be greater than 2.3 at 20°C.

#### 5.7 Core Wrapping

At least one closed helical or longitudinal application of a non-hygroscopic and non-wicking polyester tape or tape of any other suitable material shall be provided over the cable core.

#### 5.8 Screen

5.8.1 The cables shall be provided with overall screen. The screen shall be of aluminium tape with minimum thickness of 0.2mm. The overlap shall be minimum 3mm for cables having maximum diameter over inner sheath < 30mm & minimum 6mm for cables having maximum diameter over inner sheath ~ 30mm. The screen shall be coated with 0.05 mm nominal thickness polythene/copolymer on both sides. The thickness of the composite tape shall be 0.3mm±15%.

5.8.2 The aluminium tape shall be electrically continuous throughout the length of the cable.

#### 5.9 Inner Sheath

5.9.1 The inner sheath shall be as circular as possible and free from pinholes and other defects. It shall be possible to remove the inner sheath without damage to the insulation.

5.9.2 The inner sheath shall be of polythene conforming to type 03C or H03C of BS 6234 and shall contain a suitable antioxidant system. The material shall be virgin as per ASTM 0-883 and meet the following requirements.

Density                      0.910 to 0.940 glee for 03C and > 0.940 glee for H03C

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - COMMUNICATION AND FIRE ALARM CABLES (PC288-TS-0821)</b></div>	PC288-TS-0821	0	<div><div>भारतीय वैद्युत निगम <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 8 of 10		

Melt Flow index Maximum 1.0 g/10 minutes (190 °e, 2160 g load)

5.9.3 The thickness of inner sheath shall conform to Table - 6 of DOT specification no. G/CUG01/02.

5.9.4 The maximum diameter over inner sheath shall conform to Table - 7 of DOT specification no. G/CUG-O 1/02.

#### 5.10 **Armour**

5.10.1 The cables shall be provided with bedding and armour over the inner sheath.

5.10.2 The bedding shall consist of two close helical lappings of polythene or polypropylene tape. Each tape shall be applied with a minimum of 5% overlap.

5.10.3 The armour shall be made of hot dip galvanised steel tape of thickness as per Table - 8 of DOT specification G/CUG-01/02.

#### 5.11 **Outer Sheath**

5.11.1 The external protection shall consist of a polythene sheath conforming to the material specification defined in Clause 5.9 above.

5.11.2 The thickness of outer sheath shall conform to Table - 9 of DOT specification G/CUG-01/02.

5.11.3 The outer sheath shall be as circular as possible and free from pinholes and other defects. It shall be possible to remove the inner sheath without damage to the insulation.

5.11.4 The outer sheath shall be grey in colour except for cables to be used for fire alarm system where it shall be red.

5.11.5 The maximum diameter over outer sheath shall conform to Table - 7 of DOT specification G/CUG-01/02.

#### 5.12 **Cable Capacitance**

The average mutual capacitance of the pairs measured at 800 to 1000Hz shall be  $52 \pm 3$  nF/km.

However, the mutual capacitance of individual pairs shall be within the limits of  $52 \pm 4.5$  nF/km.

### 6.0 **INSPECTION, TESTING AND ACCEPTANCE**

6.1 The cables shall be tested and examined at the manufacturer's works. All the materials employed in the manufacture of the cable shall be subjected to examination, testing and approval by PDIL/Owner. Manufacturer shall furnish all necessary information concerning the supply to PDIL/Owner's inspectors. The inspector shall have free access to the manufacturer's works for the purpose of inspecting the process of manufacture in all its stages and he will have the power to reject any material, which appears to be of unsuitable description or of unsatisfactory quality.

6.2 The following acceptance tests shall be conducted on the completed jelly filled cables as per the test procedures given in DOT specification G/CUG-01/02 and this specification:

- Measurement of diameter of conductor, over inner sheath & over outer sheath.
- Measurement of Thickness of insulation, inner sheath, screen, armour & outer sheath.




 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - COMMUNICATION AND FIRE ALARM CABLES (PC288-TS-0821)</b>	PC288-TS-0821	0	
		Document No.	Rev	
		Sheet 9 of 10		

- iii. Measurement of Resistance of conductor.
- iv. Measurement of Resistance unbalance.
- v. Continuity Check & Measurement of Resistance of Poly-al tape.
- vi. Colour coding.
- vii. Conductor continuity test.
- viii. Mutual Capacitance test.
- ix. Capacitance Unbalance test.
- x. Cross talk test.
- xi. Attenuation test.
- xii. Insulation resistance test.
- xiii. Dielectric strength test.
- xiv. Drip test.
- xv. Armour Galvanisation Test.
- xvi. Conductor Annealing Test.
- xvii. Measurement of drum length.

6.3 The following tests shall be conducted on the completed non jelly filled cables as per the test procedures given in DOT specification GR/WIR-06/03 and this specification:

6.3.1 **Acceptance tests:**

- i. Measurement of diameter of conductor, over inner sheath & over outer sheath.
- ii. Measurement of Thickness of insulation, inner sheath, screen, armour & outer sheath.
- iii. Measurement of Resistance of conductor.
- iv. Colour coding.
- v. Conductor continuity test.
- vi. Mutual Capacitance test.
- vii. Capacitance Unbalance test.
- viii. Insulation resistance test.
- ix. High Voltage test.
- x. Armour Galvanisation Test.
- xi. Conductor Annealing Test.
- xii. Measurement of drum length.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - COMMUNICATION AND FIRE ALARM CABLES (PC288-TS-0821)</b>	PC288-TS-0821	0	
		Document No.	Rev	
		Sheet 10 of 10		

### 6.3.2 Special Tests

The non jelly filled cables shall also be subjected to following special tests.

- i. Oxygen Index test as per IS-I 0810 (Part 58).
- ii. Flammability test on finished cable as per IS-I0810 (part 61 & 62).

The special test shall be conducted on one sample from each lot. The sample will be selected by the inspector.

## 7.0 PACKING AND DESPATCH

- 7.1 Cables shall be despatched in non-returnable wooden drums of suitable barrel diameter, securely battened, with the take-off end fully protected against mechanical damage. The wood used for construction of the drum shall be properly seasoned, sound and free from defects. Wood preservatives shall be applied to the entire drum. Ferrous parts used shall be treated with a suitable rust preventive finish or coating to avoid rusting during transit and storage.
- 7.2 On the flange of the drum, necessary information such as project title, manufacturer's name, type, size, length of cable in meters, drum no., cable code, BIS certification mark, gross weight, 'Owner's particulars', 'P.O. numbers' etc., shall be printed. An arrow shall be printed on the drum with suitable instructions to show the direction of rotation of the drum.
- 7.3 Cables shall be supplied in drum lengths of 1000 meters, if not specified otherwise.
- 7.4 For non jelly filled cable, PVC / rubber end caps shall be supplied free of cost for each drum with a minimum of eight per thousand meter length. In addition, ends of the cables shall be properly sealed, with caps, to avoid ingress of moisture/water during transit and storage.
- 7.5 For jelly filled telephone cables, the ends of the cable shall be sealed by thermo shrinkable end caps of adequate wall thickness. Alternately ends may be sealed by enclosing them in rubber or PVC caps of wall thickness not less than 1.8mm. The caps shall be secured to the outer sheath with hose clips or ties or black adhesive tape or heat shrinkable sleeves.
- 7.6 The cables may be stored outdoors for long periods before installation. The packing shall be suitable for outdoor storage in areas with heavy rains / high ambient temperature, unless otherwise agreed.

<div> पी डी आई एल <b>PDIL</b></div>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - CAPACITOR BANK AND ASSOCIATED EQUIPMENT</b>	<b>PC288-TS-0822</b>	0	<div> कोयला Coal India</div> <div> बी एच ई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 1 of 12		

# **TECHNICAL SPECIFICATION** **CAPACITOR BANK & ASSOCIATED EQUIPMENT**

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - CAPACITOR BANK AND ASSOCIATED EQUIPMENT</div>	PC288-TS-0822	0	<div> कोयला इण्डिया</div> <div> बीएचएल</div>
		Document No.	Rev	
		Sheet 2 of 12		

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	GENERAL DESIGN FEATURES
6.0	PROTECTIVE SCHEME (PROVIDED BY PURCHASER)
7.0	ACCESSORIES
8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	DRAWINGS AND DOCUMENTS
11.0	SPARES
12.0	PACKING
13.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR CAPACITOR BANK & ASSOCIATED EQUIPMENT

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - CAPACITOR BANK AND ASSOCIATED EQUIPMENT</b>	<b>PC288-TS-0822</b>	<b>0</b>	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 3 of 12		

## 1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in packed condition of “ Indoor type Shunt Capacitor Bank & Associated Equipment” required for system power factor improvement.
- 1.2 This standard shall be read in conjunction with relevant part of Design Philosophy - Electrical.
- 1.3 The capacitor bank and associated equipment shall generally consist of the following.
- Basic Star connected capacitor bank
  - Basic capacitor unit with built in fuse
  - Discharge resistor
  - Series reactor
  - Residual V. T. for mounting voltage unbalance
  - Set of Raychem make heat insulated sleeved of suitable voltage rating for bus bars.
  - Copper bus bar interconnecting the basic units.
  - Set of supporting insulators
  - Hot dip galvanised Steel stand/racks / cabinets of mounting capacitor units complete with interconnection insulator etc.
  - Door limit switch
  - Control panel for automatic operation
  - Any other equipment not specified, but required for safe & proper operation of the system.

## 2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture & testing of the equipment covered by this specification shall comply with the latest issues of following Indian standards, unless otherwise specified.

IS: 13925-1,2,3	/IEC	Shunt Capacitor for power system
60871		
IS:5553/IEC60289	/	Series reactors
IEC60076-6/IEC 726		
IEC60186		Voltage Transformers
IEC:593/IS 12672		Internal Fuse for shunt capacitor
IS/IEC:60947		Switch gear and control-gear for voltage up to & including 1000V & 1200V DC
IS/IEC:60947		General requirements for switchgear and control-gear for voltage not exceeding 1000V & 1200V DC
IS :9921		AC Isolator & Earthing switches for voltage above 1000V
IS 2099/ IEC 60137		Bushing for voltage above 1000V
IS 13067		Impregnant For power capacitors
IS 5		Colour of mixed paints
IS 2629		Recommended practice for Hot-Dip Galvanizing of Iron and Steel
IS 4759		Hot-dip zinc coatings on structural steels and other allied products.
IS 60270		High Voltage test technique-Partial Discharge measurements
IS 8084		Interconnecting Bus bars for AC voltage above 1 kV up to and including 36 kV.

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - CAPACITOR BANK AND ASSOCIATED EQUIPMENT</div>	PC288-TS-0822	0	<div> श्री एच ई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 4 of 12		

IEEE 1036	Guide for application of shunt power capacitors
IEEE 18	Standard for shunt power capacitors
IE Act	Indian Electricity Act

2.2 The design & operation features of equipment shall also comply with provision of the latest issue of the Indian Electricity Rules & other relevant statutory acts & regulation. The supplier shall, wherever, necessary, make suitable modification in the equipment to comply with the above.

2.3 Wherever, any requirement laid down in this standard differs, from that in Indian standard specification, the requirement specified herein shall prevail. Equipment complying with equivalent IEC standards shall also be acceptable.

### 3.0 SERVICE CODITIONS

#### 3.1 Ambient Conditions

These shall be as indicated in Design Philosophy - Electrical.

#### 3.2 System Details

These shall be as indicated in Design Philosophy - Electrical.

### 4.0 OPERATING REQUIRMENTS

4.1 The capacitor bank and associated equipment shall be suitable for operating at the specified rating continuously with the specified voltage and frequency variation under the ambient condition without exceeding the permissible temperature rise and without any detrimental effect on any part of equipment.

4.2 The capacitor bank and associated equipment shall be suitable for parallel switching and withstand the thermal and dynamic stresses caused by transient during switching operations.

### 5.0 GENERAL DESIGN FEATURES

#### 5.1 Capacitor Unit

5.1.1 The capacitor bank / sub bank shall comprise of appropriate number of basic single phase units & which shall be connected in star formation to obtain rated KVAR at rated voltage.

5.1.2 Each unit shall have required number of capacitor elements housed in hermetically sealed, leak proof, sheet steel container. The container shall be provided with suitable brackets, supporting insulators, terminal & bushing for external connections.

5.1.3 Each element of basic units has its own built in fuse which shall isolate the faulty element automatically without affecting the healthy elements.

5.1.4 The capacitor units shall have overload capacity as per IS 13925. The capacitor bank shall be suitable for continuous operation at 110% of rated RMS voltage and at 130% of rated RMS current.

5.1.5 Capacitor units shall be all high grade All Polypropylene type with non-PCB base, bio degradable, non-toxic impregnant. The capacitors offered shall be built from best material and shall develop minimum losses. Capacitor bank losses shall be given at

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - CAPACITOR BANK AND ASSOCIATED EQUIPMENT</b>	PC288-TS-0822	0	 कोई एच आई एल 
		Document No.	Rev	
		Sheet 5 of 12		

45°C. Capacitor shall be compact in size, metal enclosed and hermetically sealed. Internal silver wire fuses shall be provided for protection of each capacitor element.

- 5.1.6 The Capacitor bank and associated equipments shall be suitable for parallel switching and withstand the thermal and dynamic stresses by transient during switching operation.
- 5.1.7 All the fasteners and bolts shall be hot dip galvanized or zinc passivated.
- 5.1.8 Capacitors shall be provided with Overpressure protection as necessary for safety. Overpressure switches shall be fitted to the capacitor units and connected to trip the capacitor bank.
- 5.1.9 Each unit shall have required number of capacitor elements housed in sealed, leak proof, sheet steel container. The container shall be provided with suitable mounting brackets, supporting insulators, terminal & bushing for external connections.
- 5.1.10 The indoor capacitor bank units shall be installed in metallic housing with minimum IP-43 protection.
- 5.1.11 Each capacitor unit shall be mounted so that it can be easily removed from the racks and replaced without removing other units, de-assembling any part of the rack.
- 5.1.12 The outside of the capacitor units and other structures should have smooth and tidy look and should be coated with weather-proof, corrosion resistant epoxy paint of light gray shade, shade no. 631 of IS 5. The structure shall be suitably GI coated. Minimum coating shall not less than 600 micron / sq meters.
- 5.1.13 Each element of basic units has its own built in fuse which shall isolate the faulty element automatically without affecting the healthy elements. In case of one element failure, harmful over voltage shall not be generated across remaining elements and shall not make appreciable change in the operation of capacitor bank. An operation of a single fuse element does not cause cascaded fuse blowing. Permissible over voltages and surges do not cause fuse blowing.
- 5.1.14 The operating & design temperature category of the capacitor unit shall be +5°C as per IS-13925 part-1. Only 5°C temperature rise is permissible above the design temperature of 45°C. So maximum temperature in any case shall not exceed 50° C {i.e. 45°C (design) +5°C (temperature rise)}.
- 5.1.15 The capacitor shall have low value of loss which shall not exceed 0.2 watt per KVAR. The loss value of discharge device/resistor and capacitor unit shall be indicated. The tan delta characteristics of the capacitor units shall be furnished. The losses in watts for each capacitor unit including losses in fuses and discharge resistors forming integral part of the capacitors along with losses for series reactor shall be guaranteed. If these figures of capacitor losses exceed 0.2 watt per KVAR, the capacitors will be liable for rejection. However owner reserve the right to use the faulty capacitor unit till the same are replaced/rectified. The loss temperature characteristics, capacity temperature characteristics and insulation resistance temperature characteristics shall also be furnished.
- 5.1.16 The bidder shall furnish calculations for rise in voltage in other units in the event of failure of element(s) of a capacitor unit. The maximum rise in voltage shall not be more than 10% of rated voltage even if the entire capacitor unit failed/short circuited and relevant calculations in support of this shall also be furnished.
- 5.1.17 The bidder shall furnish calculation of voltage drop at rated capacitor unit per phase & losses of the reactor.
- 5.1.18 For both capacitor and reactor, mounting arrangement and minimum clearance required from live parts shall be indicated clearly and shall be as per Indian Electricity Act/BS162 & IS-13925-Part2 / IEC-60871-2.

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - CAPACITOR BANK AND ASSOCIATED EQUIPMENT</b></div>	<div>PC288-TS-0822</div>	<div>0</div>	<div><div>श्री एच ई एल</div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 6 of 12</div>		

## 5.2 Discharge Device

- 5.2.1 A suitable discharge resistor of adequate rating shall be permanently connected across the terminals inside the container to discharge the residual voltage to 50V or less within 1 minute for capacitor rated upto 650V and within 5 minute for capacitor rated above 650V.

## 5.3 PROTECTIVE FUSES

- 5.3.1 An internal current limiting fuse with high rupturing capacity conforming to relevant IS/IEC and the specific requirements mentioned in IS13925-Part-3/IEC 60871- 3, shall be provided. The characteristics of the fuse shall be such that it shall isolate the faulty unit only, and protect it against mechanical destruction due to internal failure. The fuses shall not melt or deteriorate when subjected to inrush currents which occur during the life of the bank.
- 5.3.2 The fuses shall not make any healthy capacitor element out of circuit, either in course of isolating the faulty element or due to any external fault.
- 5.3.3 The selection of fuse to be done in such a manner that characteristic of fuse shall match suitably with over-current withstand characteristic of associated capacitor unit.
- 5.3.4 The fuses shall be of adequate thermal capacity to cater for the increased heating which may occur due to harmonics and capacitor current fluctuations.
- 5.3.5 The number of externally connected capacitors and the available short-circuit current of the supply system should not affect the current-limiting of internal fuses.
- 5.3.6 It may be noted that provided internal fuses do not lead to case rupture.

## 5.4 Series Reactor

- 5.4.1 A suitable series reactor conforming to IS: 5553 to limit the inrush current and suppress the harmonics shall also be provided whenever required.
- 5.4.2 The reactor shall be copper wound, non-magnetically shielded, oil immersed, natural cooled, sealed type and shall be provided with following fittings.
- Oil sampling cum drain valves.
  - Filter valves with plugs.
  - Buchholz relay with shut off valves, air release device & alarm and trip contact.
  - Oil temperature indicator with minimum marking.
  - Oil level indicator with minimum marking.
  - Oil conservator complete with drain plugs and oil filling hole with cover.
  - Silica gel breather with oil seal & connecting pipes.
  - Explosion vent.
  - Bi-directional rollers.
  - Thermometer pocket.
  - Radiator with isolating valves.
  - Marshalling box.
  - Rating plate, wiring diagram plate & terminal marking plate.
  - Lifting lugs.
  - Earthing terminals.
  - Air release device.
  - Cable termination arrangement for incoming & outgoing device.



<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - CAPACITOR BANK AND ASSOCIATED EQUIPMENT</div>	<div>PC288-TS-0822</div>	<div>0</div>	<div><div>श्री एच ई एल <b>BHEL</b></div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 7 of 12</div>		

5.4.3 Dry type/ Oil filled reactor shall only be offered. Such reactors shall be class F/H insulated.

5.4.4 The reactor shall have linear volt ampere characteristics upto 150% of rated capacitor current.

#### 5.5 **Residual voltage transformer**

5.5.1 3 phase dry type residual voltage transformer of adequate capacity to facilitate neutral unbalance protection and rapid discharging of capacitor shall be provided.

5.5.2 The primary winding of voltage transformer shall be star connected while the secondary winding shall be in open delta for connection to neutral phase displacement relay.

5.5.3 The accuracy class shall be 3P for protection & 1 for metering.

5.5.4 RVT shall have primary and secondary windings made of copper.

#### 5.6 **Door limit switch**

5.6.1 A door limit switch suitable for mounting on the door frame of the capacitor room shall be provided for each bank. This door limit switch shall be used to trip the power supply to capacitors with initiation of opening action of the door of the capacitor room.

5.6.2 A door limit switch shall be totally enclosed in the aluminium / cast iron housing, fully oil, water & dust tight and shall conform to utilization category AC11 / DC11 as per IS: 6875. This shall be fast actuation type provided with 6 sets of 1 NO & 1 NC contacts rated for 5 amps at 415V AC and 1A at 220V DC.

#### 5.7 **Capacitor control panel**

5.7.1 Capacitor control panel for control, protection and automatic switching operation of MV capacitor bank shall be provided.

5.7.2 Capacitor control panel shall be of dust, damp & vermin proof construction having enclosure class IP-51 as per IS/IEC:60947.

5.7.3 The enclosure shall be fabricated out of the cold rolled sheet steel having minimum thickness of 2 mm. the doors shall have concealed hinges & provided with neoprene gaskets.

5.7.4 The panel shall be liberally designed. All the components shall be accessible from the front. It shall be possible to attend any component without the necessary removing adjacent ones. All the relays, meters, push buttons including lamps etc. shall be flush mounted. The mounting height of components requiring operation & observation shall not be lower than 300 mm & higher than 1800 mm.

5.7.5 The capacitor control panel shall control the capacitor bank which in turn shall have a number of sub banks for easy of control & to maintain the desired power factor under varying load conditions.

The owner shall arrange C.T supply to sense the power factor. Necessary C.T., selector switch, power factor meter and power factor correction relay shall be provided in the control panel. In addition, the control panel shall have Photo manual selector switch and P.F. raise lower push buttons for manual operation. These common features shall be located near the incoming unit.

5.7.6 Each control shall be provided with TPN switch, voltmeter with selector switch, Ammeter with selector switch and other auxiliaries, as required to receive the incoming power.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - CAPACITOR BANK AND ASSOCIATED EQUIPMENT</b>	<b>PC288-TS-0822</b>	<b>0</b>	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 8 of 12		

- 5.7.7 No. of out going feeders for the control panel shall be decided as per the no. of sub banks to be controlled by it. Each feeder shall be provided with TP switch, fuses, contacts, “ON”& “OFF” indication lamps and other auxiliaries as required.
- 5.7.8 Required no. and size of heavy duty double compression type Aluminium cable glands suitable for incoming and out going power and control cables shall be mounted on removal gland plate provided at a minimum height of 75 mm from the bottom of the panel. Crimping type Aluminium and copper lugs for aluminium and for copper cable respectively shall be provided for termination of cables.
- 5.7.9 The control panel shall be complete with its base channels, foundation bolt etc.
- 5.7.10 A continuous earth bus of aluminium, running along the entire length of the lower part of the control panel shall be provided with lugs at two ends for connection with external earth grid. The minimum size of earth bus shall be 150 sq. mm.
- 5.7.11 Components Details
- 5.7.11.1 The switches shall be of capacitor duty type rated for 1.5 times the rated capacitor current with a minimum rating of 25 A and shall conform to IS/IEC:60947.
- 5.7.11.2 The fuses shall be of non-deteriorating HRC link type and suitably rated for capacitor switching. These shall conform to IS: 13703.
- 5.7.11.3 All contactors shall be of capacitor duty type rated for 50% higher than rated capacitor current & shall conform to IS/IEC:60947. Control supply voltage shall be 240V single phase AC unless otherwise stated. One set of NO & NC potential free contacts shall be made available as spare.
- 5.7.11.4 Ammeter, Voltmeter & power factor meter shall be of accuracy class 1.5 as per IS: 1248 of minimum 96 sq.mm size & shall have 0-240<sup>0</sup> scale.
- 5.7.11.5 The push buttons & selector switches shall conform to utilisation category AC11/ DC11 as per IS: 6875. Contacts shall be rated for 5A at 415V AC and 1A at 220V DC. The push button shall be of momentary contact spring loaded type with a set of 1 NO & 1 NC contacts. The selector switches shall be stay put type and provided with oval shaped handles.
- 5.7.11.6 The signal lamps shall be LED type. Colour of lamp shall be “Red” for “ON” & “Green” for “OFF” signals.
- 5.7.11.7 Terminal blocks shall be pressure clamp type up to 35 sq. mm. cable and bolted lugs type for higher sizes of cables. The minimum current rating of terminal block shall be 16A. 20% extra terminals shall be provided in the terminal block.
- 5.8 **Bus Bars**
- 5.8.1 All bus bars interconnecting the basic units shall be of copper and shall be fully insulated by using Raychem make heat shrinkable sleeves. All bus bar joints and tap-off connections shall be provided with removable FRP shrouds. The sleeves shall be rated to withstand the system Line-to-Line voltage for 1 minute.
- 5.8.2 The minimum clearances shall be as per relevant standards suitable for the nominal voltage of capacitor banks.
- 5.9 **External cable termination**
- 5.9.1 Each capacitor bank / sub bank shall be provided with proper termination arrangement where terminal connection from all the three phases shall be brought for connection with external cable. The termination arrangement shall include cable glands, cable lugs, termination kits, supporting arrangements etc. complete in all respect.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - CAPACITOR BANK AND ASSOCIATED EQUIPMENT</b>	PC288-TS-0822	0	 कोयला इंडिया  बी.एच.एल.
		Document No.	Rev	
		Sheet 9 of 12		

5.9.2 A cable box for termination of control cables shall be provided on the RVT. The cable boxes shall be provided with adequately sized cable entries and suitable double compression cable glands made of stainless steel. Tinned copper lugs shall be provided for the connection of all cable cores.

5.10 **Interlocks**  
All necessary interlocks to ensure correct & safe operation of capacitor banks shall also be provided.

5.11 **Earthing**  
Each basic capacitor unit shall be connected to the earth strip provided on the steel racks which in turn shall be connected to the main earth grid through two nos. suitable earth terminals provided on the racks.

## 6.0 **PROTECTIVE SCHEME (PROVIDED BY PURCHASER)**

6.1 The vendor shall confirm the adequacy of these protective devices and also suggest the setting and any other additional protective devices required.

7.0 **Accessories**  
The supply shall include the following accessories.

7.1 **Control panel space heater**  
The control panel shall be provided with a thermostatically controlled space heater, rated for 240V, 50Hz & controlled through double pole miniature circuit breaker.

## 7.2 **Name plate**

7.2.1 All the equipment shall be provided with name plates containing all the information's as per relevant standard.

7.2.2 All control switches, push buttons, lamps etc. shall have functional identification labels.

7.2.3 Name plate of capacitor control panel shall be of black prespex with white engraving and of minimum 3 mm thickness while those on other equipment shall be of stainless steel.

## 7.3 **Warning Plates**

7.3.1 Warning plates shall be provided on the door and inside of the equipment, comprising following information:

CAUTION: HIGH VOLTAGE CAPACITORS.

AT BLOWN FUSES, CHARGES MAY REMAIN

7.3.2 The warning plates shall be UV resistant engraved plastic.

## 7.4 **Steel racks**

7.4.1 Sheet steel racks shall be provided to house the capacitor units, residual P. T. etc. in tier formation.

7.4.2 The racks shall be suitable for assembly at site. The racks & hardware used for assembly shall be hot dip galvanized.

7.4.3 The rack shall be complete with rack insulators, foundation bolts or any other hardware etc. for assembly into complete bank.

7.4.4 Complete assembly of capacitor bank shall be mounted on a pedestal GI frame, which shall be 300 mm high.

7.4.5 Any other accessories required but not specified, shall be supplied to make the capacitor installation complete in all respect and ensure safe & proper operation.

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - CAPACITOR BANK AND ASSOCIATED EQUIPMENT</b></div>	<div>PC288-TS-0822</div>	<div>0</div>	<div><div>को ई एच डी एल <b>BHEL</b></div></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 10 of 12</div>		

## 8.0 PAINTING

- 8.1 The sheet steel enclosure after degreasing, pickling in acid, cold rinsing, phosphatising passivating etc. shall be painted with two coat of anti-rust paints followed by two coats anti corrosive paints.
- 8.2 Epoxy based paint shall be used.
- 8.3 All paint shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.
- 8.4 Unless otherwise specified, the finishing shade shall be light gray shade no. 631 as per IS: 5.

## 9.0 TESTS AND INSPECTION

- 9.1 All capacitor banks and control panel shall be subjected to routine tests as per IS: 2834 and its associated equipment as per relevant standards.
- 9.2 Additional tests, wherever specified, shall be carried out.
- 9.3 All the above tests shall be carried out in presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works & site inspection.
- 9.4 These inspections shall, however, not absolve the vendor from his responsibility for making good any defect which may be noticed subsequently.

## 10.0 DRAWINGS AND DOCUMENTS

- 10.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.
- 10.2 All drawings and documents shall have following description written boldly.
- Name of client
  - Name of consultant
  - Enquiry / Order Number with plant / project name
  - Code No. and Description

## 11.0 SPARES

- 11.1 Commissioning Spares: Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval.
- 11.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 11.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 11.4 All spare parts shall be identical to the parts used in the equipment.

## 12.0 PACKING

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION - CAPACITOR BANK AND ASSOCIATED EQUIPMENT</div>	PC288-TS-0822	0	<div><div>श्री एच डी एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 11 of 12		

- 12.1 All the equipment shall be properly packed before despatch to avoid damage during transport, storage & handling.
- 12.2 The packing box shall contain a copy of the installation, operation & maintenance manual.
- 12.3 A sign to indicate the upright position on the position of the package to be placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.
- 13.0 **DEVIATIONS**
- 13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION - CAPACITOR BANK AND ASSOCIATED EQUIPMENT</b>	PC288-TS-0822	0	 कोयला इंडिया  बी.एच.एल.
		Document No.	Rev	
		Sheet 12 of 12		

## ANNEXURE - I


### DOCUMENTATION FOR CAPACITOR BANK & ASSOCIATED EQUIPMENT

Sl. No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	General Arrangement Drgs. with Overall dimensions of the following equipment. - Capacitor bank - Reactor - Control panel	N	Y	Y
4.	Foundation plan indicating certified dimensions floor opening, weight, clearance etc. - Capacitor bank - Reactor - Control panel	N	Y	Y
5.	Schematic & wiring diagram	N	N	Y
6.	Descriptive literature of Various equipment	N	N	Y
7.	Installation, operation & maintenance manual	N	N	Y
8.	Guarantee certificate	N	N	Y
9.	Test certificate	N	N	Y
10.	Spare parts list with identification marks	N	N	Y

#### Note:

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION</b> <b>(FIRE DETECTION AND ALARM SYSTEM)</b>		PC288-TS-0826		1
			Document No.	Rev	
			Sheet 1 of 20		






# **TECHNICAL SPECIFICATION** **FIRE DETECTION AND ALARM SYSTEM**

## CONTENTS




SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	GENERAL REQUIREMENTS
4.0	DEFINITIONS
5.0	SYSTEM AND SITE CONDITIONS
6.0	FIRE ALARM SYSTEM DESCRIPTION
7.0	ENGINEERING REQUIREMENTS
8.0	ADDRESSABLE FIRE ALARM SYSTEM
9.0	INTEGRATION WITH VARIOUS PLANT SYSTEMS
10.0	PANEL CONSTRUCTION
11.0	AUTOMATIC FIRE DETECTORS AND ACCESSORIES
12.0	FIELD DEVICES FOR HAZARDOUS AREA
13.0	CABLE AND CABLE ACCESSORIES
14.0	INSPECTION, TESTING AND ACCEPTANCE
15.0	PACKING AND DESPATCH
16.0	INSTALLATION AND COMMISSIONING
17.0	TRAINING



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION</b> <b>(FIRE DETECTION AND ALARM SYSTEM)</b>	<b>PC288-TS-0826</b>		1	 श्री एच डी एल 
		Document No.		Rev	
		Sheet 3 of 20			

Abbreviations:

BIS	Bureau of Indian Standards
BASEEFA	British Approvals Service for Electrical Equipment in Flammable Atmosphere
CCE	Chief Controller of Explosives
CFAP	Central Fire Alarm Panel
CMRI	Central Mining Research Institute
CPU	Central Processing Unit
DGFAP	Data Gathering cum Fire Alarm Panel
ERTL	Electronic Regional Test Laboratory
FAT	Factory Acceptance Tests
FDD	Floppy Disk Drive
FM	Factory Mutual
FRP	Fibre Reinforced Plastic
FO	Fibre Optic
GUI	Graphic User Interface
HAB	Hooter acknowledgement box (to mute hooters)
HDD	Hard Disk Drive
ISDN	Integrated Service Digital Network
ITU-T	International Telecommunication Union- (Telecom)
LED	Light Emitting Diode
LPC	Loss Prevention Council
LIFO	Last In First Out
MCP	Manual call point (break glass unit; BGU)
MMI	Man Machine Interface
MR	Material Requisition
Ni-Cd	Nickel Cadmium (battery)
PO	Purchase Order
RF	Radio Frequency
SAT	Site Acceptance Tests
SOE	Sequence Of Event
TAC	Tariff Advisory Committee
UWL	Under Writers Laboratory
UPS	Uninterrupted Power Supply
VRLA	Valve Regulated Lead Acid (battery)
WP	Weather Proof
ZFAP	Zonal Fire Alarm Panel

 <div>प्री डी आई एल <b>PDIL</b></div>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION</b> <b>(FIRE DETECTION AND ALARM SYSTEM)</b>	<b>PC288-TS-0826</b>	<b>1</b>	 
		Document No.	Rev	
		Sheet 4 of 20		

## 1.0 SCOPE

- 1.1. The intent of this specification is to define the functional and design requirements for an Integrated Fire Alarm System for industrial plants and buildings. This specification covers the requirements for selection, design, and engineering, manufacture, testing at vendor's works, supply, installation, testing at site and commissioning of the system.
- 1.2. The Integrated Fire Alarm System shall be microprocessor based analog addressable system comprising of MCP, detectors, microprocessor based Fire Alarm panels, panels, hooters, sirens, exit signs, Loop/network/power cables, earthing, Junction box & associated equipments detailed hereunder and as per codes standards mentioned below and in Project data sheets/ drawings.
- 1.3 The fire alarm system shall integrate




## 2.0 CODES AND STANDARDS

- 2.1 The system and equipment shall comply with relevant BIS (Bureau of Indian Standards) and other Indian/ International standards, as applicable. In case Indian standards are not available for any equipment, standards issued by IEC/ BS/ VDE/ IEEE/ NEMAINFPA or equivalent agency shall be applicable. In case of imported equipment, the standards of the country of origin shall be applicable if these standards are equivalent or more stringent than the applicable Indian standards.
- 2.2 The equipment shall also conform to the special requirement/ provisions of applicable statutory regulations currently in force in the country.
- 2.3 In case of any contradiction between various referred standards/ specifications/ data sheets and statutory regulations, the following order of decreasing priority shall govern:

- Statutory regulations
- This specification
- Codes and standards

- 2.4 The fire alarm system and the components used shall conform to the latest edition of the following and also the other Indian and International Standards as applicable.

IS-5	Colours for ready Mixed Paint & Enamels.
IS - 513	Specification for cold rolled low carbon steel sheets and strips
IS/IEC:60079	Flameproof enclosures for electrical apparatus
IS - 1646	Code of practice for fire safety of buildings (general): Electrical Installations
IS - 2175	Specification for heat sensitive fire detectors for use in automatic fire alarm system
IS - 2189	Code of practice for selection; installation and maintenance of automatic fire detection and alarm system.
IS - 3034	Code of practice for fire safety of Industrial buildings: Electrical generating and distributing stations
IS - 3700	Essential ratings and characteristics of semi conducting devices (Applicable parts)

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION</b> <b>(FIRE DETECTION AND ALARM SYSTEM)</b>	<b>PC288-TS-0826</b>	<b>1</b>	 कोयला इंडिया लि. 
		Document No.	Rev	
		Sheet 5 of 20		

IS - 3826	Connectors for frequencies below 3 kHz General requirements Part-I and tests
IS/IEC:60079	Code of practice for the use of semi-conductor junction devices (Applicable parts)
IS - 5780	Specification for Intrinsically safe electrical apparatus and circuits
IS - 11360	Specification for smoke detectors for use in automatic electrical fire alarm system.
IS - 12459	Code of practice for fire safety in cable runs
IS - 13346	General requirements for electrical apparatus for explosive gas atmosphere
IS-14154 Part 2	Electrical apparatus with protection of enclosure for use in the presence of combustible dust
NFPA 72 Vol 4	National Fire Alarm code
LPC	Loss prevention council recommendations.
BS - 5839	Specifications for manual call points.
BS-EN 50081-1	EMC (Electromagnetic compatibility test)
BS-EN 50082-1	EMC (Electromagnetic compatibility test)

### 3.0 GENERAL REQUIREMENTS

- 3.1 The offered equipment shall be brand new with state of the art technology and a proven field track record. No prototype equipment shall be offered.

Bidder shall consider adequate nos. of Fire Alarm panels which shall be located at plant and control room of building/substation.

Bidder shall also consider repeater panels (min 3 nos.) which shall be installed in fire station. All the fire alarm and repeater panels shall be connected in ring network.


Repeater panel shall be replica of main fire alarm panel.

Minimum 3 nos. Siren shall be provided with 5 Km audio range.

In case of a Fire alarm initiation by a alarm initiating device, the audio-visual fire alarm shall be generated at Fire Alarm Control Panels (FACP) located at each substation & building and repeater panels for each Fire Alarm panel at Fire safety station as well as in CCR which also initiate signal to operate hooters/siren located in various locations in building and plant area.

The Fire Alarm System envisaged for Building shall be “2-Wire Analog Addressable” type.

The communication between detectors and the FACP is by means of digital communication over 2-wire, which further provides power to the detectors, devices & Sounders. There shall be A/D and D/A conversion happening inside the detectors and FACP.

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION</b> <b>(FIRE DETECTION AND ALARM SYSTEM)</b>		PC288-TS-0826	1
			Document No.	Rev
			Sheet 6 of 20	



All the detectors shall be incorporated with microprocessors and shall be provided with Analog to Digital Converter (ADC), which enables the detector to provide linear output corresponding to the quantity of smoke or fire, the detector encounter.

All types of detectors offered will be of restorable type i.e. suitable for operating a fresh after each actuation on alarm without replace mentor adjustment.

The sensitivity of each sensor shall be individually adjusted from the FACP to suit the conditions of each location. Each detector shall have self-test facility, which is monitored in the FACP. Each detector shall have drift compensation.

The response sensitivity shall also be field adjustable and not only from fire panel over a wide range to suit site shall conditions. It be possible to test the sensitivity of a detector in the field. The sensitivity/threshold value of detectors which are cross zoned must be compatible.

The FACP shall also check each sensor for contamination of dust/dirt and give signal for "Service" in case of accumulation of dust/dirt reaches a preset limit.

The fire alarm system shall work without any problem both in networked mode and in standalone mode.

The electronic circuit shall be of solid state and of failsafe design and virtually hermetically sealed to have resistance to humidity and corrosion and to prevent its operation from being impaired by dust and dirt.

The circuit shall be protected against usual electrical transients, electromagnetic and electrostatic interference (EMI&RFI) present in the Building.

Reverse polarity or fault in the field wiring shall not damage the detector.

No moving parts subject to wear & tear shall be provided.



The system shall have following self diagnostic features:

- Detector cabling shall be completely supervised for open circuit and short circuit and exact location of fault shall be displayed in the panel under Trouble/Faults.
- Un-authorized removal of a detector head from its base shall be supervised to give an alarm on the connected control panel.
- Annunciation shall be provided for DC fuse blown and loss of main AC supply etc.
- Alarm verification features.

If the Equipments to be located in hazardous areas, then same shall have test certificates issued by recognized independent test house such as CIMFR, ERTL, BASEEFA, UL, FM or equivalent. All indigenous equipment shall conform to Indian standards and shall be certified by Indian testing agencies. All equipment (indigenous & imported) shall also have valid statutory approvals e.g. PESO, DGMS as applicable for the specified location. All indigenous flameproof equipment shall have valid BIS license and marking as required by statutory authority.

Fire alarm system shall be interfaced with the owner's system.

The system shall be provided with siren/s to be located at a suitable location/s in the plant and it shall be actuated manually and automatically as selected by operator from Fire Alarm panel located at fire station/ other buildings.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION</b> <b>(FIRE DETECTION AND ALARM SYSTEM)</b>	PC288-TS-0826	1	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 7 of 20		

- 3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply. The spares shall be available ex-stock with the vendor.
- 3.3 Vendor shall give a notice of at least one year to the end user of equipment and PMC before phasing out the product/ spares to enable the end user to place order for spares and services.
- 3.4 The vendor shall be responsible for design, engineering and manufacturing of the complete system and equipment to fully meet the intent and requirements of this specification and attached data sheets.
- 3.5 All equipment and accessories required for completeness of the system, whether specifically mentioned or not but considered essential for satisfactory performance, shall be included as a part of the offered system.
- 3.6 The system integrator shall coordinate with the manufacturers of various bought-out items associated with the system, as required, and shall freely and readily supply all technical information as and when called for.

## 4.0 DEFINITIONS

### 4.1 Hazardous Area

An area in which an explosive gas/ dust atmosphere is present, or likely to be present in quantities such as to require special protection for the construction, installation and use of electrical apparatus.

## 5.0 SYSTEM AND SITE CONDITIONS

All equipment shall be designed to operate with power supply and site conditions as specified below:

### 5.1 Input Power Supply




- 5.1.1 Power supply for fire alarm panels shall have battery backup as per IS-2189. Battery AH rating shall be determined on the basis of maintaining the system in normal operation for a period of not less than 48 hours (quiescent condition) and successive full load alarm condition of period not less than 30 min after the failure of normal mains supply. The switch over from mains to back up, in the event of mains failure, shall be automatic.

Batteries shall be Ni-Cd type. Suitable and adequately rated battery charger shall be supplied as a part of back up battery system.

The secondary power supply capacity required shall include all power supply loads that are not automatically disconnected upon the transfer to secondary power supply.

Battery sizing shall consider the maximum quantity of detector/equipment that can be connected in the loops, as well as 5 hooters and 5 exit signs per loop in Fire Alarm panels. Battery sizing calculations shall be reviewed during detailed engineering and there shall be no cost/time implication for providing adequately sized batteries and chargers of approved rating during the order execution. Separate battery charger shall be provided in case battery charger part of the Fire Alarm panel cannot cater to the boost charging requirement of battery.

An overall ageing factor of 0.8 and a temperature correction factor corresponding to minimum temperature of 5°C shall be considered for battery sizing. The battery calculations shall include a 10 percent safety margin to the calculated amp-hour rating. Operation on secondary power shall not affect the required performance of a fire alarm system or supervising station facility. The system shall produce the same alarm, supervisory and trouble signals and indications.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION</b> <b>(FIRE DETECTION AND ALARM SYSTEM)</b>	PC288-TS-0826		1	 श्री एच डी एल 
		Document No.		Rev	
		Sheet 8 of 20			

Operation on secondary power shall not affect the required performance of a fire alarm system or supervising station facility. The system shall produce the same alarm, supervisory and trouble signals and indications.

The switch-over from primary source to secondary source, in the event of mains failure, shall be automatic. Battery shall be Ni-Cd type.

## 5.2 Site Conditions

The offered equipment shall be capable of operating continuously and maintaining its guaranteed performance at the site ambient conditions indicated in data sheet.

Unless specified otherwise, fire alarm panels along with associated hardware shall be suitable for installation and operation in a closed building/ room with restricted ventilation. Any specific requirements for air conditioned/ dust free environment, etc. for the panels, if absolutely necessary, shall be clearly highlighted by the vendor in the offer.

## 6.0 FIRE ALARM SYSTEM DESCRIPTION

### 6.1 General

Fire alarm system under this specification is envisaged to provide fire monitoring in industrial plants/ chemical plants/ plant and non- plant buildings. The system shall be designed to detect incipient fires and generate audio/ visual alarm in case of fire.

The system shall consist of automatic fire detectors and manual call point or break glass unit. Automatic fire detectors shall work on the principle of sensing of smoke, heat or infrared rays. Depending on type of smoke, optical or ionization type detectors shall be used. Detectors shall generally be provided in plant/ non-plant buildings. Manual Call Point shall be provided at exit doors of the buildings and at exit route of industrial plants. Number of detectors and break glass unit shall be decided as per guidelines given in applicable codes and standards.

Alarms, if specified, shall be relayed to repeater panel provided in buildings like control rooms/administrative buildings to provide zone wise annunciation. In addition facility shall be provided to actuate siren/ hooter.




For integrated fire alarm system where plant-wide large numbers of fire alarm panels are envisaged, these panels shall be integrated to CFAP, which shall be located in fire station or in administrative control room of the building as per the job requirements. The connectivity shall be achieved using data high way or dedicated cable connection from each fire alarm panel to CFAP. Mimic at CFAP shall be provided for fire/ fault annunciation on geographical location in addition to the text/ LED. If defined, CFAP shall have provision for automatic and manual actuation of plant-wide siren as per operator's choice. Interface with other systems such as telephone exchange/ plant's public address system/Pager system shall be provided for communication required for disaster management.

6.2.3 As specified in data sheet, the system shall be provided with siren/s to be located at a suitable location/s in the plant and it shall be actuated manually and automatically .

## 7.0 ENGINEERING REQUIREMENTS

vendor shall design entire fire alarm system including design of system architecture with details of integration, cabling requirement and protocol selection etc. Vendor's scope shall also include basic design and preparation of layouts for fire alarm system for plant/ buildings as specified in the data sheet/ purchase documents.



 <div>प्री डी आई एल <b>PDIL</b></div>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION</b> <b>(FIRE DETECTION AND ALARM SYSTEM)</b>	<b>PC288-TS-0826</b>	<b>1</b>	 
		Document No.	Rev	
		Sheet 9 of 20		

## 8.0 ADDRESSABLE FIRE ALARM SYSTEM

### 8.1 ANALOGUE ADDRESSABLE FIRE ALARM CONTROL PANEL (FACP)

The FACP used in the Building shall confine to the EN54 standards having the following features.


- i) FACP provided shall have the capacity to expand from at least loop for Future expansion.
- ii) Each loop shall accommodate maximum 250 detectors and devices in any combination with a loop length capable up to 2kms with 2Cx1.5sqmm cable. However bidder shall consider maximum number of detectors/ MCP/ addressable devices in a signal loop shall be 60.
- iii) It shall have facility to discriminate between a real fire alarm and false alarms.
- iv) FACP will function as fully stand-alone panel& also networked to other FACPs & repeater with peer to peer communication.
- v) Each FACP shall have redundant controller to takeover in case of a Failure in the Primary Controller and also redundant loop card for each loop to takeover in case of a Failure in the Primary Loop Card.
- vi) Each FACP shall have inbuilt LCD colour touch screen (320\*240 pixels) to clearly indicate the location of fire, type of device activated other indications like service requirement of a component, etc.
- vii) In case of a Loop Card Failure, the FACP shall allow to replace the Loop card without switching off the panel and reprogramming.
- viii) The FACP shall be capable of Public Address system integration with the use of RS232/RS485 module or with the use of relays.
- ix) FACPs shall have inbuilt buzzer to alert the personnel in case of maintenance requirement.
- x) FACP shall have facilities for sequence of events to happen in case of fire like closing of fire dampers, shutting down supply fans for HVAC, Deactivating the access control system and activating the hooters with the help of a control relay module provided near the system to be activated.
- xi) The fire alarm control panel shall be suitable for Class-A type of wiring as per NFPA-72.
- xii) The fire alarm control panel shall work on positive sequence as per NFPA – 72.
- xiii) The fire alarm control panel shall be capable of disabling an individual detector, a group and or zone off or building maintenance purposes. Facility shall be provided on the FACP for simulating the fire condition to enable testing of the various alarm circuits.
- xiv) All the fire alarm modules (loop cards, networking cards, and communication card. Etc.) should be hot pluggable and hot swappable to facilitate easy replacement of faulty modules. All the electronic components shall be compatible to non-air-conditioned environment for working satisfactorily.
- xv) The fire alarm control panel normal power supply failure shall be annunciated audio-visually.

- xvi) In case of multiple alarms the multiple alarm indication shall be ON. The multiple alarm indication shall be displayed in chronological order.
- xvii) FACP shall have the facility such that each detector can be identified as a separate zone.
- xviii) The FACP shall be reset only by authorized users after the clearance of a fault.
- xix) Whenever there is a third party actuation to happen, like closing of fire dampers, switching off supply/exhaust units etc, the actuation shall happen only when the fire signal is received from two different initiating devices located in a zone connected to different fire alarm panels. The communication between the FACPs shall happen with two pair cables and the fire alarm status of one panel shall be communicated to the second panel in which the control relay module of the third party device is connected to. Inter panel communication is a must and needs to be provided for controlled actuations. All the necessary systems to ensure reliable communications between panels are to be built into the FACPs.
- xx) FACP shall have the facility to silence/ acknowledge/ reset the alarm. Apart from the FACP.
- xxi) The FACP shall have FALSE ALARM REDUCTION algorithms like.
- Alarm Verification, Dual Detector/Group Dependency, and Intermediate Alarm Storage to eliminate False alarms due to Dirt/Dust/Disturbance values.
  - EMC/EMI Monitoring - Signal-to noise ratio shall be high. To inform the possibility of a false alarm caused due to interferences from sources such as Motors, power cables, Wi-Fi routers, fluorescent lamps, network switches, mobile signals...etc. The panel shall display the EMI/EMC Current and Average Values reported by the detector. The User/Installer shall have access to this reading during Maintenance (with password protection).
- xxii) When fire condition is confirmed, the following sequence of annunciation will take place on the FACP:

Alarm Condition	Audible Alarm	Visual Alarm
First Fire Condition	ON	ON FLASHING/Description of area of fire origin with detector type
Acknowledge (first Alarm)	OFF	ON STEADY
New Fire Alarm Condition (after acknowledge of First alarm)	ON	ON FLASHING
Acknowledge (New fire alarm)	OFF	ON STEADY
Back to normal	OFF	ON STEADY
Reset	OFF	OFF
Reset Before Normal	OFF	ON STEADY

- xxiii) System shall provide adequate EEPROM size to store minimum of 200 events fire/ fault. The event shall be stored in LIFO structure. All events shall be time stamped. FACP shall have real time clock for event time stamping.





	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION</b> <b>(FIRE DETECTION AND ALARM SYSTEM)</b>		PC288-TS-0826	1
			Document No.	Rev
			Sheet 11 of 20	



- xxiv) Software access for either Zone programming or access to plant/ building graphic on monitor shall be password protected. For viewing status of various field devices e.g. fire and fault status password protection shall not be given.
- xxv) Fire Alarm & repeater panels shall be certified/ approved by an international approving agency/ approving agency of country of origin as applicable.
- xxvi) The FACP shall have a process or which shall be of at-least 32bit, which shall be designed to accept all the input and process the outputs within the time stipulated by the standards.
- xxvii) The CPU shall have the facility to communicate with other FACPs and process the fire signals received from other FACPs to actuate a third party device.
- xxviii) The processor shall be designed in such a way that the parameters in the repeater panel shall be refreshed in 1sec.
- xxix) The capacity of the processor shall be adequately designed include all input/output signals and various functional requirements.
- xxx) It shall have its own, built in advanced microprocessor, sophisticated software and extensive memory for storing the logs of alarms, times and action taken report.
- xxxi) Loop module shall have a line length up to 1600m or 3000m depending upon the configuration & cable type. It shall have an LED test button.
- xxxii) The loop module shall be encapsulated & shall be hot pluggable.
- xxxiii) The front fascia of the loop cards shall be visible for easy identification of faults.
- xxxiv) In case of the failure of loop card, it should be replaced without the need of any additional programming.

## 8.2 Repeater Panels

- i) These panels shall be required for repeat of alarm in buildings/ plant control rooms/Fire station.
- ii) It shall be a LCD touch screen same as main panel. The MMI shall be the same as the main Controller.
- iii) Repeater panels shall be suitable for Wall mounting which will be displayed from all the major entrances and staircases which will enable the staff and fire fighting personnel to exactly locate the fire.
- iv) It shall be compatible to receive data from FACPs.
- v) Audio visual Alarms during fire shall be generated in case of fire.
- vi) All fire alarm panels including repeater panel shall be networked through copper/FO communication cable.
- vii) The Power supply to the Repeater Panel shall be drawn from the Fire Panel
- viii) The Repeater Panel shall display Messages like Alarm & Fault similar to the Main Panel and shall be accessed only by Authorized Users through a passcode.
- ix) The Repeater Panel shall be connected to the Main Panel and other repeater panels in such a way – 1 pt Failure in the cable shall not affect the performance and shall intimate the exact location of failure in all Panels.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION</b> <b>(FIRE DETECTION AND ALARM SYSTEM)</b>	PC288-TS-0826	1	 बी एच ई एल
		Document No.	Rev	
		Sheet 12 of 20		

- x) The Repeater Panel shall be equipped with a Key switch that allows Authorized users to Acknowledge/Reset Alarms.
- xi) The Repeater Panel shall be equipped with 2 different power inputs. On failure of primary power, the secondary shall take over.
- xii) The Repeater panel shall allow the users to login locally or login to the remote FACP.
- xiii) The repeater panels shall integrate with the main panels without any additional interface or the bidder shall consider necessary accessories required to complete the system and quote as part of this model.

## 9.0 INTEGRATION WITH VARIOUS PLANT SYSTEMS

9.1 Fire Alarm System shall have required hardware to have interface with following plant systems as specified in data sheet.

- i. Public Alarm Announcement system
- ii. Paging and plant intercom systems.
- iii. Plant data network
- iv. ISDN telephone exchange and pager system
- v. Fire suppression system
- vi. PLC Data Communication through serial common modbus
- vii Shutdown signals to various air-handling units relative to the zone of fire.
- viii Siren



## 10.0 PANEL CONSTRUCTION

### 10.1 Equipment Mounting

- 10.1.1 All apparatus, display screen, instruments and indicating lamps mounted on the panel front shall be flush mounting type. The external cabling shall not be terminated directly on the base connector of PCBs but shall be terminated on separate terminal block. Further connection to PCBs shall be as per manufacturer's standard. Routine calibration, adjustments, programming and operation shall be accessible from the front of the panel without opening the door. External cabling shall preferably be done from the rear.
- 10.1.2 Power supply system including battery bank shall be mounted inside the panel.
- 10.1.3 Doors shall be provided with pistol grip handle with lock. Lamps shall be provided inside the panel to provide adequate light for maintenance of equipments.
- 10.1.4 Cable entry shall be from bottom unless otherwise specified in the data sheet. Terminal strip shall be provided for incoming / outgoing cables.

### 10.2 Wiring and Terminals

- 10.2.1 Wiring within the panel shall be laid in slotted plastic raceways enclosed with cover. Control connections shall be done with 660V grade PVC insulated wires having stranded copper conductors. 1.5mm<sup>2</sup> size of wire shall normally be used for circuits with control fuse rating of IOA or less. Control wiring for electronic circuits shall be through ribbon

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION</b> <b>(FIRE DETECTION AND ALARM SYSTEM)</b>	PC288-TS-0826	1	 बी एच ई एल
		Document No.	Rev	
		Sheet 13 of 20		

cable or through copper wire minimum of 0.5mm dia. Panels shall be supplied completely pre-wired, such that only field termination shall be required at site before it is energized.

10.2.2 PCBs for identical functions shall be interchangeable. PCBs shall be plug in type having pin/edge connectors. PCBs shall be suitable for use in tropical, humid and dusty environment. These shall be protected with anti fungus treatment.

10.2.3 Cables shall be terminated on terminal blocks. Clamp type terminals shall be of spring-loaded, stacking type, mounted on rails. Terminals shall be sized to accept, as a minimum 2.5mm<sup>2</sup> cross section conductors. Not more than one conductor shall be terminated on the outgoing side of each terminal. At least 20 % spare terminals shall be provided in each panel for termination of spare cores of cables.

### 10.3 Earthing

10.3.1 A common earth bar of minimum 25 x 3 mm. copper or equivalent aluminium shall be provided throughout the length of the panel. All non-current carrying metallic parts of the panel mounted equipment shall be earthed. Flexible jumpers shall connect all doors and movable parts to the earth bus. Two numbers earth lugs shall be provided outside the panel.

The FACPs shall be provided with triplicated earthing terminals on the either side. The grounding terminal G1 shall be for safety grounding, G2 shall be for shield grounding and G3 shall be for signal grounding

### 10.4 Name Plates / Warning plates

10.4.1 All nameplates for panel shall be engraved out of 3 ply (black-white- black) lamicoide sheets or anodized aluminum. Back-engraved Perspex sheet nameplates will also be acceptable. Engraving shall be done with square groove cutters. Hard paper or self-adhesive plastic tape nameplates shall not be acceptable.

10.4.2 Labels shall be provided for every component on the cards, connecting wires as well as for the terminals in the terminal strip inside the panel. Wiring diagram shall be pasted inside the panel door as required for termination and maintenance.

10.4.3 Special warning plates shall be provided on all removable covers or doors giving access to energized metallic parts above 24 volts.

### 10.5 Painting




10.5.1 All metal surfaces shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The undersurface shall be made free from all imperfections before undertaking the finishing coat.

10.5.2 After preparation of the undersurface, the panel shall be powder coated. The colour shade of final paint shall be as approved by the purchaser. The finished panels shall be dried in dust free atmosphere. Panel finish shall be free from imperfections like pinholes, orange peels, run-off paint etc.

10.5.3 All unpainted steel parts shall be cadmium plated or suitably treated to prevent rust-corrosion. Moving elements shall be greased.

## 11.0 AUTOMATIC FIRE DETECTORS AND ACCESSORIES

i) Detectors for microprocessor shall be addressable type. Detectors shall be plug-in type and shall have twist lock action fitting. Multicolour LEDs provided on the detectors




 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION</b> <b>(FIRE DETECTION AND ALARM SYSTEM)</b>	PC288-TS-0826	1	 श्री एच डी एल 
		Document No.	Rev	
		Sheet 14 of 20		

shall indicate Normal and Alarm state. Essential features of detectors are indicated as below.

- ii) Detectors shall be supplied with mounting bases. Mounting base shall be identical for all type of detectors. Detector housing (body and cover) shall be made up of damage resistant, fire resistant polycarbonate and shall be suitable for either surface or recess mounting. Detector base shall be mounted on Junction boxes having terminals for cable termination. Installation equipment such as GI conduits, GI junction box/ conduit box etc. shall also be included in vendor's scope.
- iii) Detectors shall be suitable for storage at ambient condition specified in data sheet.
- iv) All detectors shall be on the approved list of LPC, UL / FM/ equivalent international approving agency as applicable.

## 11.1 Intelligent Addressable Dual Optical Smoke/Heat (Multi-sensor) Detector

- i) The Intelligent Addressable Multi sensor Detector with 2 LED's-Infrared & Blue used and shall confine to the relevant standard shaving the following features.
- ii) It shall be combination of Smoke detection and heat detection. The smoke detection system shall work on Light scattering type principle using Infrared & Blue LED's, and the Heat detection system shall be of Rate of rise of temperature and Fixed Temperature.
- iii) The Intelligent Addressable Multi sensor Detector shall be of Spot type and Addressable type.
- iv) The Intelligent Addressable Multi-sensor Detector shall be addressed either by DIP switches or through Programming from the Panel.
- v) The Detector shall monitor EMC/EMI values in the surroundings on a continuous basis and report the current & average values to the panel. The detector and the panel shall together avoid the possibility of false alarm caused due to interferences from sources such as Motors, power cables, Wi-Fi routers, fluorescent lamps, network switches, mobile signals...etc.
- vi) All the detectors shall have a visible multi-color LED to indicate the healthiness/trouble/alarm condition of the detector. The LED shall be located in such away that it shall be visible from all the 360 degree from below. In some cases where the visibility of the detector is obstructed by cable trays, false ceiling etc. Facility for connecting the detector to a response indicator has to be present. The response indicator derives the power to glow from the loop.
- vii) It shall possess False alarm immunity and a superior signal to noise ratio.
- viii) It shall have drift compensation facility built-in.
- ix) The detectors shall communicate the ambient reading to the FACP on time to time basis, and the FACP shall make the decision about the current status of the detector, whether it is in fire/pre-alarm/maintenance requirement etc.
- x) The detector shall have different levels of sensitivity settings based on the application and room where it is installed.
- xi) The detector shall provide a chamber maid plug to blow out the dust/dirt using a blower.
- xii) In case of a failure, panel shall allow to replace the detector with the same type without the need of additional programming
- xiii) The detector shall be programmed to work as Optical only or Thermal only detectors. It shall a provision to switch off any component (optical or thermal) of the detector.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION</b> <b>(FIRE DETECTION AND ALARM SYSTEM)</b>	PC288-TS-0826	1	 श्री एच डी एल 
		Document No.	Rev	
		Sheet 15 of 20		

- xiv) The detector shall work with 2 different sensitivity settings at any point of time and the User shall have access to choose the desired settings without programming or Laptop/PC for configuration.
- xv) The detector shall change sensitivity settings based on day/night mode or with schedules based on the programming.
- xvi) The detector shall have Intermediate Alarm Storage, Dual Detector Dependency, Dual group Dependency features that shall be programmed based on site application.
- xvii) The detector shall be capable of detecting both smoldering fires and open fires and shall be EN54 /VdS approved

## 11.2 Heat Sensing Cables




Heat sensing cable shall be analogue type. It shall consist of four copper conductors, each covered with a colour coded, negative temperature co-efficient material. The cores shall be twisted together and protected by an outer sheath of high temperature, flame retardant PVC insulation. External mechanical protection shall be provided over the sensor cables. Vendor shall provide control unit for each 100 m length of the sensor cable.

## 11.3 Manual Call Point (MCP)/Break Glass Unit (BGU)

- i) Manual break glass unit shall be fabricated out of 14-gauge cold rolled sheet steel. Alternately the break glass unit may be made of die cast aluminium alloy such as LM6.
- ii) It shall have IP-55 enclosure and weatherproof construction suitable for outdoor installation. The break glass unit shall have a minimum dimension of 100x100x80mm.
- iii) The box shall be fabricated in such a way it can be mounted flush to the wall or on the surface without any modification. Two nos. 19 mm knockouts shall be provided at the bottom of the box to facilitate cable / conduit entry. The glass shall cover at least 30cm<sup>2</sup> area and shall have a thickness not exceeding 2mm.
- iv) The box shall have a push button element kept in pressed condition by a glass sheet fitted in the front of the box.
- v) The enclosure shall be painted with fire red colour (shade 536 of IS-5) epoxy painting and an inscription "Break Glass in case of Fire", shall be painted in white letters or riveted on the enclosure by a steel nameplate. A suitable nickel-plated brass hammer, duly chained to the box with stainless steel chain shall be provided with each box for breaking the glass. Each box shall have a distinct identification number boldly painted on it.
- vi) One no. blanking plug shall be provided for 5% of the total quantity of MCPs.
- vii) Hazardous area Break Glass Units shall meet the requirement of clause 13 of this specification.

## 11.4 Response Indicator

Response indicators shall be provided suitable for wall/ ceiling mounting as required. Response indicator shall be provided where the detector is located either above false ceiling or below false floor or where detectors are not directly visible. The response indicators shall be connected to the detectors directly and shall be complete with terminal blocks suitable to accept cables with up to 1.5mm<sup>2</sup> copper conductor. In the normal state of detector, the LEO shall flicker, but in the event the detector goes into alarm condition, the LEO shall glow steadily. LEOs shall be red in colour with 5mm dia. as a minimum.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION</b> <b>(FIRE DETECTION AND ALARM SYSTEM)</b>	PC288-TS-0826	1	 श्री एच डी एल 
		Document No.	Rev	
		Sheet 16 of 20		

## 11.5 Exit signs

Exit signs shall be fabricated out of 1.6mm thick cold rolled sheet steel. This shall be suitable for wall mounting or suspension from ceiling. Exit signs suspended from the ceiling shall have text/ direction printed on both the side of exit sign.

Fire exit shall be displayed by means of 5mm dia LEDs or backlit text. It shall be powered from the fire alarm panel. Exit sign shall operate on DC power supply.

The exit sign shall be either in red letter on white background or white letter on green background.

Where specified in data sheet, self-luminous exit sign shall be provided.

## 11.6 Hooters

The unit shall consist of solid-state circuitry on a printed circuit board, a loudspeaker and a flashing lamp housed in a weatherproof dust tight, wall mounting type enclosure. The hooter shall, at least, have 102 db (A) output measured at 1-meter distance. The unit shall be powered from the fire alarm panel and operate on DC power. In the event of fire, the hooter shall raise pulsating audio alarm and the lamp shall start flashing.

HAB shall be provided at exit doors of buildings to mute the hooters after evacuation.

## 11.7 Flashing Lights (Beacon)

The unit shall consist of solid-state circuitry on a printed circuit board and a red-capped incandescent lamp and audio unit housed in a dust tight, wall/ ceiling mounting type enclosure. It shall derive power from the Fire Alarm Panel and shall operate on DC supply.

Flashing lights shall be installed in the enclosed areas where clean agent/ CO<sub>2</sub> to be released. In the event a signal for clean agent/CO<sub>2</sub>, release is given, the lamp shall start blinking with a warning sound enabling operating personnel to evacuate the area. The audio unit (hooter) shall have 102 db (A) output measured at 1-meter distance.

## 11.8 Fault Isolator

Fault isolator shall be designed to provide short circuit protection to an addressable detector loop. It shall be possible to wire the fault isolator at any point in the detector loop.

On occurrence of a fault (short circuit), the isolator shall cut power to all devices installed between the two isolators minimizing the outage of all the detectors in a loop.

The fault isolator shall have the capability to continuously check the faulted side of the loop to determine if the fault still exists. On rectification of the fault, the isolator shall automatically reset itself.

Fault isolator modules shall be housed in a enclosure having IP-55 degree of protection as a minimum. If located in hazardous area, it shall also be tested and approved for use in area classification defined in the data sheet.



## 11.9 Sirens

Sirens shall be industrial type with minimum 2.5 km unidirectional range (i.e. 5km diametrical range) against the wind direction.

The decibel level of the siren shall, at least be 132 db(A) at 1 meter, to meet the audibility requirement for the above range. Unless otherwise specified, Sirens shall operate at 240 V, AC supply. Sirens shall be housed in weatherproof enclosure.

Starter shall be DOL and shall be housed in a separate IP55 enclosure suitable for installation indoor/ outdoor.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT TECHNICAL SPECIFICATION (FIRE DETECTION AND ALARM SYSTEM)</b>	PC288-TS-0826	1	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 17 of 20		

The siren shall provided with five tones suitable for various conditions as follows:

- i) SMALL FIRE: No siren.
- ii) MAJOR FIRE: A wailing siren for two minutes.
- iii) DISASTER: Same type of siren as in case of Major Fire but the same will be sounded for three times at the interval of one minutes i.e.(wailing siren 2min + gap 1 min + wailing siren 2min + gap 1 min + wailing siren 2min) total duration of Disaster siren to be eight minutes.
- iv) ALL CLEAR (For fire): Straight run siren for two minutes.
- v) TEST: Straight run siren for two minutes at frequency at least once a week.

The siren controller shall be as below:

- a. The operation of siren shall be in Manual mode with single button operation through Push Buttons - 5 Nos. mounted on the control desk for tone selection.
- b. The siren shall be initiated with a single pulse from the Push Button. The logic shall be such that first Push Button pressed shall be accepted till the completion of cycle of that particular siren tone.
- c. One no Push Button shall be provided for EMG STOP in case the siren tone is required to be stopped mid way.

The operation of the siren shall also be possible in Auto mode. The arrangement for the same shall be possible from the Fire Alarm panel

#### 11.10 Clean Agent / CO<sub>2</sub> Release and Inhibit Switches

This unit is required to be provided at the exit of the protected buildings/ rooms. If specified, this unit is integrated with *DGFAP*/ ZFAP. This shall consist of pull type release and inhibit switches clean agent / CO<sub>2</sub>. The unit shall be fabricated out of 2mm thick cold rolled sheet steel suitable for wall mounting. Switches shall be pulled to release or inhibit clean agent / CO<sub>2</sub>. Release switches shall have inscription:




"PULL TO RELEASE CLEAN AGENT / CO<sub>2</sub>"

And inhibit switches shall have inscription:

"PULL TO INHIBIT CLEAN AGENT / CO<sub>2</sub>"

#### 11.11 Zener Barrier

- 11.11.1 Preferably flameproof (Ex'd') equipment that does not require the use of Zener barrier shall be used. When necessary, intrinsically safe (Ex 'i') detectors and MCPs, Zener barriers shall be provided. These shall be located in unclassified/ non-hazardous areas.
- 11.11.2 Normally not more than 10 detectors shall be connected to one zener barrier. However vendor shall indicate maximum number of detectors MCPs that can be connected to one Zener barrier without compromising on working of loop zone. Vendor shall also indicate the maximum loop length from zener barrier considering 1.5 mm<sup>2</sup> copper conductor, screened cable.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION</b> <b>(FIRE DETECTION AND ALARM SYSTEM)</b>	PC288-TS-0826	1	 कोयला इण्डिया  BHEL
		Document No.	Rev	
		Sheet 18 of 20		

11.11.3 In case loop length permits, zener barrier shall be located at DGFAP itself else it shall be located in safe area nearest to the *detector*/MCP.

11.11.4 Wherever zener barriers are provided in safe area outside the Zonal panel or DGFAP, these shall be housed in their own enclosure with IP-55 degree of protection as a minimum.

## 11.12 Fault Isolator

11.12.1 Fault isolator shall be installed, if specified in the data sheet.

11.12.2 Fault isolator shall be designed to provide short circuit protection to an addressable detector loop. It shall be possible to wire the fault isolator at any point in the detector loop.

11.12.3 On occurrence of a fault (short circuit), the isolator shall cut power to all devices installed between the two isolators minimizing the outage of all the detectors in a loop.

11.12.4 The fault isolator shall have the capability to continuously check the faulted side of the loop to determine if the fault still exists. On rectification of the fault, the isolator shall automatically reset itself.

11.12.5 Fault isolator modules shall be housed in a enclosure having IP-55 degree of protection as a minimum. If located in hazardous area, it shall also be tested and approved for use in area classification defined in the data sheet.

## 12.0 FIELD DEVICES FOR HAZARDOUS AREA

12.1 Hazardous area is classified as Zone 1/ Zone 2, gas group IIA/ IIB or IIC, temperature class T3 (200 DC) as specified in data sheet. The field devices shall be suitable for installation in hazardous area as per specified area classification.

12.2 Field devices such as detectors, MCPs, fault isolators, Beacons, hooters etc for use in hazardous area, if specified in the data sheet shall have flame proof enclosure conforming to IS 2148. All equipment for hazardous area installation shall be complete with flame proof, weather proof cable glands as specified in clause 11.5.




12.3 Equipment, which cannot have flameproof construction, shall be intrinsically safe in design and shall be used with Zener barriers located in safe area.

12.4 Equipment that are tested / certified by a recognized test laboratory of country of origin shall only be offered. The vendor shall possess valid test certificate issued by a recognized independent test house such as CMRI/ BASEEFA/ UL/ FM or Equivalent for the offered equipment.

12.5 All equipment (indigenous or imported) shall have valid statutory approval as applicable for the specified hazardous location from CCE or any other applicable statutory authority. All indigenous flameproof equipment shall also have valid BIS license and corresponding marking as required by statutory authority.

12.6 A separate name plate shall also be provided on each equipment to indicate details of testing agency, test certificate number with date, statutory approval number with date, approval agency, BIS license number with date, applicable gas group, temperature class etc. The nameplate shall be riveted/ fixed with screws and not pasted. In case above information are embossed on the enclosure, the same need not be repeated.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION</b> <b>(FIRE DETECTION AND ALARM SYSTEM)</b>	PC288-TS-0826	1	 श्री एच डी एल 
		Document No.	Rev	
		Sheet 19 of 20		

### 13.0 CABLE AND CABLE ACCESSORIES

- a) Supply and laying of FA cables shall be as per the requirement. Vendor shall provide JB's for detectors, BGUs, exit signs, hooters etc as required.
- b) Supply and installation and terminations of all cables at both ends shall be in bidder's scope.
- c) Bidder, as a part of integration and selection of fire alarm equipment, shall furnish detailed specifications for loop/zone cables, data highway cables, cables for hooter/exit signs etc giving details such as type of cables, number of pairs, size of cable, inductance and capacitance data, number of fibres/ connectors etc.

#### d) Data Cables

Unless specified otherwise, vendor shall supply Copper cable/ FO type data communication cable to suit system design and equipment specification. Copper cables, if supplied, shall be of adequate size, twisted pair, PVC insulated, overall screened, PVC inner sheathed, armoured, FR type PVC outer sheathed as the minimum requirement. Fibre Optic cables, if supplied, shall be armoured, overall FR PVC outer sheathed and shall be as per ITU-T recommendation as a minimum.

Vendor shall supply and install all hardware and cabling accessories as per data highway design including modems, repeaters etc as part of the FA system. Modems/ repeaters shall be powered by the supply provided for Fire Alarm panel.

#### e) Cable Glands / Accessories




All cable glands/ lugs/ connectors as required for the equipment shall be included in bidder's scope and shall be supplied along with the system.

All the cable glands for outdoor application shall be weatherproof, nickel-plated brass and double compression type, whereas those for indoor application shall be single compression type.

Cable glands for hazardous area equipments shall be flameproof, weatherproof and nickel plated brass double compression type.

### 14.0 INSPECTION, TESTING AND ACCEPTANCE

- 14.1 All the equipment shall be tested to the defined specifications as per mutually agreed test plan/ FAT procedure, which shall be submitted and got approved from Purchaser at least one month before inspection. PMC/ Purchaser's inspectors shall witness all the tests.
- 14.2 During manufacture, the equipment shall be subject to inspection as per attached inspection plan to assess the progress of work and to ascertain that the quality controls are being maintained. Vendor shall provide all necessary assistance and information concerning the supply to PDIL/Purchaser's inspectors.
- 14.3 Tests shall be carried out at the vendor's works under his care and expense and Purchaser shall be informed at least 4 weeks in advance regarding this.
- 14.4 FAT shall include simulation of operational field conditions and test for functional adequacy. Besides all routine, and acceptance tests specified by applicable codes and standards, shall be performed on the complete system.
- 14.5 For bought out items, the routine and acceptance tests shall be conducted at the respective equipment manufacturer's works.

 <b>पी डी आई एल</b> <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION</b> <b>(FIRE DETECTION AND ALARM SYSTEM)</b>	<b>PC288-TS-0826</b>	<b>1</b>	 <b>कोयला इण्डिया</b>  <b>BHEL</b>
		Document No.	Rev	
		Sheet 20 of 20		

14.6 At the time of inspection, vendor shall produce original of all the type test certificates, test and approval certificates for hazardous area equipment from testing and approving authority and any other certificates as required from statutory authority for the review of inspectors.

14.7 Vendor shall submit a SAT procedure for PMC/ Purchaser's approval. All equipment and systems shall be tested at site as per the approved SAT procedure.

14.8 SAT shall be conducted by vendor after the entire fire alarm system is installed and inter connected by cables. These tests shall establish the operational correctness of the system. Vendor shall rectify deficiencies noticed during SAT with no commercial implication to Purchaser including replacement of system components and supply of new component for making system successfully operational.

## 15.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation i.e. by ship/rail or trailer. The panels shall be wrapped in polythene sheets before being placed in crates to prevent damage to finish. Crates shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight' etc., shall be clearly marked on the package together with Tag nos., Purchase order Nos. etc. The equipment may be stored outdoors for long periods before erection. The packing shall be completely suitable for outdoor storage in areas with heavy rains/ high ambient temperature.

## 16.0 INSTALLATION AND COMMISSIONING

As installation of the system is included in the scope of the vendor, vendor shall arrange all necessary manpower and equipment required for the same. Commissioning of the complete system is to be carried out by vendor in all cases irrespective of whether the installation was performed by vendor or not. All tools, test equipment etc. for the successful commissioning of the system shall be arranged by the vendor. Only the cabling specifically excluded from vendor's scope shall be installed by others. However, termination at panels for purchaser's cables shall be done by the vendor.



## 17.0 TRAINING

The vendor shall provide, free of cost, comprehensive training to Purchaser's personnel on various operation and maintenance aspects of the Fire Alarm system as agreed during ordering.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – DIESEL GENERATOR SETS</b>	PC288-TS-0828	0	 कोयला Coal India  बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 1 of 17		



# **TECHNICAL SPECIFICATION** **DIESEL GENERATOR SET**

## **CONTENTS**


 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – DIESEL GENERATOR SETS	PC288-TS-0828	0	 नवी एण्ड ई एन <b>BHEL</b>
		Document No.	Rev	
		Sheet 2 of 17		

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	DIESEL ENGINE
6.0	GENERATOR
7.0	CONTROL PANEL BOARD
8.0	INSTRUMENTATION
9.0	ACCESSORIES
10.0	PAINTING
11.0	TESTS AND INSPECTION
12.0	SPARES
13.0	PACKING
14.0	DRAWING AND DOCUMENTS
15.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR DIESEL GENERATOR SET

## 1.0 SCOPE

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – DIESEL GENERATOR SETS	PC288-TS-0828	0	 नवी एण्ड ई एन <b>BHEL</b>
		Document No.	Rev	
		Sheet 3 of 17		

- 1.1 This standard covers the technical requirements of design, engineering, manufacture, assembly, testing at works and delivery in well packed condition of diesel generator set (D.G. Set) complete with all required accessories and control equipment to supply continuous electrical power.
- 1.2 This standard is applicable for D.G. set having rating more than 500 KVA.
- 1.1 This standard shall be read in conjunction with relevant part of Design Philosophy – Electrical.
- 1.3 The scope of supply shall include, but not limited to the following:
- Diesel engine, complete with all the required accessories and components.
  - Generator set, for operation with the above diesel engine, complete with all the required accessories and components.
  - Drive coupling between diesel engine and generator set complete with guard.
  - Engine flywheel, if required, with starter ring and guard.
  - Fuel oil system comprising of fuel oil tank, supply pump, filter, piping, valves, fittings etc.
  - Air intake system comprising of air blower, air filter, turbo charger etc.
  - Lubrication oil system comprising of lube oil pump, filter, cooler, piping, valves, fittings etc.
  - Jacket cooling system comprising of radiator, water circulation pump, necessary piping and fittings etc.
  - Starting system complete with battery, battery charger, starter motor, control system etc.
  - All inter connecting piping, valves and fittings up to the battery limits.
  - Torsional vibration damper at the free end of the crank shaft.
  - Speed regulation system.
  - Provision for hand barring of the engine along with the hand barring tool.
  - Platforms, walkways, stairs and hand racks, as required, for adequate access during operation and maintenance.
  - A common base frame suitable for assembly of engine, radiator and alternator with there accessories. Anti, vibration mounting and foundation bolts shall also be supplied. Base frame shall be designed for transportation of above items duly assembled on it.
  - Exhaust manifold complete with silencers, asbestos lagging, metallic expansion bellows and piping as per lay out of D.G. room.
  - All necessary instruments for monitoring and safe starting, running and stopping of the D.G. set their auxiliaries complete with tubing and cabling.
  - Control panel.
  - Cabling material between control panel and all equipment within the battery limit including cables, racks, earthing terminating materials etc.
  - All safety and protective devices.

 <div>पी डी आई एल PDIL</div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div> <div>TECHNICAL SPECIFICATION – DIESEL GENERATOR SETS</div>	PC288-TS-0828	0	 <div>नवी एण्ड ई एन BHEL</div>
		Document No.	Rev	
		Sheet 4 of 17		

- u) All other items not specified here but, necessary for safe, satisfactory and uninterrupted operation of D.G. set.
- v) Set of special tools and tackles required for installation and maintenance.
- w) Spare parts for the specified duration.
- x) All other services as required.

1.4 Erection and commissioning of the above shall be carried out by LSTK Contractor.

## 2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of the following codes and other relevant Indian standard specifications unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

- i) BS 649 - Diesel engines for general purpose.
- ii) IS-10000 - Methods of test for internal combustion engine.
- iii) ASME codes.
- iv) IS 4722 - Rotating Electrical Machines - Specification.
- v) Oil coolers as per TEMA class “C”

2.2 Equipment designed and manufactured to other national standards shall be acceptable provided they are in no way inferior to the above mentioned standards. The Contractor shall supply English version of the relevant standard in such case.

2.3 The design and operational features of the equipment offered shall also comply with the provisions of latest issue of the Indian Electricity Rules and other statutory regulations. The Contractor shall, wherever necessary, make suitable modification in the equipment to comply with the above.

2.4 Wherever any requirement, laid down in this standard, differs from that in Indian standard / IEC, the requirement specified here in shall prevail.

## 3.0 SERVICE CONDITIONS




### 3.1 Ambient Conditions

These shall be as indicated in Design Philosophy – Electrical.

### 3.2 System Details

These shall be as indicated in Design Philosophy – Electrical.

## 4.0 OPERATING REQUIREMENTS




 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – DIESEL GENERATOR SETS</b>	<b>PC288-TS-0828</b>	0	 नवी एण्ड ई एन 
		Document No.	Rev	
		Sheet 5 of 17		

- 4.1 The D.G. set shall be suitable for “black start” operation. The equipment offered shall be suitable for operating at their rated capacity continuously under the ambient conditions and voltage & frequency variations indicated in Design Philosophy – Electrical, without exceeding the temperature rise limits specified in relevant standards and without any detrimental effect on any part.
- 4.2 The D.G. set shall be designed for continuous operation at full load or partial load and have the capability to run at 110% of the MCR for one hour in every 12 hrs.
- 4.3 The D.G. set covered under this standard shall be meant to supply power in one of the following modes.
- Type A - Emergency power i.e. to provide reliable power due to failure or outage of normal supply automatically within a specified time to critical devices and equipment of the installation.
- Type B - Stand by power i.e. to provide reliable power due to failure or outage of the normal supply to all devices and equipment of the installation.
- Type C - Backup power i.e. to provide reliable power due to restriction imposed by the supply authorities of the normal supply to some section of the installation.
- 4.4 The D.G. set meant to supply emergency power (Type A) should start automatically and quickly on receipt of starting impulse from owner’s remote panel after prolonged idle period. Under such conditions, the auxiliary power and cooling water shall not be available. The starting and lubrication system shall be suitably designed to take care of these conditions and allow easy, safe and quick starting. The loading sequence and its duration are as specified by Owner elsewhere.
- 4.5 The D.G. set meant to supply standby power (Type-B) shall be started automatically and conditions mentioned above shall also apply. However, the loading sequence is not automatic and hence need not be defined by Owner.
- 4.6 The D.G. set meant to supply backup power (Type-C) shall be manually controlled and started manually. Idle period may not be long and the requirement of auxiliary power and cooling water can be ensured due to the availability of the normal supply.

## **5.0 DIESEL ENGINE**

### **5.1 General Design Feature**

- 5.1.1 The diesel engine shall be of multistroke, multicylinder with mechanical fuel injection arrangement and complete with all the required accessories.
- 5.1.2 The engine output shall be at least 25% greater than the power required for the loads (including internal consumption by D.G. set) and loading sequence as required.
- 5.1.3 The engine shall be suitable for trouble free operation with high speed diesel conforming to IS: 1460.
- 5.1.4 The unbalance force transmission to the foundation shall be minimum. Critical speed of the assembly shall be sufficiently higher than the rated speed of the engine.
- 5.1.5 The engine shall be provided with turbo charger, filter and silencer mounted suitably on the engine frame and complete with necessary ducts work for air intake.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – DIESEL GENERATOR SETS	PC288-TS-0828	0	 नवी एण्ड ई एन 
		Document No.	Rev	
		Sheet 6 of 17		

5.1.6 The engine shall be provided with exhaust silencer, necessary ducts, minimum 2 nos. expansion bellows and supporting arrangement from ceiling for exhausting the gases to outside.

## 5.2 Fuel Oil System

5.2.1 The system shall comprise of gravity fed oil tank, unless otherwise specified.

5.2.2 The gravity tank shall be complete with the provision of filling up by Motor driven pump and Hand Pump from the standard drums. The motor driven pump and associated hose pipe shall be provided by the Contractor.

5.2.3 The gravity fed oil tank shall be located at a height from floor and near the wall of the engine room. Suitable brackets / structure shall be provided by the Contractor for this purpose. The tank shall be fabricated out of M.S. plates in cylindrical construction. The capacity of the tank shall be adequate for 24 hours continuous running of the engine at full load. . It shall be complete with valves for filling & draining, vent connection, level gauge glasses, level switches for low level alarm.

## 5.3 Jacket Cooling System

5.3.1 The engine shall be provided with radiator type air cooling system.

5.3.2 All the necessary items for the system such as water pump, radiator, fan, piping and fittings shall be provided to make the system complete in all respects.

5.3.3 Head tanks, if required, shall be included in the scope of supply for make up water as well as taking care of the expansion of the jacket water.

## 5.4 Lube Oil System

5.4.1 Proper lube oil system shall be provided for all lubricating points of the engine. The system shall be automatic pressure feed type and provided with a gear type pump driven from the crank shaft. The system shall be complete with fine wire mesh duplex strainer, valves, tank, oil cooler, header and branch piping suitably mounted on bed plate. Necessary accessories like pressure gauge, temperature and pressure switches for alarm and controls shall be provided.

5.4.2 The cooler shall be shell and tube type and connected to the engine cooling water system.

## 5.5 Starting System

5.5.1 The Electrical starting system shall be provided up to 1000 KVA DG set. However, for more than 1000 KVA DG set electrical / pneumatic starting shall be provided.



5.5.2 Both manual and automatic starting scheme shall be provided. The manual starting system shall be local while automatic starting system shall be suitable for impulses from owner's remote panel.

5.5.3 The starting system shall be such that the D.G. set shall start & come up to rated speed and be ready to accept full load within the period as per the process requirement .

5.5.4 The electric starting system shall comprise of starter motor, battery, battery charger, necessary cabling, required instruments and accessories.

5.5.5 The Ni-Cd battery shall be heavy duty type and suitable for 20 successive starting attempts of the engine without draining. The charger shall have both float / boost



 <div>पी डी आई एल PDIL</div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div> <div>TECHNICAL SPECIFICATION – DIESEL GENERATOR SETS</div>	PC288-TS-0828	0	 <div>नवी एण्ड ई एन BHEL</div>
		Document No.	Rev	
		Sheet 7 of 17		

charging facilities. The battery shall be complete with suitable stand and other required accessories.

5.5.6 The pneumatic starting system may comprise of a camshaft driven rotary air distributor admitting air to a series of automatic air starting valves fitted on individual cylinder heads or an air cranking motor operating through a ring gear on the engine fly wheel. The pneumatic starting system shall consist of:

- One 100% capacity A.C. motor driven air compressor, additional engine driven air compressor shall be provided, as required.
- One air receiver of adequate capacity to supply air for minimum six (6) starts of engine.
- Solenoid operated valves.
- Pressure switches for automatic starting and stopping of the compressor.
- After-coolers for compressor, if required, suitable for raw cooling water.

5.5.7 The compressor for charging the starting air receiver shall be driven by an A.C. motor. The starting and stopping of this motor driven compressor shall be controlled automatically by suitable pressure switches so that the air receiver remains charged always.

5.5.8 Contractor shall provide all necessary devices including solenoid valves so that with an impulse for starting of the engine received from emergency equipment or manual start push button, the entire operation of starting of the diesel set shall take place automatically.

## 5.6 Governing System

5.6.1 The speed governing system of the diesel engine shall satisfy the following requirements:

- Steady state speed regulation shall be adjustable between 0 to 5% manually.
- Steady state speed regulation once fixed, shall not vary beyond + 0.5%.
- Transient speed regulation shall not exceed 4.5% of rated speed. Momentary under speed and over speed shall not exceed 2% and 8% respectively.
- Recovery time shall be within 3 seconds.

5.6.2 The governor system shall be electronic type and provided with adequate scheme to control the speed in the event of failure of power to the governor.

5.6.3 A mechanical over speed trip device shall be provided to operate at 110% of rated speed.

5.6.4 An engine mounted emergency push button shall be provided to trip the engine in case of emergency.

5.6.5 Separate Tachometer shall be provided to indicate the speed of the engine locally.



## 6.0 GENERATOR

### 6.1 General Design Features

6.1.1 The generator shall be directly coupled to the engine.

6.1.2 The ingress protection class of the enclosure shall be IP44 as per IS: 4691.

6.1.3 The generator and its accessories shall be capable of withstanding electrical, mechanical and thermal stresses while meeting the performance requirements.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – DIESEL GENERATOR SETS	PC288-TS-0828	0	 नवी एण्ड ई एन <b>BHEL</b>
		Document No.	Rev	
		Sheet 8 of 17		

6.1.4 The generator shall be synchronous A.C. Generator; star connected and shall have C.M.R. of specified output at 0.8 lag p. f. at rated voltage and frequency.

## 6.2 Winding and Insulation

6.2.1 The stator and rotor coils shall be made out of electrolytic grade copper conductors. Successive coils shall be connected by accessible and well brazed joints.

6.2.2 The coils shall be class F insulated and treated with tropical and fungicidal treatments.

6.2.3 The windings shall be dried, properly impregnated with suitable varnish to withstand the site conditions and properly baked. At least two additional impregnations and baking shall be applied to the assembled coil making a total of three impregnations and baking. Finally the windings shall be painted with special anti-acid and anti-alkali paint to withstand the site condition.

6.2.4 The leading wire between the windings and the outside terminals shall be through bushings.

## 6.3 Performance Requirement

6.3.1 The generator and the diesel engine shall match properly to deliver the rated load under the specified ambient and system conditions.

6.3.2 The specified rating of the D.G. set indicated are net electrical power output required for owner's use and does not include the power required by the auxiliaries of the diesel set. The actual output rating of the generator to be offered by Contractor shall take into account the power requirement of the auxiliaries, 15% extra margin.

6.3.3 The generator shall have an overload capacity of 10% for 1 hour in any consecutive period of 12 hours after having attained the thermal equilibrium corresponding to the rated load. The terminal voltage shall be equal to the rated value. At the time of switching 'ON' the emergency loads, restarting or reacceleration of squirrel cage motors shall be required, in addition to switching 'ON' of the lighting loads, which will be six times the rated load at power factor of 0.35 lagging. The generator and its accessories shall be capable of supplying this load at the above mentioned low power factor. Limitations, if any, shall be clearly indicated by the Contractor.

6.3.4 The transient reactance shall be as low as possible to limit the voltage drop to 10% due to above loading conditions.

### 6.3.5 Largest Motor Starting Requirement


The D.G. set shall be designed such that it can start squirrel cage induction motor of specified rating by D.O.L. starting method when already loaded up to 80% of its rated load. The voltage dip at the generator terminal shall not exceed 10% of its rated voltage during the entire starting period which will not exceed 5 seconds.

Limitations of the engine size offered by the bidder, if any, shall be indicated clearly by the bidder.

Supporting calculation shall be supplied by the successful bidder for approval of the owner.

6.3.6 The short circuit ratio, of the generator at rated KVA and rated voltage shall not be less than 0.5.

6.3.7 The generator shall withstand 20% over speed for 2 minutes without any damage to any part.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – DIESEL GENERATOR SETS	PC288-TS-0828	0	 नवी एण्ड ई एन <b>BHEL</b>
		Document No.	Rev	
		Sheet 9 of 17		

6.3.8 The generator shall be capable of withstanding the three phase short circuit at its terminals while operating at its voltage without sustaining any damage.

6.3.9 The temperature rise of stator windings, exciter and other parts shall not exceed the limits specified in relevant IS.

#### 6.4 **Excitation System**

6.4.1 The generator shall be provided with static brushless excitation system comprising of shaft driven rotor exciter, thyristor and other associated items.

6.4.2 The armature and field windings shall be class F insulated similar to that of generator.

6.4.3 The capacity of the system shall be adequate to meet the performance and largest motor starting requirement of the generator.

#### 6.5 **Voltage Regulator**

6.5.1 The generator shall have static type voltage regulators to be mounted on the control panel. The regulator system shall be suitable to meet the following requirements:

- Allow the generator to meet the performance requirements.
- Both auto and manual control.
- Prevent automatic rise of field voltage in the event of excitation supply failure.
- Transfer to manual mode in the event of control circuit failure in auto mode.
- Operated by the output current and voltage of the generator.

#### 6.6 **Space Heater**

6.6.1 Space heaters rated for 240V A.C. shall be provided to keep the winding dry during idle conditions.

6.6.2 The location of the space heaters shall be such as to allow easy access for inspection, maintenance and replacement.

#### 6.7 **Embedded Temperature Detectors**

6.7.1 The generators shall be provided with 6 nos. of embedded resistance temperature detectors for measurement of winding temperature. Three of these shall be provided between the coils, one in each phase and the other three at the base of the slots, one in each phase, placed 120° apart.

6.7.2 The ETD's shall be of platinum having 100 ohm resistance at 0°C and temperature coefficient as  $3.85 \times 10^{-5}$ .



6.7.3 The ETD's shall be 3 lead type having power frequency insulation level of 2 KV.

6.7.4 The temperature indicator with selector switches shall be provided in the control panel.

#### 6.8 **Terminal Boxes**

6.8.1 All the terminal boxes shall have IP-54 degree of protection.

6.8.2 The power and control terminal boxes shall be separate. All the six leads of the generator stator shall be taken out, three to one side and three to the other side to separate power terminal boxes.

 <div>पी डी आई एल PDIL</div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div> <div>TECHNICAL SPECIFICATION – DIESEL GENERATOR SETS</div>	PC288-TS-0828	0	 <div>नवी एण्ड ई एन BHEL</div>
		Document No.	Rev	
		Sheet 10 of 17		

- 6.8.3 The power terminal box shall be spacious and have adequate clearance between the terminals and the cable gland for proper termination of required nos. of aluminium cables.
- 6.8.4 The power terminal boxes shall be provided with tinned copper sockets suitable for crimping.
- 6.8.5 The control terminal boxes shall be provided with pressure type terminal blocks.
- 6.8.6 All terminal boxes shall be complete with heavy duty double compression type aluminium cable glands suitable for the cable sizes required.



## 7.0 CONTROL PANEL BOARD

### 7.1 Requirements

- 7.1.1 The control panel board shall comprise of control & instrument section, power & protection section and distribution section for satisfactory and trouble free operation of the set. Each section shall be a complete panel.
- 7.1.2 The control and instrument panel shall house the following:
- All the required controlling elements for the engine, generator and exciter control, for both manual and automatic operations.
  - Panel mounted instrument
  - The required protective devices for the engine.
  - The audiovisual annunciation system indicating abnormal operating conditions.
  - Control switches and indicating lamps.
  - Automatic voltage regulator.
  - All other items, as required.
- 7.1.3 The power and protection panel shall house the following:
- Circuit breaker in draw out execution suitable for local/remote operation and provided with protective relays, C.T.s Ammeters, Voltmeters, KWH meters, Frequency meters, ON/OFF/Trip indicating lamps, control switches etc. for the control of generator.
  - M.W.S. operated A.C.B. in draw-out execution suitable for local remote operation and provided with protective relays, C.T.s, Ammeters, ON/OFF/Trip indicating lamps, control switches etc. for the control of outgoing power feeders, as indicated else where.
- 7.1.4 The distribution panel shall house the following:
- Necessary feeder circuit outlets complete with switches, fuses, contactors, overload devices, ON/OFF/Trip indicating lamps, Ammeters etc. for the D.G. set auxiliaries, if required.
  - D.C. battery charging equipment required for the start up and control of the D.G. set. The charger shall be complete with float and boost charging arrangement both in auto and manual mode.

### 7.2 General Design Features

- 7.2.1 The panels shall be free standing, floor mounting, identical, metal clad cubicle type in construction and placed side by side to form a compact assembly in dust/ damp and vermin proof type equivalent to IP-54 as per IS-13947 Part-1.

 <div>पी डी आई एल PDIL</div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div> <div>TECHNICAL SPECIFICATION – DIESEL GENERATOR SETS</div>	PC288-TS-0828	0	 <div>नवी एण्ड ई एन BHEL</div>
		Document No.	Rev	
		Sheet 11 of 17		

- 7.2.2 The thickness of sheet steel members shall not be less than 2 mm for cold rolled steel. Suitable reinforcement, wherever necessary, shall be provided. The base channel shall be more than 3 mm thick.
- 7.2.3 The door hinge shall be concealed type. All threaded screws in the removable parts shall be provided with retaining rings.
- 7.2.4 All the components shall be accessible for checking and taking off without the necessity of removing the adjacent ones. Their mounting shall be accessible and ensure the necessary degree of safety.
- 7.2.5 The relays, meters, switches and lamps shall be flush mounted type. Their minimum mounting height shall be 900 mm from the base of the panel.
- 7.2.6 The bus bars shall be for three phase and neutral and made of electrolytic copper or aluminium of required cross section and PVC sleeved. These shall be amply sized to carry the rated continuous current under the specified ambient temperature without exceeding the total temperature of 90°C. The thermal rating of the bus bars shall be designed to withstand the system fault current for one second without exceeding the temperature of 250°C for bare copper.

7.2.7 The clearances and creepage distance shall not be lower the values specified below:

### 7.3 Control Wiring

7.3.1 The panel board shall be completely factory wired and ready for external connections.

- Minimum clearance between two live conductors - 20 mm.
- Minimum clearance between live parts and accidentally dangerous part - 20 mm.
- Minimum creepage distance - 28 mm.

7.3.2 The wiring shall be carried out with flexible stranded PVC insulated copper conductor cables for 1100 volts grade.

The size of wires shall be as follows:

C.T. Circuit - 2.5 sq. mm copper

V.T. & Control circuits - 1.5 sq. mm copper


7.3.3 All wiring shall be marked in accordance with IS-375. Numbered Ferrules reading from the terminals outwards shall be provided at both ends of all wiring for easy identification. These shall be interlocking type plastic ferrules.

### 7.4 Circuit Breakers

7.4.1 The circuit breakers shall generally comply with the requirements of IS: 13947, having P2 category, capable of carrying the specified current at the site conditions and making/ breaking of the system fault current.

7.4.2 Type test certificates from an independent testing authority shall be furnished along with the offer, for each circuit breaker rating, which shall clearly prove the capability of circuit breakers and include the short circuit tests, temperature rise test, electrical overload tests and endurance test (both electrical and mechanical).

7.4.3 The circuit breakers shall be provided with motor wound spring closing mechanism and electrically and mechanically trip free and have anti pumping features.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – DIESEL GENERATOR SETS	PC288-TS-0828	0	 नवी एण्ड ई एन <b>BHEL</b>
		Document No.	Rev	
		Sheet 12 of 17		

7.4.4 The circuit breakers shall have three positions for service, test and isolated with the cubicle door closed, and position indicators provided to indicate the positions of the breaker. Stoppers shall be provided to prevent excessive movement of the breaker cradle than desired, for each position. Each position of the breaker shall have monitoring switch having 1 NO + 1 NC contacts.

7.4.5 Provision shall be made for testing the circuit breaker in test position.

7.4.6 Automatic safety shutters shall be provided to screen the cable and the bus bars spouts when the circuit breaker is withdrawn from the cubicle.

7.4.7 The circuit breakers shall be provided with an emergency manual trip device, mechanical 'ON' 'OFF' and 'ISOLATED' position indicators and operation counter.

7.4.8 Mechanical safety interlock shall be provided for safe operation movement of the breaker.

7.4.9 The closing coil and other associated auxiliary relays shall operate satisfactorily at all voltages between 85 to 110% of the rated control voltage. The tripping coil and other associated relays shall operate satisfactorily at all voltages between 70 to 110% of the rated control voltage.

#### 7.5 **Control Fuses**

The fuses shall be of non-deteriorating HRC cartridge link type and conform to IS: 2208. They shall be suitable for the load and the service required in the circuit.

#### 7.6 **Current Transformers**

7.6.1 C.T's shall be cast resin emulated, accuracy class as per IS-2705, 1 for metering and SP/PS for protection.

7.6.2 All the C.T's shall be provided with terminals and shorting links. One of the terminals of the C.T.s shall be earthed. The polarity of the C.Ts shall be clearly marked.

#### 7.7 **Voltage Transformer**

The V.T. shall be cast resin insulated having secondary terminal voltage of 110V unless specified otherwise and accuracy class of shall be 1 as per IS: 3155 and provided with primary / secondary fuses.

#### 7.8 **Relays**




All protective relays shall be provided in drawout and dust proof cases and shall be flush mounted type. They shall be fully tropicalised. Relays shall be of make and type as approved.

The following protective relays shall be provided.

- i) IDMTL over current and Residual earth fault.
- ii) IDMTL standby earth fault.
- iii) Over voltage or under voltage
- iv) Reverse power
- v) Hand reset tripping relay

#### 7.9 **Instruments and Metering**



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – DIESEL GENERATOR SETS	PC288-TS-0828	0	 नवी एरा डी एनए 
		Document No.	Rev	
		Sheet 13 of 17		

- 7.9.1 All instruments shall be flush mounting type with square face of 96 sq. mm. They shall be tropicalised and dust tight. Make and type of instruments shall be as approved.
- 7.9.2 Marking of the scale shall be black on white background and suitable for direct reading.
- 7.9.3 Zero adjusters shall be provided for operation from the front of the cases.
- 7.9.4 All indicating instruments shall be moving iron spring controlled type of class 1.5 accuracy as per IS: 1248.
- 7.9.5 The KWH meter shall be as per relevant IS and provided with test blocks for current and voltage coils for testing them at site without interrupting their recording while in service.
- 7.9.6 The following instruments shall be provided.
- Voltmeter with selector switch
  - Ammeter with selector switch
  - Frequency meter
  - KW meter
  - KWH meter

#### 7.10 **Signal Lamps**

LED type signal lamps shall be provided to indicate the various circuit conditions and these shall be placed at suitable height. The colour of the lamps for various functions shall be as follows:

Red	-	Circuit breaker 'ON'
Green	-	Circuit breaker 'OFF'
White	-	Trip circuit healthy
Amber	-	Alarm and auto trip fault
Blue	-	Non trip fault

#### 7.11 **Name Plate**



- 7.11.1 The panel board shall have a large name plate on the top to indicate its name and designation. Each feeder shall be provided with name plates. Each panel shall have name plates both in front and back.
- 7.11.2 All control switches, push buttons, lamps etc. shall have function identification labels.

#### 7.12 **Cable Termination**

Necessary cable glands and lugs for power and control cables shall be provided.

### 8.0 **INSTRUMENTATION**

- 8.1 The instrumentation requirement shall include field / panel mounted instruments, push buttons, lamps, audio-visual alarm system and other accessories as required.
- 8.2 The provision required in the control panel board shall include the followings:
- Multipoint electronic self balancing temperature indicator with selector switch for generator winding.
  - Tachometer for engine speed.
  - Fuel oil day tank level indicator.
  - Audio-visual alarm system for:

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – DIESEL GENERATOR SETS	PC288-TS-0828	0	 नवी एण्ड ई एन <b>BHEL</b>
		Document No.	Rev	
		Sheet 14 of 17		

- a) Low lube oil pressure
- b) Over speed of engine
- c) High jacket water temperature
- d) Low jacket water pressure
- e) Winding temperature high
- f) All shutdown condition
- g) Other abnormal conditions, as required

v. Shutdown system for:

- a) Maximum jacket water temperature
- b) Engine over speed
- c) Minimum lube oil pressure
- d) High winding temperature
- e) Generator faults
- f) Faults in the excitation system
- g) Failure of engine to start after a preset time
- h) Other faults, as required

vi. Excitation control system complete with:

- a) Rheostat for manual control
- b) Automatic voltage regulator
- c) Field discharge resistance
- d) Diodes / Rectifiers
- e) All other items, as required

vii. Engine control system complete with:



- a) Auto / manual switch
- b) Control equipment and circuitry for Auto Mains Failure starting other than for type 'C' sets.
- c) Push buttons and other control equipment for manual start.
- d) Equipment and circuitry for pre-start priming, if required.
- e) Equipment and circuitry for repeated attempt to start.
- f) Indicating lamps for fail to start.
- g) Audio visual alarm as specified and required.
- h) Instrumentation as specified and required
- i) Operation hour counter
- j) All other items, as required

8.3 The field mounted instruments shall include the followings:

- a) Pressure gauge for lube oil
- b) Dial type thermometer for jacket water and various bearings.
- c) Tachometer for engine speed.
- d) Fuel oil day tank level indicator.
- e) Other items, as required.

8.4 The supply shall be complete with all instrument erection materials with 10% extra provision.



<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – DIESEL GENERATOR SETS</div>	PC288-TS-0828	0	<div> नवी एण्ड ई एन <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 15 of 17		

8.5 All instruments, shall be suitable for site maximum ambient temperature, All electrical and electronic instruments shall be tropicalised and fungus proof.

## 9.0 ACCESSORIES

The D.G. set shall be complete with all required accessories, whether indicated or not, to make the installation complete in all respects and to ensure its safe and proper operation.

## 10.0 PAINTING

The enclosures, after suitable pre-treatment, shall be painted with two coats of anti rust paint followed by two coats of anti-corrosive epoxy based paints.

## 11.0 TESTS AND INSPECTION

11.1 All routine tests as per relevant standards shall be carried out in the presence of Owner's representative.

11.2 The D.G. set shall be tested for output, general performance, overloads and other tests sufficient to prove the correctness of the design both at works and at site.

11.3 In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and site inspection.

11.4 These inspections shall, however, not absolve the Contractor free from his responsibility for making good any defect which may be noticed subsequently.

## 12.0 SPARES

12.1 Spares for operation and maintenance

Item wise unit prices of spare parts shall be quoted.

12.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval..

12.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

12.4 All spare parts shall be identical to the parts used in the equipments.




## 13.0 PACKING

13.1 The equipment shall be properly packed before despatch to avoid damage during transport, storage and handling.

13.2 The equipment shall be wrapped in polythene to make it water proof. Bags of silica gel shall be kept inside to absorb moisture present during transport and storage. An additional wrapping with bitumen paper shall also be provided before the equipment is packed in wooden crates.

13.3 A sign indicating the position of the equipment placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.

## 14.0 DRAWING AND DOCUMENTS

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION – DIESEL GENERATOR SETS</b>	<b>PC288-TS-0828</b>	<b>0</b>	 नवी एण्ड ई एन 
		Document No.	Rev	
		Sheet 16 of 17		

14.1 Drawings and documents as per Annexure-I shall be supplied unless otherwise specified.

14.2 All drawings and documents shall have the following descriptions written boldly.

- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description


## 15.0 DEVIATIONS

15.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

## ANNEXURE – I

### DOCUMENTATION FOR DIESEL GENERATOR SET

Sl.No.	Description	Documents Required (Y / N)
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 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION – DIESEL GENERATOR SETS	PC288-TS-0828	0	 नवी एरा डी एनए <b>BHEL</b>
		Document No.	Rev	
		Sheet 17 of 17		

		With Bid	For Approval	Final
1	Specification Sheet, duly completed	N	Y	Y
2	Technical Particulars, duly filled-in	N	Y	Y
3	General arrangement and foundation drg. for all the equipment.	Y	Y	Y
4	Civil scope drawings	N	Y	Y
5	Earthing layout	N	Y	Y
6	Terminal arrangement drg. and Interconnection.	N	Y	Y
7	Sectional view of D.G. Set	N	N	Y
8	Illustrative and descriptive literature.	Y	N	Y
9	Catalogue for bought out accessories.	Y	N	Y
10	Installation operation & maintenance manual	N	N	Y
11	Type test certificates for engine, alternator and circuit breaker	Y	N	Y
12	Guarantee certificate	N	N	Y
13	Spare parts list with identification	N	N	Y
14	Calculations for justifying DG set size offered with respect to load and starting of largest load.	Y	N	Y

**Note:**




1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION</b> <b>(AUXILIARY SERVICE TRANSFORMER)</b>		PC288-TS-0829	0
			Document No.	Rev
			Sheet 1 of 8	





# **TECHNICAL SPECIFICATION** **AUXILIARY SERVICE TRANSFORMER**

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION (AUXILIARY SERVICE TRANSFORMER)	PC288-TS-0829	0	 कोयला कोयला 
		Document No.	Rev	
		Sheet 2 of 8		

## CONTENTS

SECTION NUMBER	DESCRIPTION	SHEET NUMBER
1.0	SCOPE	3
2.0	STANDARDS TO BE FOLLOWED	3
3.0	SERVICE CONDITIONS	3
4.0	OPERATING REQUIREMENTS	3
5.0	GENERAL DESIGN FEATURES	3
6.0	CONSTRUCTIONAL FEATURES	5
7.0	FITTINGS	5
8.0	PAINTING	6
9.0	TESTS AND INSPECTION	6
10.0	DRAWINGS AND DOCUMENTS	6
11.0	SPARES	7
12.0	PACKING	7
13.0	DEVIATIONS	7
ANNEXURE - I	DOCUMENTATION FOR AUXILIARY SERVICE TRANSFORMERS	8

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION (AUXILIARY SERVICE TRANSFORMER)	PC288-TS-0829	0	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 3 of 8		

## 1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, manufacture, testing at works and despatch in well packed condition of auxiliary service transformers.
- 1.2 This standard shall be applicable for 3 phase / single phase, separate winding transformers of rating below 315 KVA used for Auxiliary services such as lighting, control, Instrument supply etc.
- 1.3 This standard shall be read in conjunction with the relevant specification sheet.

## 2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of following Indian Standards. Equipment complying with equivalent IEC standards shall also be acceptable.
  - IS: 1180 Part -- Outdoor type 3 phase distribution transformers up to and  
- 1 & 2 including 100 KVA, 11 KV
  - IS: 2026 -- Power transformers
  - IS: 11171 -- Dry type power transformers
- 2.2 The design and operational features of the equipment offered shall comply with the provisions of the latest issue of the Indian Electricity Rules and other relevant statutory acts and regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.
- 2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

## 3.0 SERVICE CONDITIONS

### 3.1 Ambient Conditions

These shall be as indicated in Design Philosophy – Electrical.

### 3.2 System Details

These shall be as indicated in Design Philosophy – Electrical.



## 4.0 OPERATING REQUIREMENTS

- 4.1 The transformer shall be suitable for operating at the rated capacity continuously at any of the taps, under the ambient conditions and with the voltage and frequency variations as indicated in specification sheet without exceeding the permissible temperature and without any detrimental effect on any part.

## 5.0 GENERAL DESIGN FEATURES

### 5.1 Rated voltage and frequency

These shall be as indicated in Design Philosophy – Electrical.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION</b> <b>(AUXILIARY SERVICE TRANSFORMER)</b>	<b>PC288-TS-0829</b>	<b>0</b>	 श्री एच ई एल 
		Document No.	Rev	
		Sheet 4 of 8		

## 5.2 Phase connections

### 5.2.1 Three phase transformer

The primary winding shall be connected in delta and secondary winding in star with neutral point earthed (Vector group Dyn-11)

### 5.2.2 Single phase transformer

Primary winding shall be connected between two phases of a 3 phase system or to the three phases in open delta execution as specified in specification sheet and secondary single phase winding shall have one terminal earthed with the tank through link inside the secondary terminal box.

## 5.3 Tapping

5.3.1 The transformers shall be provided with off circuit tap changer with tapping of  $\pm 2.5\%$  and  $\pm 5\%$ .

5.3.2 For transformers having primary 3.3 KV and above, tap changing shall be effected with an externally operated handle, capable of being padlocked in any position on the primary side.

5.3.3 For transformers having primary 415V and below, tap changing shall be effected by means of links in the terminal chamber on the primary side.

## 5.4 Impedance voltage

The impedance voltage of the transformer at 75°C shall be 4% unless indicated otherwise in specification sheet.

### 5.4.1 Losses

The losses shall be indicated by the vendor and shall be guaranteed, within tolerable limits specified in IS: 2026 at rated voltage and frequency.

### 5.4.2 Terminal Arrangement



The primary and secondary side terminals shall be brought outside the tank through porcelain bushing in dust and weather proof terminal boxes, with links for tap changing where required and suitable heavy duty double compression type aluminium cable glands and cable lugs for receiving cables as indicated in specification sheet. The neutral point of the secondary winding shall be brought out separately and earthed to the transformer body through test link. Terminal board for the primary and the secondary winding shall be amply sized and made of SRBP/ FRP materials.

### 5.4.3 Resistance to short circuit

The transformers shall be able to with stand electrodynamic stresses due to terminal short circuit of the secondary assuming primary side fed from the infinite bus.

### 5.4.4 Cooling System

Transformers rated up to 50 KVA shall be natural air cooled type and above 50 KVA shall be natural oil cooled / natural air cooled type as indicated in specification sheet.

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>TECHNICAL SPECIFICATION</b> <b>(AUXILIARY SERVICE TRANSFORMER)</b></div>	<div>PC288-TS-0829</div>	<div>0</div>	<div><p>बी एच ई एल <b>BHEL</b></p></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 5 of 8</div>		

## 6.0 CONSTRUCTIONAL FEATURES

### 6.1 Core

The transformer core shall be of high grade non ageing electrical silicon cold rolled magnetic sheet steel of low hysteresis loss and high permeability. The maximum flux density in any part of the core and yoke at rated voltage and frequency shall not exceed 1.7 Tesla for oil cooled transformers and 1.3 Tesla for air cooled transformers.

6.1.1 The tank for oil cooled transformer shall be made of mild steel plate of adequate thickness. Cooling tubes, where necessary, shall be provided.

6.1.2 Air cooled transformer shall be sheet steel enclosed having minimum thickness of 2.0 mm and shall be provided with suitable reinforcement as required. The minimum degree of protection for the enclosure shall be IP: 31. Ventilating louvers, if provided, shall be covered by fine wire mesh.

6.1.3 All external hardware shall be cadmium plated.

### 6.2 Windings

6.2.1 Coil shall be made out of electrolytic grade copper conductor.

6.2.2 Class-F / class-H insulating material shall be used for air cooled transformers.

6.2.3 For oil cooled transformer class-A insulating material shall be used. Mineral oil shall comply with IS: 325. 10% extra oil shall be supplied along with transformer in non-returnable drums.

6.2.4 Winding assembly shall be dried and impregnated in vacuum with tested insulating oil / varnish.

### 6.3 Bushing

The bushing insulators shall be rated for the maximum system voltage and shall comply with the requirement laid down in IS: 2099 / IS: 7421. The minimum current rating shall be 250A.

## 7.0 FITTINGS




7.1 Following fittings shall be provided for air cooled transformers.

- i) Rating and diagram plate
- ii) Lifting lug
- iii) Primary and secondary cable boxes with heavy duty double compression type aluminium cable glands and lugs.
- iv) Earthing terminals
- v) Rollers (for 25 KVA and above)

7.2 In addition to the above following fittings shall be provided for oil cooled transformer.

- i) Oil conservator complete with drain plug, oil filling hole with cover and oil level indicator with minimum marking.
- ii) Silica gel breather
- iii) Dial type thermometer
- iv) Oil sampling cum drain valve



<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION (AUXILIARY SERVICE TRANSFORMER)</div>	<div>PC288-TS-0829</div>	<div>0</div>	<div> श्री एच ई एल </div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 6 of 8</div>		

- v) Explosion vent
- vi) Air release plug

7.3 Any other fittings which may be necessary for satisfactory operation of the transformer shall also be provided.

7.4 All fittings shall conform to relevant Indian Standards.

## 8.0 PAINTING

8.1 The surface shall be painted after removing all dust, scale and foreign adhering matter. All traces of oil and greases should be removed by suitable treatment.

8.2 All steel surfaces in contact with insulating oil shall be painted with heat resistant oil insoluble insulating varnish.

8.3 All steel surfaces exposed to outside shall be painted with suitable anti rust and anti corrosive paints. Epoxy paints shall be used, if indicated in specification sheet.

8.4 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

8.5 Unless otherwise specified, the finishing shade shall be light grey shade no. 631 as per IS: 5.

8.6 1 litre paint per air / oil cooled transformer shall be supplied for touch up at site.

## 9.0 TESTS AND INSPECTION

9.1 All transformers shall be routine tested as per IS: 2026.

9.2 Additional tests, wherever specified, shall be carried out on one transformer of each rating.

9.3 All the above mentioned tests shall be carried out in the presence of purchaser's representative. In addition, the transformer shall be subjected to stage inspection at works and inspection at site for final acceptance.



9.4 These inspections shall, however, not absolve the vendor from his responsibility for making good any defect which may be noticed subsequently.

## 10.0 DRAWINGS AND DOCUMENTS

10.1 The drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

10.2 All drawings and documents shall have the following descriptions written boldly.

- Name of client
- Name of Consultant
- Enquiry / Order No. with plant / project name
- Equipment Code no. and Description

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION (AUXILIARY SERVICE TRANSFORMER)	PC288-TS-0829	0	
		Document No.	Rev	
		Sheet 7 of 8		

## 11.0 SPARES



- 11.1 Commissioning Spares: Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval.
- 11.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 11.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 11.4 All spare parts shall be identical to the parts used in the equipment.

## 12.0 PACKING

- 12.1 The transformers shall be suitably packed in wooden crates to avoid damage in transit. Oil cooled transformers shall be properly sealed so as to completely exclude oxygen and moisture from coming in contact with oil.
- 12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

## 13.0 DEVIATIONS

- 13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
- 13.2 Deviations, if any, from the data furnished in specification sheet shall be indicated therein beside the data by encircling it.

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> TECHNICAL SPECIFICATION (AUXILIARY SERVICE TRANSFORMER)</div>	<div>PC288-TS-0829</div>	<div>0</div>	<div> बी एच ई एल <b>BHEL</b></div>
		<div>Document No.</div>	<div>Rev</div>	
		<div>Sheet 8 of 8</div>		

## ANNEXURE – I

### DOCUMENTATION FOR AUXILIARY SERVICE TRANSFORMERS

Sl.No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet, duly completed	N	Y	Y
2.	Technical Particulars, duly filled-in	N	Y	Y
3.	Dimensional drawing with terminal arrangement details	N	Y	Y
4.	Illustrative and descriptive literature	N	N	Y
5.	Installation, Operation and maintenance manual	N	N	Y
6.	Test Certificates	N	N	Y
7.	Guarantee certificate	N	N	Y
8.	Spare parts list with identification marks	N	N	Y

#### Note:

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No



## ENGINEERING STANDARD

### VENTILATION SYSTEM

2	20.01.07	01.02.07	ISSUED FOR IMPLEMENTATION	<i>Amur</i> AV	<i>Rev</i> BKC / SC	<i>BB</i>
1	16.01.06	30.01.06	ISSUED FOR IMPLEMENTATION	AV	BKC	BB
0	FEB'99	--	ISSUED FOR IMPLEMENTATION	SC/SC/JKT/RNS	JKT	HSW
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

**ENGINEERING STANDARD****ES: 8205****2**

DOCUMENT NO.

REV.

**VENTILATION SYSTEM**

SHEET 2 OF 13

**CONTENTS**

SECTION NUMBER	DESCRIPTION	SHEET NUMBER
1.0	SCOPE	3
2.0	STANDARDS TO BE FOLLOWED	3
3.0	SERVICE CONDITIONS	4
4.0	DESIGN AND OPERATIONAL REQUIREMENTS	4
5.0	EQUIPMENT SPECIFICATION	5
6.0	EARTHING	8
7.0	PAINTING	8
8.0	CO-ORDINATION WITH OTHER CONTRACTORS	9
9.0	TESTS AND INSPECTION	9
10.0	ERECTION, TESTING AND COMMISSIONING	9
11.0	DRAWINGS AND DOCUMENTS	10
12.0	SPARES	10
13.0	MAKE OF EQUIPMENT	10
14.0	DEVIATIONS	11
ANNEXURE - I	DOCUMENTATION FOR VENTILATION SYSTEM	12
ANNEXURE - II	LIST OF SPARES	13



## ENGINEERING STANDARD

ES: 8205

2

DOCUMENT NO.

REV.

## VENTILATION SYSTEM

SHEET 3 OF 13

### 1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, manufacture, testing at works, supply, packing, loading, transportation, unloading, storage of equipment at site, erection, site testing and commissioning of forced air ventilation system on turnkey basis.
- 1.1.1 The ventilation system shall consist of inlet air duct, air filters, centrifugal type fan, air distribution ducts, grills, damper etc.
- 1.1.2 Rain protection louvers with bird screen at the outlet of exhaust dampers shall be provided which shall be gravity operated.
- 1.1.3 All other items not specifically mentioned, but required for the completeness of the system shall be supplied.
- 1.2 This standard shall be read in conjunction with relevant specification sheets.
- 1.3 The broad scope of work shall be as indicated in specification sheet.
- 1.4 The work outside the scope of supply and to be carried out by the owner shall be as indicated in specification sheet.
- 1.4.1 The owner shall provide starter feeders for each blower motor from their own PMCC/ MCC located within 50 metre from the blowers.
- 1.4.2 The owner shall provide local control stations with ammeter near each motor.
- 1.4.3 Supply, laying & termination of power, control cables up to motors and local control stations shall be arranged by owner.
- 1.4.4 The vendor shall furnish the rated power of each blower motor to enable the owner to provide suitable starter feeders.
- 1.4.5 The owner shall carry out all the civil works such as provision of foundations for blowers and motors, plate inserts, wall and floor cut-outs necessary for installation of ventilation equipment.
- 1.4.6 The vendor shall supply the civil scope drg. (Good for construction) and necessary information as per agreed time schedule.
- 1.4.7 If the civil data and drawing furnished by the vendor require any modification after the execution of the civil work, the same has to be carried out by the vendor free of cost after having the modification approved by the owner.

### 2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of the equipment and their standard shall comply with the latest issue of relevant Indian Standard Specification.
- 2.2 The design and operational features of the equipment and their installation shall also comply with the provisions of the latest issue of the Indian Electricity Rules and other Statutory Acts and Regulations. The vendor shall, wherever necessary, make suitable modifications in the equipment to comply with the above.



## ENGINEERING STANDARD

ES: 8205

2

DOCUMENT NO.

REV.

## VENTILATION SYSTEM

SHEET 4 OF 13

- 2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specification, the requirement specified herein shall prevail. Equipment complying with equivalent IEC standards shall also be acceptable.

### 3.0 SERVICE CONDITIONS

#### 3.1 Ambient Conditions

These shall be as indicated in specification sheet

#### 3.2 System Details

These shall be as indicated in specification sheet.

### 4.0 DESIGN AND OPERATIONAL REQUIREMENTS

- 4.1 The ventilation system and installation shall be designed as per latest practice to provide maximum reliability, flexibility, safety to personnel and equipment and ease of operation and maintenance.
- 4.2 All the equipment shall be suitable for operating at their rated capacity continuously, under the ambient conditions and voltage and frequency variations indicated without exceeding the temperature rise limits specified in relevant standards and without any detrimental effect on it.
- 4.3 All the equipment shall have adequate and standardised ratings.
- 4.4 The system design and selection of equipment ratings as well as their installation shall ensure adequate fresh air throughout the ventilated plant area for personnel comfort and proper functioning of the plant equipment.
- 4.5 For the main ventilation equipment, a room has been shown in the attached duct layout. The supplier shall confirm the adequacy of the room size.
- 4.6 The requirement of blowers where indicated is tentative. The vendor may alternatively offer ventilation schemes considered by him superior than specified.
- 4.7 The ventilation equipment offered shall be designed to affect the required number of air changes per hour and supply fresh air to the areas indicated in specification sheet.
- 4.8 Two numbers of blower shall be provided and each rated for 100%. The discharge of each blower shall be connected to a common duct and an isolation valve shall be provided on discharge side of each blower.
- 4.9 A positive pressure of 5 mm of water gauge shall be maintained with in the area to be ventilated.
- 4.10 The concentration of the dust in the area is expected to be in milligrams and the size of dust particles will be 25 microns.



## ENGINEERING STANDARD

ES: 8205

2

DOCUMENT NO.

REV.

## VENTILATION SYSTEM

SHEET 5 OF 13

- 4.11 Discharge velocity of the air should be within comfortable limits and uniform distribution of air shall be achieved.
- 4.12 Every precautions shall be taken to reduce the sound level from the blowers to a minimum of 90 dB (A) at 1 metre distance. If required, silencers may be fitted to bring down the sound level.
- 4.13 Vendor shall indicate the thickness and height up to which acoustic insulation is considered in the offer.
- 4.14 Vibration pads shall be used so that no vibration is transmitted to the buildings.
- 4.15 All safety regulations must be taken into consideration in the design and equipment layout. All moving and rotating parts shall be suitably guarded against accidental contacts by working personnel.

### 5.0 EQUIPMENT SPECIFICATION

#### 5.1 Air Filters

- 5.1.1 The dry type air filters shall be provided at the air intake side for filtering dust particles of the air.
- 5.1.2 The filter shall be capable of removing dust particles of about 10 micron and above, the efficiency of the filter shall not be less than 99%. If considered necessary, double filter may be provided.
- 5.1.3 The velocity of air inside the filter shall not exceed 3 m/s.
- 5.1.4 The air filter shall be of robust construction fabricated out of 14 gauge sheet metal work.
- 5.1.5 The filters shall be capable of reuse after cleaning. Each filter shall be mounted in such a way that the removal and re-fixing after cleaning and maintenance is easier.
- 5.1.6 The filter shall be made of high efficiency particulate air filtration (HEPA).
- 5.1.7 Where filters are supplied in dismantled condition, assembly drawing shall be furnished by manufacturer.

#### 5.2 Air supply blower

- 5.2.1 The blowers shall be in conformity with IS: 4894.
- 5.2.2 Blowers shall be centrifugal type and shall either be single width single inlet or double width double inlet type as per the volume and head of the air to be handled. The blowers shall have non overloading type characteristics.
- 5.2.3 The blowers shall be heavy duty type suitable for uninterrupted and trouble free service.
- 5.2.4 The blowers shall have end suction and upward / downward / inclined discharge as per requirement.
- 5.2.5 The blowers shall be coupled to the motors by pulley and V-belt arrangement.



**ENGINEERING STANDARD****ES: 8205****2**

DOCUMENT NO.

REV.

**VENTILATION SYSTEM**

SHEET 6 OF 13

- 5.2.6 The blowers shall be designed to operate within 9% and 25% of system throttling line.
- 5.2.7 The first critical speed of the rotating assembly shall be at least 25% above the operating speed.
- 5.2.8 The blowers shall be complete with all required accessories.
- 5.2.9 The casing shall be of welded construction and complete with inlet and outlet flanges, inspection holes, mounting legs and fittings lugs.

**5.3 Ducting**

- 5.3.1 Ducts for distribution of air shall either be of galvanised sheet steel having galvanising thickness of 150 microns or aluminium sheet conforming to IS: 1285, designation 52,000 as specified in specification sheet. The thickness of GI sheet / aluminium sheet shall be as follows:

- GI sheet - 1.2 mm
- Aluminium sheet - 1.6 mm

- 5.3.2 The following principles shall be adopted in the selection of duct sizing.

- Velocity of air shall not exceed 1.2 m/s in any section throughout the entire run.
- While changing the cross sections, the air velocity should not change abruptly.
- Bends shall be minimum wherever required, the bending radius should be more than 1.5 times the width of the ducts.
- Right angle bends shall have deflectors to reduce the pressure loss.
- The cross section of the ducts shall be preferably of square type.
- Interior shall be smooth and free from obstruction.
- The duct section shall be cross broken type.

- 5.3.3 Flexible bellows shall be provided for connecting the duct and the blowers to isolate the vibrations.

- 5.3.4 All longitudinal joints of the various sections of the ducts shall be either riveted by slip joints or bolted by angle ring joints. The centre distance of rivets / bolts shall not exceed 150 mm for sheets and 75 mm for structural steels.

- 5.3.5 All joints shall be properly sealed to prevent leakage of air by suitable sealing compounds.

- 5.3.6 The ducts shall be provided with continuous transverse bracing by angle irons. Longitudinal seams shall be provided for reinforcement, wherever required.

- 5.3.7 Along the main ducts, access doors shall be provided. Such doors shall be provided with sponge rubber gaskets for leak proofness.

**5.4 Hanger and supports**

- 5.4.1 The duct work shall be either hanged from the ceiling or supported on the sides of the column as the case may be. They shall be fixed to the ceiling / column by anchor bolts or welding.

- 5.4.2 The hangers / supports shall be adequate in number and size to prevent sagging, buckling or vibration. All hangers shall be of trapezoid type constructed out of 40 x 40 x 6 mm angle iron and suspended from two steel rods of 10 mm dia.
- 5.4.3 While crossing the floors, the ducts shall be supported by suitable collars fabricated out of angle iron. The opening left out after the erection of ducts and collars shall be filled up with bitumen compound of superior quality.
- 5.4.4 The fixing and support intervals shall not be more than 3 metres.
- 5.4.5 The complete supporting arrangement shall be subject to the approval of the purchaser before their installation.
- 5.5 Grills / Dampers**
- 5.5.1 The air ducts shall be provided with grills having air turning devices, manually adjustable multilouvre dampers of contrarotating type for discharge of fresh air.
- 5.5.2 The controlling device for the dampers shall have provision to keep the damper in one position.
- 5.5.3 Thick wire netting guards shall be provided in the grills.
- 5.5.4 The mouth of the grills shall be downward having an angle of inclination of 30°.
- 5.5.5 The numbers, size and material of construction of discharge nozzles to be provided shall be subject to purchaser's approval.
- 5.6 Motors**
- 5.6.1 The motors shall be of squirrel cage induction, totally enclosed, fan cooled having IPW-55 degree of protection complying with IS-325.
- 5.6.2 The insulation of the motors shall be class B/F as indicated in specification sheet. For class 'F' insulated motors, the temperature rise shall be limited to that of class B.
- 5.6.3 The rating and frame sizes of the motors shall be as per IS.
- 5.6.4 The motors shall be suitable for 3 successive starts from cold and 2 successive starts from hot when coupled to the driven equipment. The temperature of the rotor shall not exceed 300°C.
- 5.6.5 The motors shall be suitable for D.O.L starting even at a terminal voltage of 80%. The starting current shall not exceed 6 times when full voltage is applied.
- 5.6.6 All the six leads shall be brought out to the terminal box where suitable connection shall be made through shorting links.
- 5.6.7 The terminal box shall be amply sized and provided with terminal block of non cracking, non inflammable, non-hygroscopic and mould proof material.
- 5.6.8 All motors shall preferably be coupled to the driven equipment through flexible coupling.
- 5.6.9 In place of geared motors, motors with separate gear boxes between the motor and the driven equipment shall be preferred.



## ENGINEERING STANDARD

ES: 8205

2

DOCUMENT NO.

REV.

## VENTILATION SYSTEM

SHEET 8 OF 13

- 5.6.10 All motors shall be complete with on-line greasing facility and complete with required accessories such as name plate, lifting eye bolt, drain plug, earthing terminals, cable glands, slide rails etc.
- 5.6.11 All motors rated 30 KW and above shall be provided with space heater along with separate terminal box.
- 5.6.12 Rating of the motor shall be 15% higher than the driven load requirement and duty cycle shall match the requirement of driven machine.

### 5.7 Cable laying and terminations

- 5.7.1 Power, control cables (supplied by owner) shall be laid from owner's PMCC/ MCC to the blower motors and local control stations. This shall include, installation of cable racks and its supports, laying fixing, jointing, terminating, testing and commissioning of cables with in the ventilation room.
- 5.7.2 The installation of cables shall be carried out as per the best practices and shall be in line with guidelines contained in IS: 1255.
- 5.7.3 Normally, plate inserts for fixing cable supports shall be provided by owner's civil contractor. However, if any extra inserts are required the same shall be fixed by the vendor.
- 5.7.4 All cables shall be laid in single layer. Control and power cables shall preferably be laid on separate trays. Cables shall be clamped at a maximum distance of 1500 mm of straight runs and at each end of bend.
- 5.7.5 Identification tags made of Aluminium with numbers punched on it shall be attached to each end of cable by means of G.I. binding wire. Tags shall additionally be put at an interval of 30 M on straight runs of cables.
- 5.7.6 Individual cores of control cables shall be provided with plastic interlocked type identification ferrules at both ends.
- 5.7.7 All cable termination shall be solderless crimping type.

### 6.0 EARTHING

- 6.1 Complete earthing installation shall be done as per IS: 3043.
- 6.2 The owner shall provide required number of earth buses from their earthing grid with in the ventilation room. Vendor shall earth all the equipments under his scope of supply by using 1.1 KV, single core, PVC aluminium conductor cable from these earth buses.

### 7.0 PAINTING

- 7.1 The surfaces to be painted shall be pretreated to remove all dust, scale and foreign adhering matter by suitable treatment.
- 7.2 All steel surfaces shall be painted with suitable anti-rust and anti-corrosive paints. Epoxy paints shall be used, if indicated in the specification sheet.

**ENGINEERING STANDARD****ES: 8205****2**

DOCUMENT NO.

REV.

**VENTILATION SYSTEM**

SHEET 9 OF 13

7.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

7.4 Unless otherwise specified, the finishing shade shall be light grey shade no. 631 as per IS: 5.

**8.0 CO-ORDINATION WITH OTHER CONTRACTORS**

8.1 The successful vendor shall co-ordinate with owner's other vendors and shall freely exchange all technical information required for this purpose.

8.2 The successful vendor shall ensure that the variation in estimated quantities for ducting and acoustic insulation during quotation stage and quantities of actual execution at site shall be maximum  $\pm 10\%$ . Beyond this limit, their extra claim at any stage of the contractual period, if any, shall not be entertained.

**9.0 TESTS AND INSPECTION**

9.1 All equipment shall be routine tested as per relevant Indian Standard Specification.

9.2 Additional tests, wherever specified, shall be carried out on one equipment of each rating.

9.3 All the above mentioned tests shall be carried out in the presence of purchaser's representative.

9.4 The owner's inspection shall, however, not absolve the vendor from his responsibility for making good any defect which may be noticed subsequently.

**10.0 ERECTION, TESTING AND COMMISSIONING**

10.1 The vendor shall undertake installation of all equipment in accordance with code of practices in conformity with statutory regulations and to the entire satisfaction of the owner.

10.2 The vendor shall arrange all the necessary erection tools and tackles, testing and measuring instruments and shall supply the required erection materials.

10.3 The vendor shall obtain the necessary clearance from the electrical inspector for equipment and installation. All necessary drawings and test certificates as required by the inspector shall be furnished. Any modification / rectification as required by him shall be carried out.

10.4 Package vendor shall demonstrate the guaranteed performance data, like discharge capacity, outlet velocity, static pressure developed and noise level inside the room before handing over ventilation system.

10.5 Following tests shall be specifically conducted before commissioning in presence of owner's representative. All the test results shall be recorded and submitted to the owner.



## ENGINEERING STANDARD

ES: 8205

2

DOCUMENT NO.

REV.

## VENTILATION SYSTEM

SHEET 10 OF 13

1. Insulation test.
2. Continuity test.
3. High voltage test.
4. Simulation test.

### 11.0 DRAWINGS AND DOCUMENTS

- 11.1 The drawings and documents as per Annexure-I shall be furnished unless otherwise specified.
- 11.2 All drawings and documents shall have the following descriptions written boldly.
- Name of client
  - Name of consultant
  - Enquiry / Order Number with plant / project name
  - Code No. and Description
- 11.3 At the time of handing over the installation, the vendor shall supply as built drgs. Taking into consideration the actual execution carried out at site.
- 11.4 The vendor shall furnish a Bill of Material covered in his offer. However, this shall be treated for information only and shall not absolve him from his obligation to supply the required items and quantities for making the plant complete as per intent of the specification.

### 12.0 SPARES

- 12.1 Spares for operation and maintenance
- Item wise unit prices of spare parts with recommended quantity shall be quoted along with the equipments as listed in Annexure-II for the period as indicated in the specification sheet.
- 12.2 Commissioning Spares
- Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.
- 12.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.
- 12.4 All spare parts shall be identical to the parts used in the equipments.

### 13.0 MAKE OF EQUIPMENT

The make of all the electrical equipment shall be as indicated in specification sheet. The vendor shall supply the equipment of specified make only.

**ENGINEERING STANDARD****ES: 8205****2**

DOCUMENT NO.

REV.

**VENTILATION SYSTEM**

SHEET 11 OF 13

**14.0 DEVIATIONS**

- 14.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
- 14.2 Deviations, if any, from the data furnished in specification sheet shall be indicated therein beside the data by encircling it.

**ENGINEERING STANDARD****ES: 8205****2**

DOCUMENT NO.

REV.

**VENTILATION SYSTEM**

SHEET 12 OF 13

**ANNEXURE - I****DOCUMENTATION FOR VENTILATION SYSTEM**

Sl.No	Description	Documents Required (Y / N)		
		With Bid	For approval	Final
1.	Equipment Layout Drgs.	Y	Y	Y
2.	Civil Scope Drgs. (good for construction)	N	Y	Y
3.	Duct Layout Drg.	Y	Y	Y
4.	Filled in specification sheet	Y	Y	Y
5.	Technical Particulars	Y	Y	Y
6.	Bill of Material	Y	Y	Y
7.	Catalogues of Bought out items	Y	N	Y
8.	I.O.M. Material	N	N	Y
9.	Spare Parts List	Y	N	Y
10.	Test certificates	N	N	Y
11.	Guarantee Certificate	N	N	Y

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

**ENGINEERING STANDARD****ES: 8205****2****VENTILATION SYSTEM**

DOCUMENT NO.

REV.

SHEET 13 OF 13

**ANNEXURE - II****LIST OF SPARES**

The spares listed below shall be offered:

**MOTORS**

1. Set of bearings
2. Cooling fans
3. Grease nipple and plug

**BLOWER**

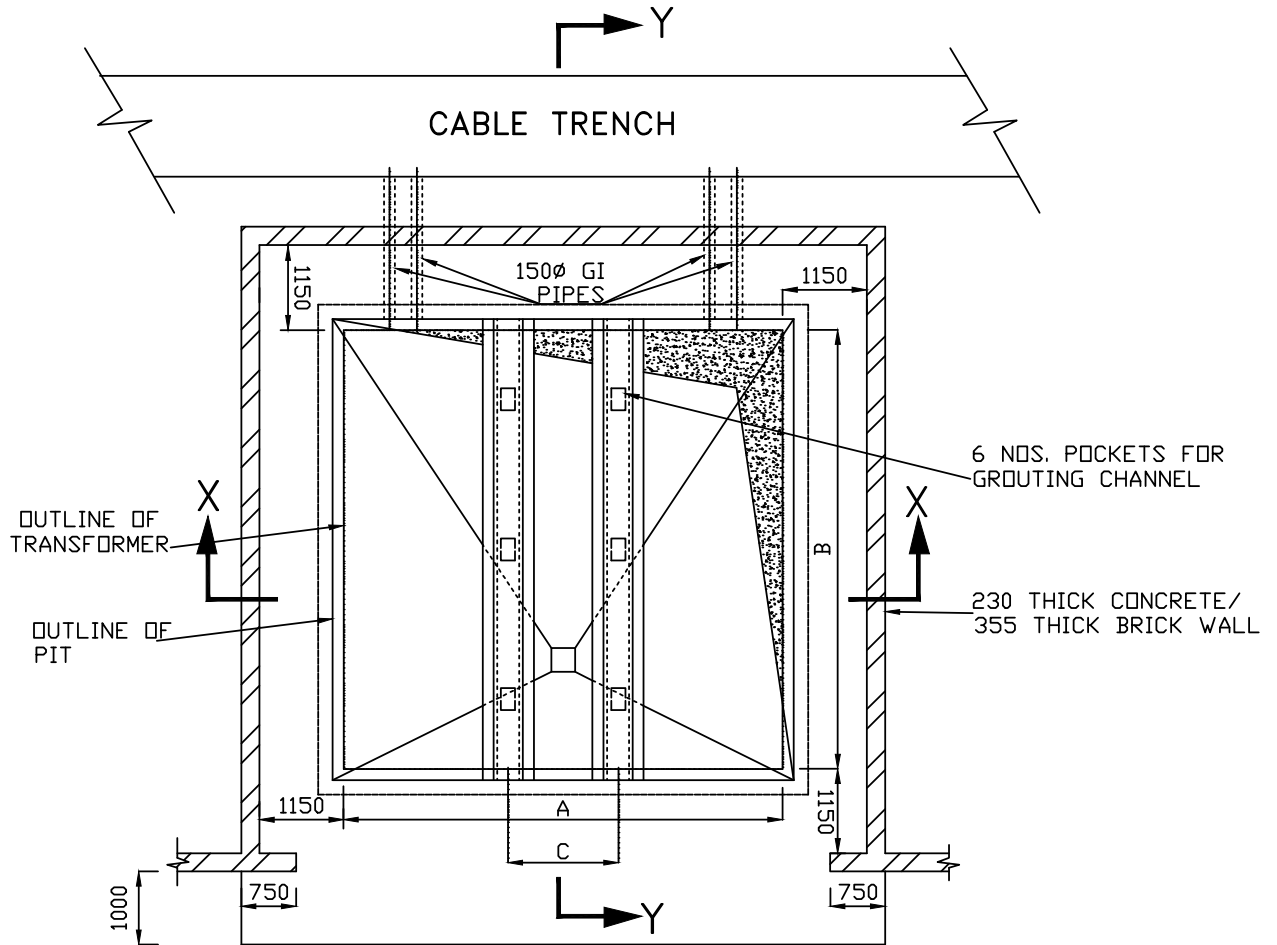
1. Set of Blower Bearings
2. V-Belts

**FILTER**

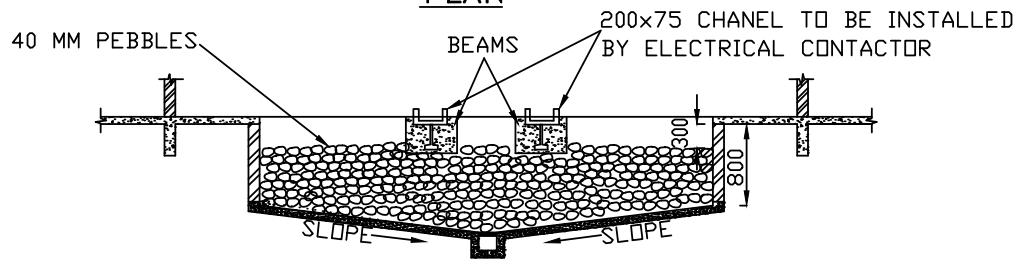
1. Pre-filter
2. Fine Filter



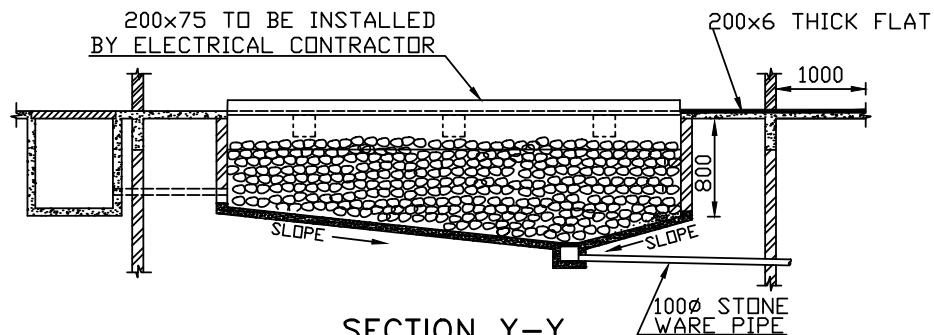




PLAN



SECTION X-X



SECTION Y-Y

NOTE :

TRANSFORMERS RATED ABOVE 10MVA SHALL BE MOUNTED ON 200MM x 8MM THICK PLATES.



# TYPICAL DETAILS OF TRANSFORMER ROOM DOOR

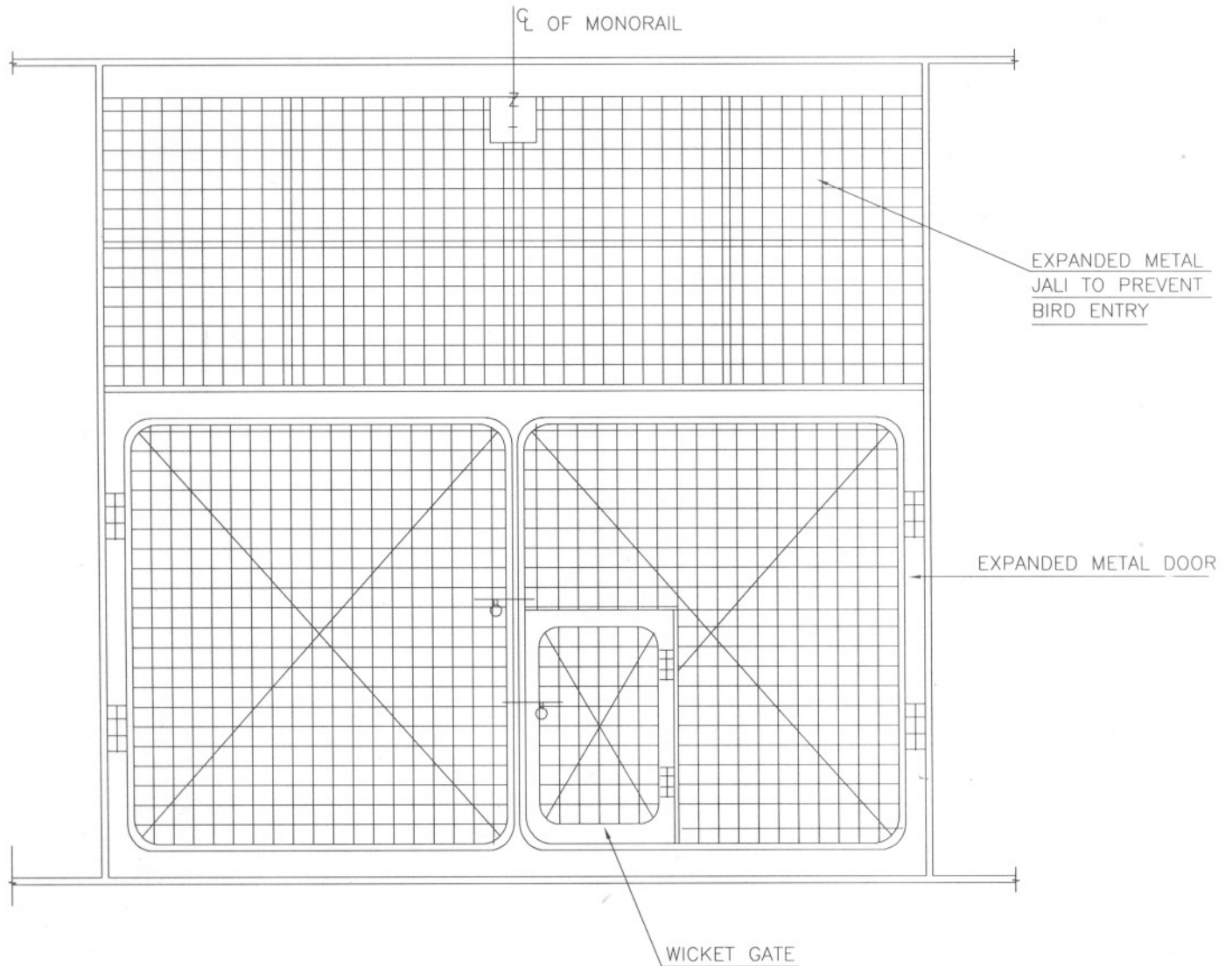
PC288 E 115

0

DOCUMENT NO.

REV

SHEET 1 OF 1



## NOTE :-

1. THIS STANDARD IS INDICATIVE ONLY, THE EXACT DIMENSIONS SHALL BE DECIDED AS PER TRANSFORMER SIZE & SUB-STATION LAYOUT.
2. TRANSFORMER GATE HEIGHT SHALL BE 250MM MORE THAN THE TRANSFORMER HEIGHT AND SHALL BE OPENABLE OUTSIDE.

0	20.01.07	01.02.07	ISSUED FOR IMPLEMENTATION	<i>Shunil</i> RUNDA/AV	<i>SC</i> SC	<i>Rashid</i> BB
REV	REV.DATE	EFF.DATE	PURPOSE	PREPD	REVWD	APPD



# SUMP PIT FOR TRANSFORMER OIL

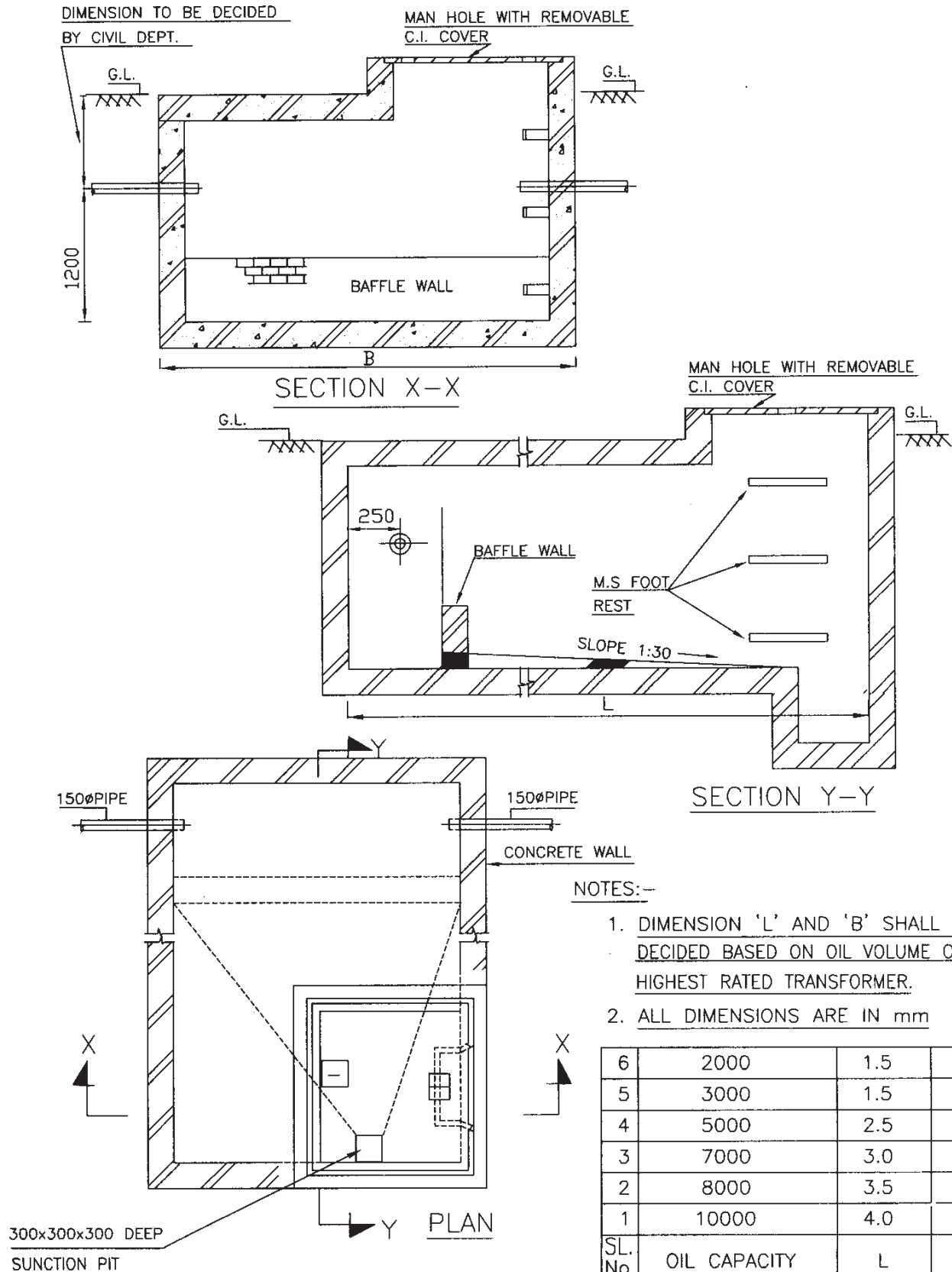
PC288 PDS: E116

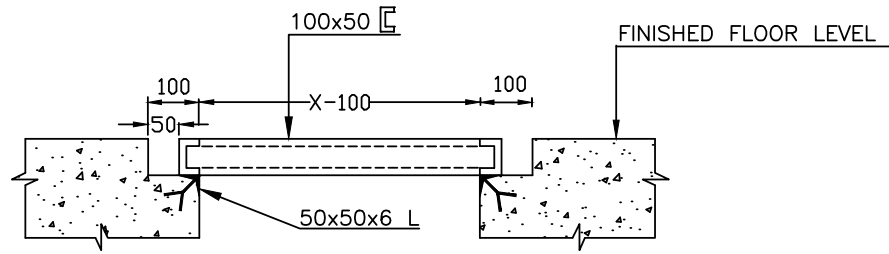
1

DOCUMENT NO.

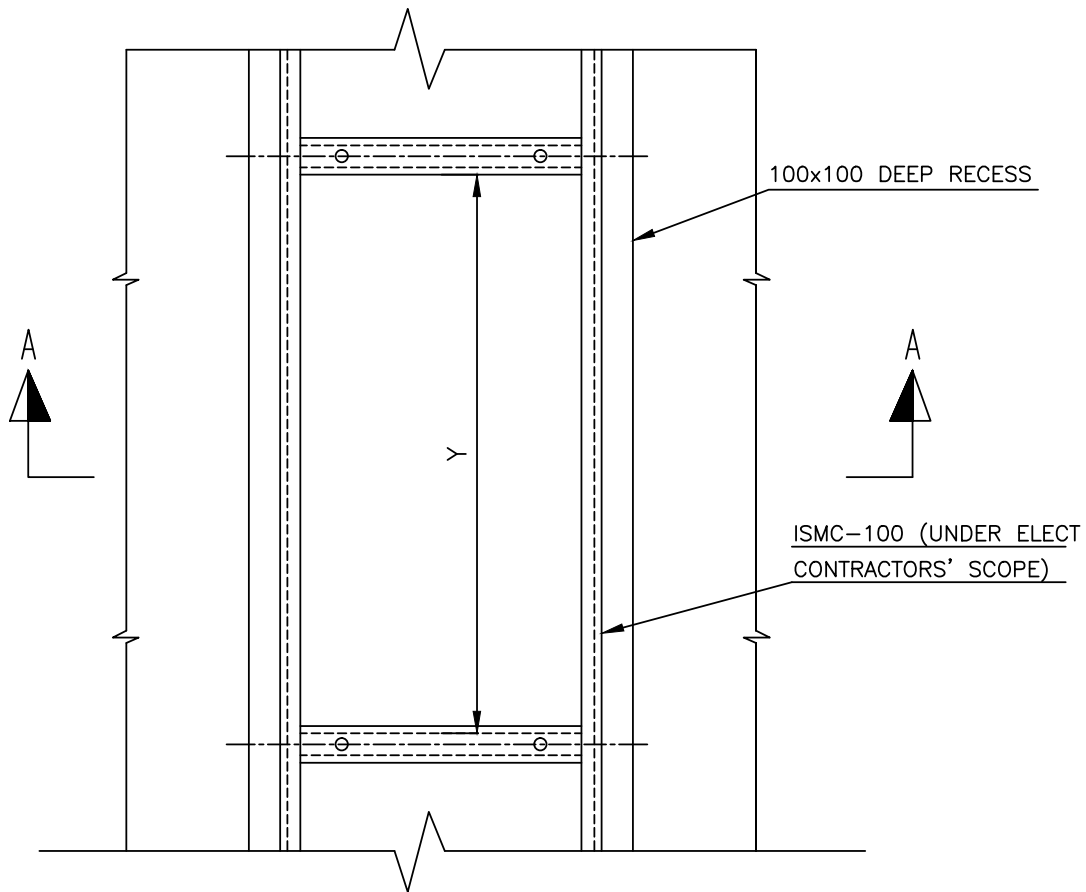
REV

SHEET 1 OF 1





SECTION-A A



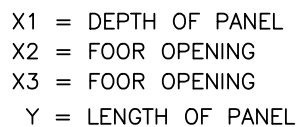
PLAN

X- DEPTH OF PANEL

Y- LENGTH OF TWO PANELS

NOTES:-

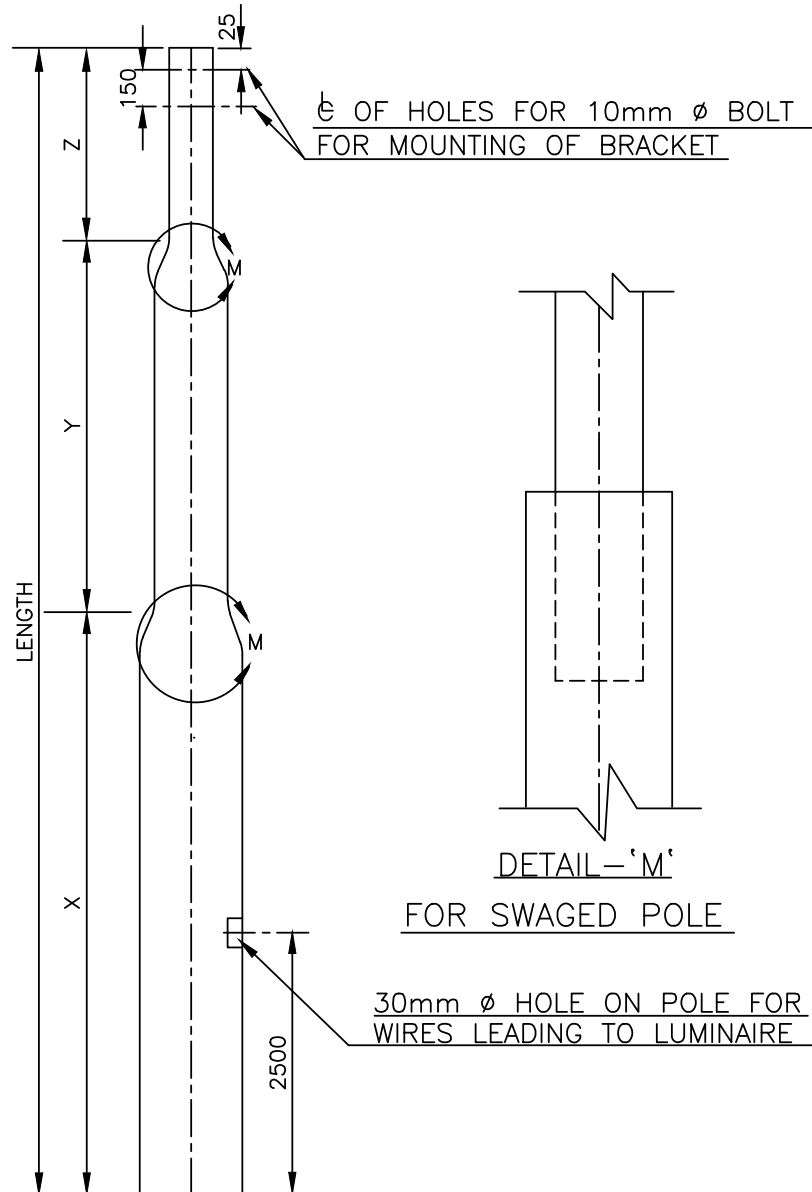
1. THIS ARRANGEMENT SHALL BE APPLICABLE FOR M.C.C., DISTRIBUTION BOARDS, CONTROL PANELS ETC.
2. PANELS AFTER ERECTION SHALL BE TAG WELDED TO FOUNDATION CHANNELS



PLAN

NOTES:-

1. PANELS AFTER ERECTION SHALL BE BOLTED TO FOUNDATION CHANNELS
2. POWER & CONTROL CABLES SHALL ENTER THROUGH OPENING X2
3. DEPENDING UPON THE FINAL DATA FROM THE VENDOR, ONLY TWO CHANNELS MAY BE NECESSARY IN WHICH CASE THE 3RD. RECESS SHALL BE FILLED AT SITE.

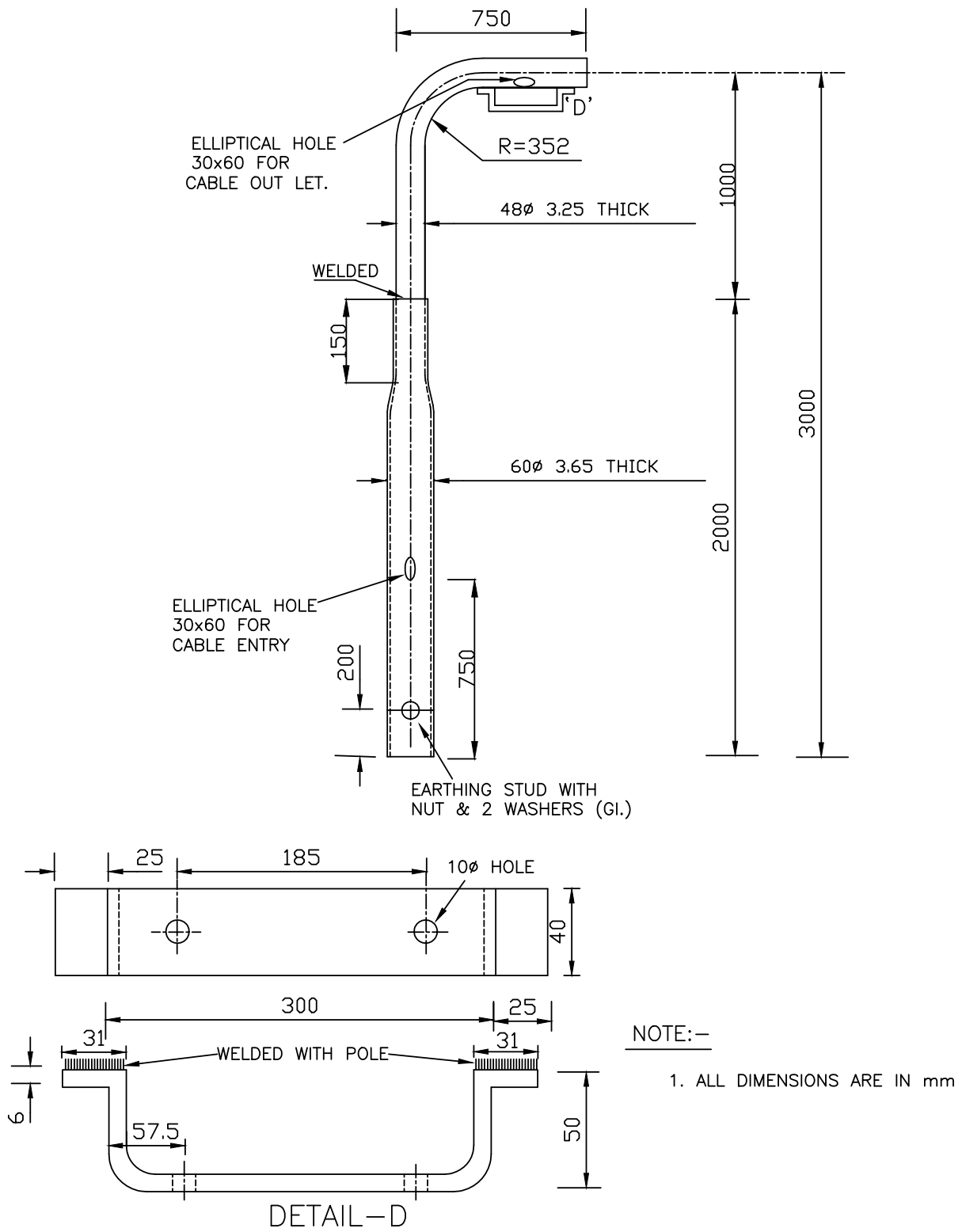


POLE DESIGNATION	LENGTH(M) $X+Y+Z=L$	PLANTING DEPTH(M)	DIAxTHICKNESS BOTTOM(mm)	DIA MIDDLE(mm)	DIA TOP(mm)	WEIGHT OF POLE (Kg)
410 TP3/SP3	$X+Y+Z=7$	1.25	114.3x4		78.1	87/85
410 TP12/SP12	$X+Y+Z=8$	1.5	114.3x4		78.1	101/97
410 TP13/SP13	$X+Y+Z=8$	1.5	139.7x4		88.9	125/119
410 TP27/SP27	$X+Y+Z=9$	1.5	114.3x4		76.1	113/108
410 TP30/SP30	$X+Y+Z=9$	1.5	139.7x4		88.9	140/133
410 TP33/SP33	$X+Y+Z=9$	1.5	165.1x4		114.3	170/184

NOTE:-

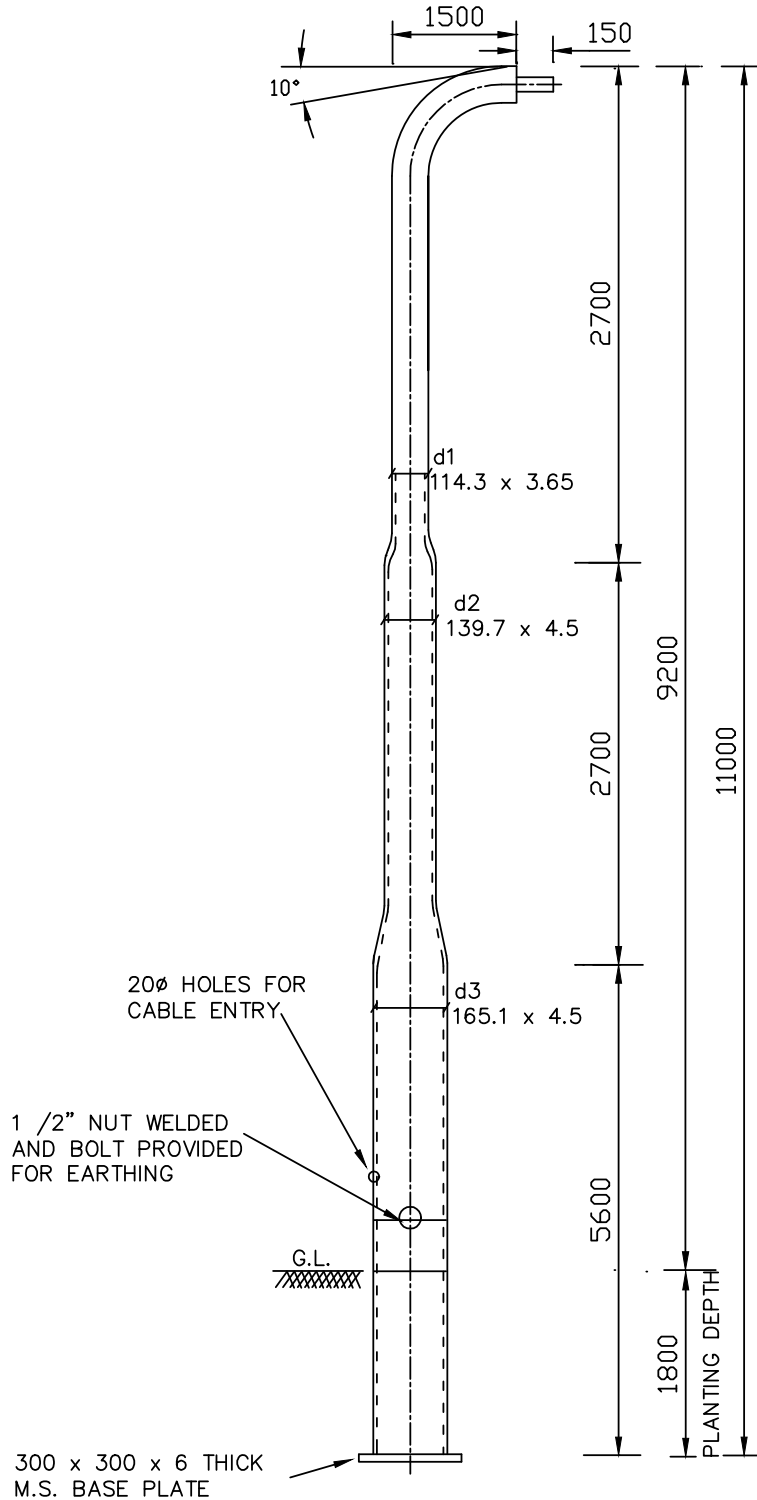
1. TP REFER TO STEPPED POLE.
2. SP REFER TO SWAGED POLE.
3. POLE DESIGNATION IS AS PER IS: 1239

SWAGED POLE TYPE 'B'



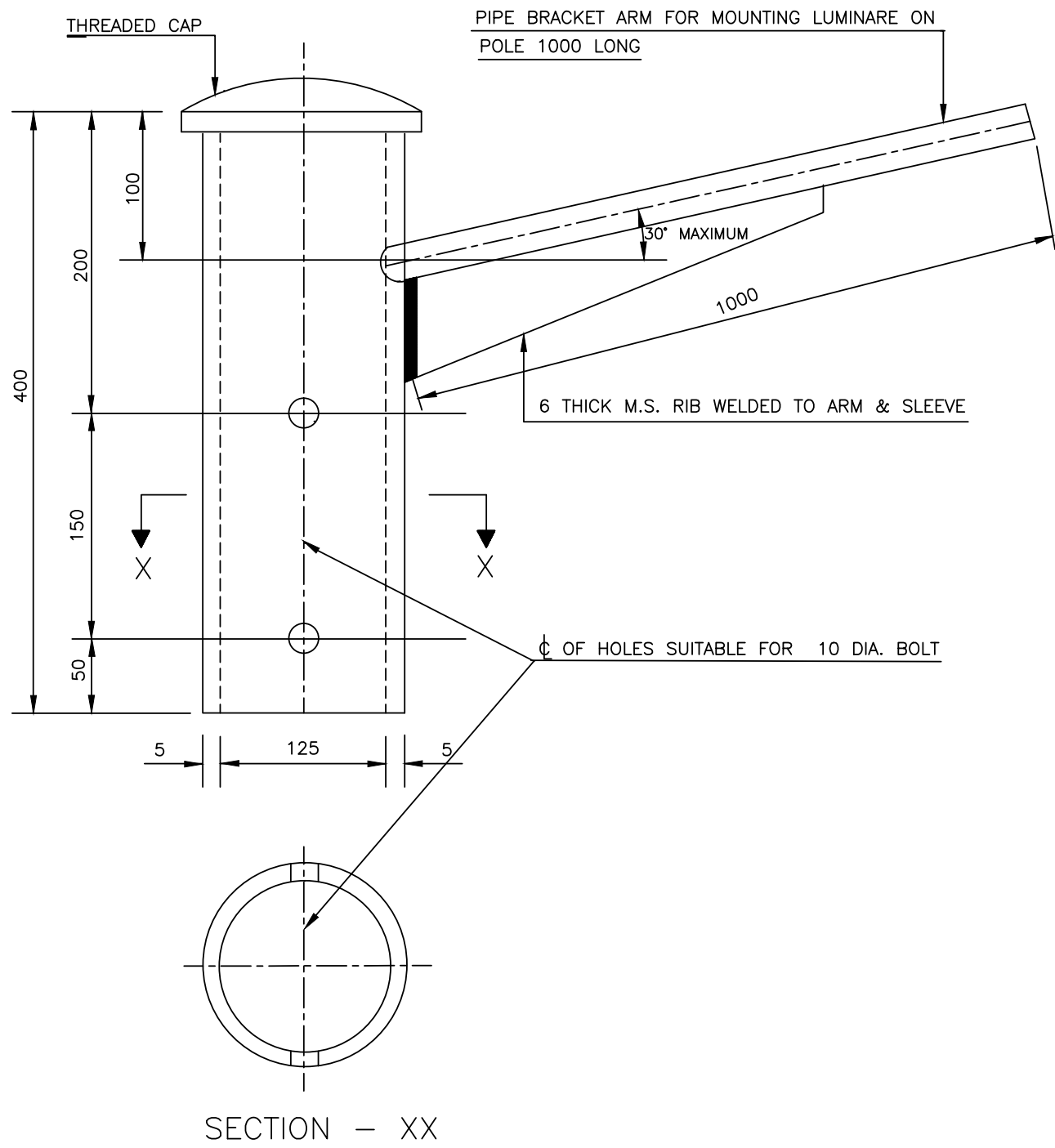


SWAGED POLE TYPE 'C'  
(FOR PLANT GROUND MOUNTING)



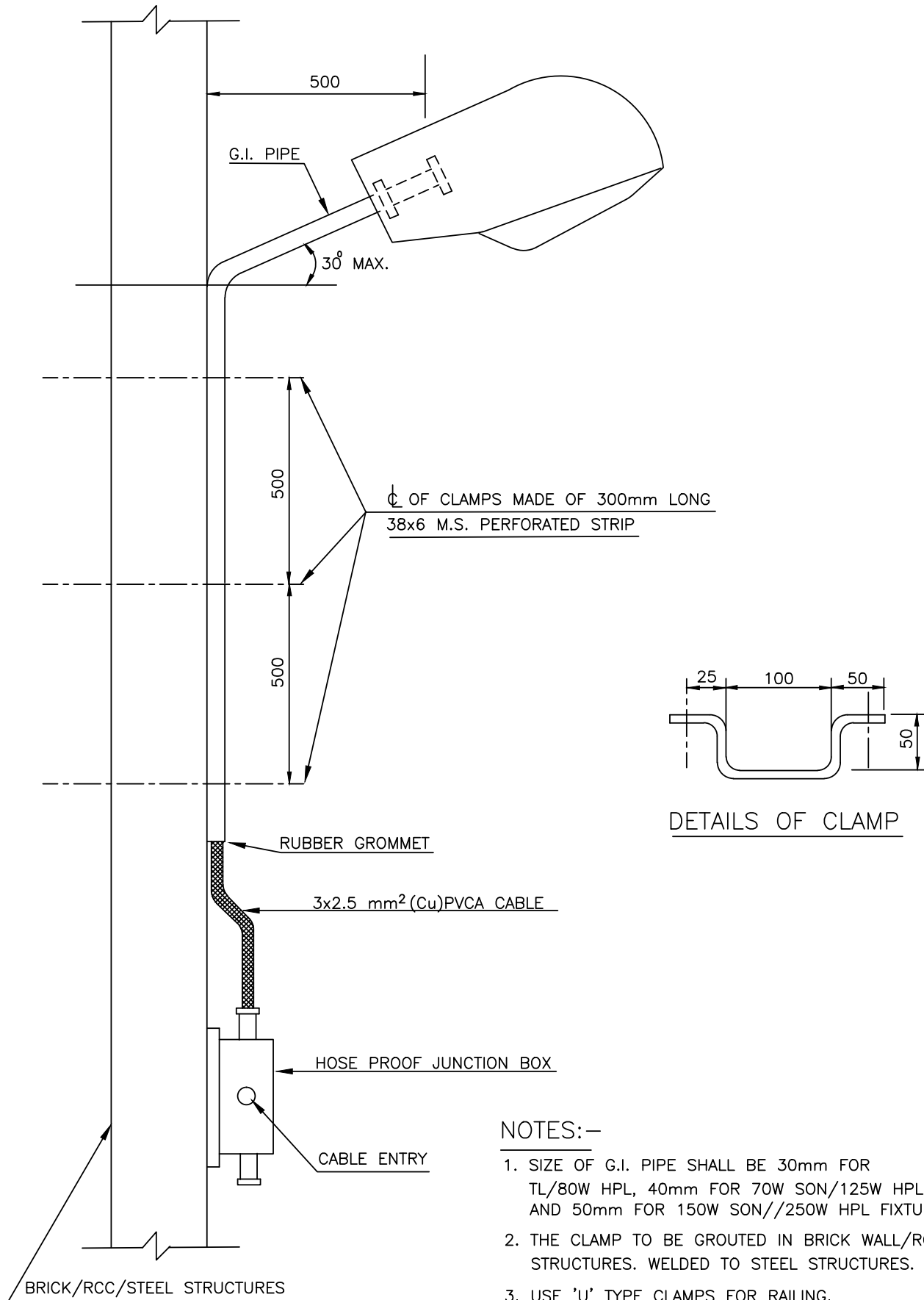
NOTES: -

1. NIPPLE OF DIA. 45 (NIPPLE TO BE PREPd. BY DIRECT REDUCTION OF DIA OF TOP PIPE WITHOUT USE OF ANY WASHER)
2. POLE MATERIAL MS AS PER IS 1239 ABOVE GROUND PORTION TO BE PAINTED 2 COATS OF RED OXIDE PRIMER, UNDER GROUND PORTION PAINTED BITUMINUS PAINT.
3. FOR FLOOD LIGHTING POLE THE TOP PORTION NOT TO BE TILTED BUT A 300 x 300 x 6mm THICK M.S. PLATE WELDED AT THE TOP SHALL BE PROVIDED TO MOUNT FLOOD LIGHT.
4. ALL DIMENSIONS ARE IN mm



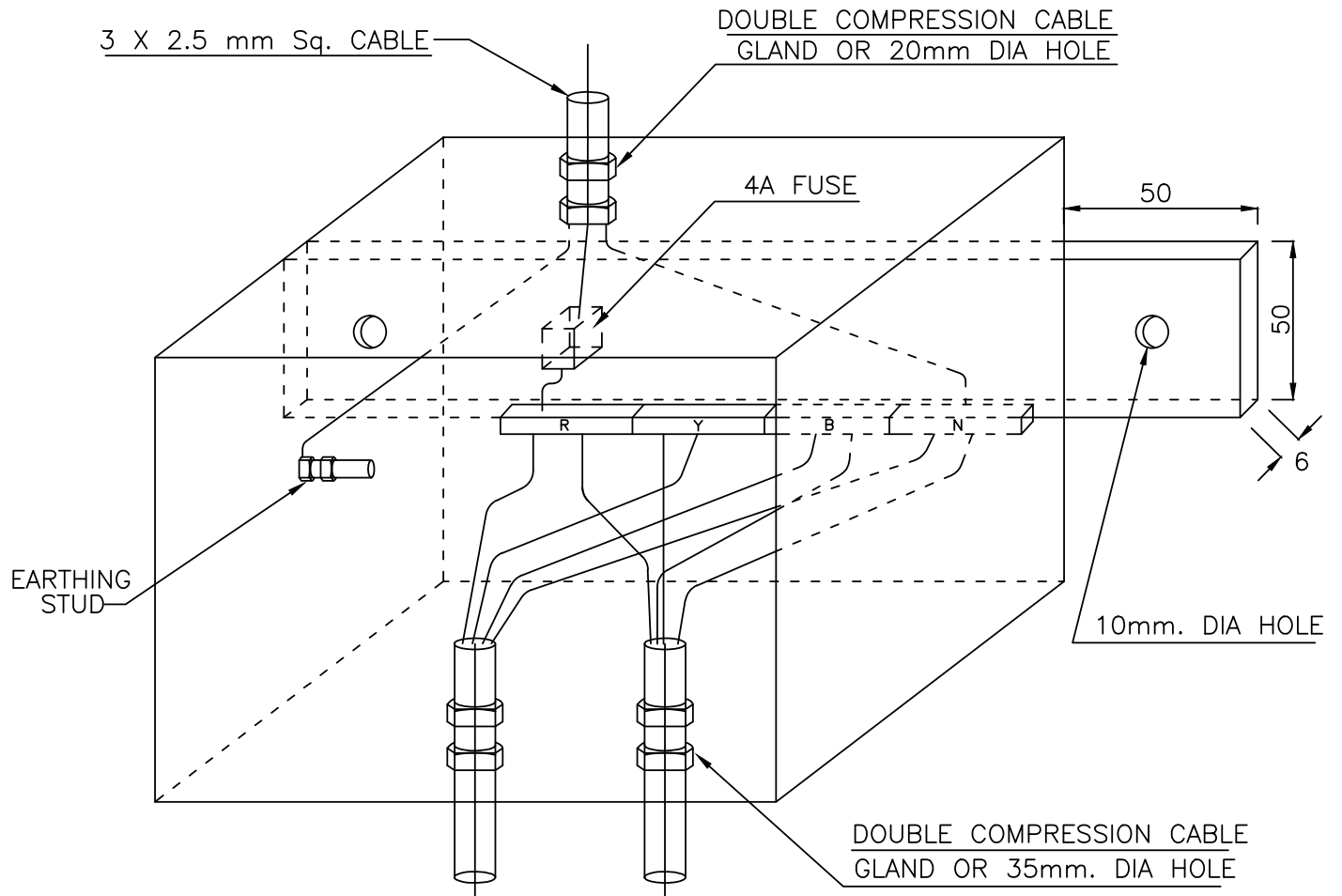
NOTES:-

1. SIZE OF PIPE SHALL BE 30mm FOR TL/80W HPL FIXTURES, 40mm FOR 70W SON/125W HPL FIXTURES AND 50mm FOR 150W SON/250W HPL FIXTURES.
2. ALL DIMENSIONS ARE IN mm.



NOTES:—

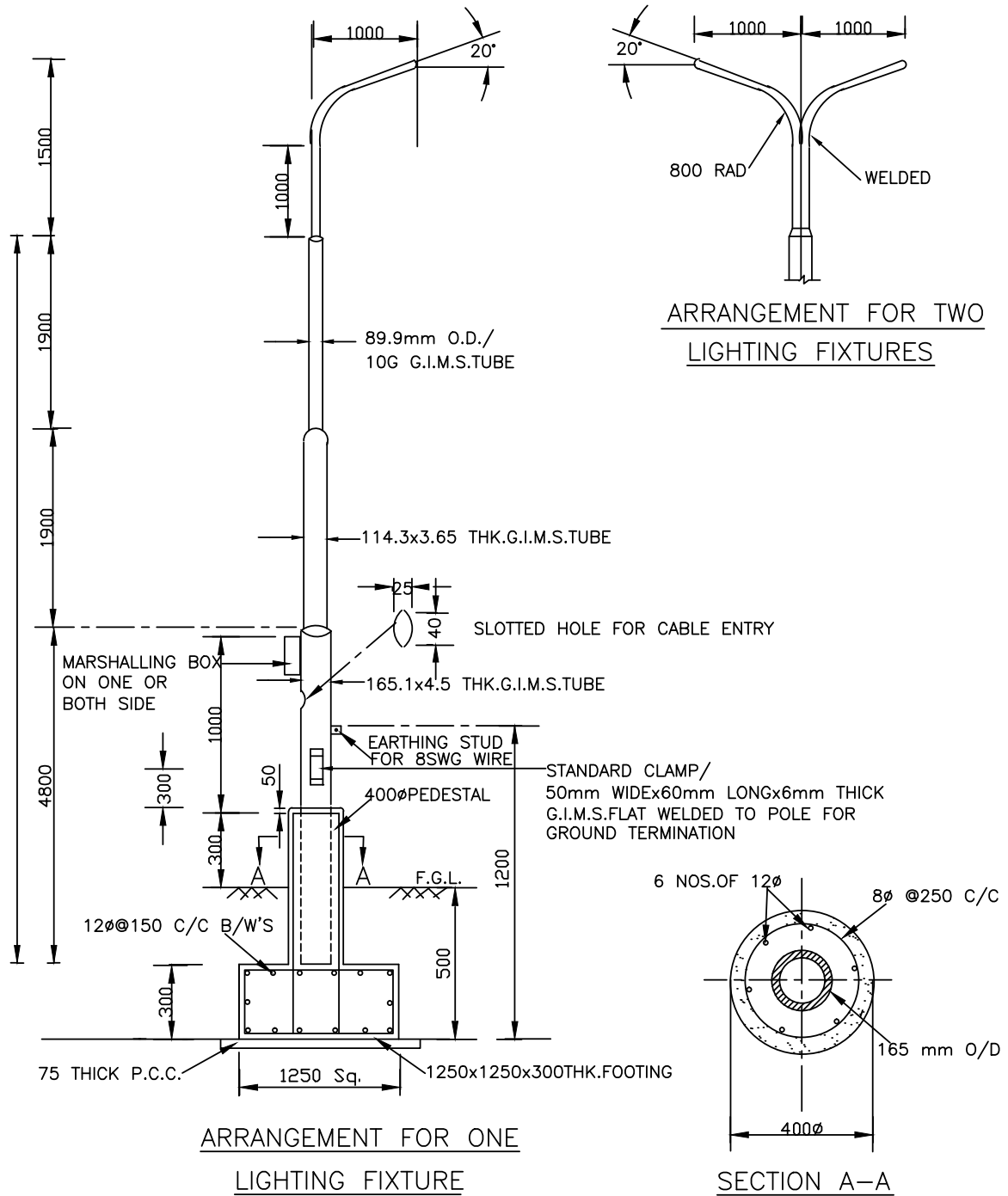
1. SIZE OF G.I. PIPE SHALL BE 30mm FOR TL/80W HPL, 40mm FOR 70W SON/125W HPL AND 50mm FOR 150W SON//250W HPL FIXTURES.
2. THE CLAMP TO BE GROUTED IN BRICK WALL/RCC STRUCTURES. WELDED TO STEEL STRUCTURES.
3. USE 'U' TYPE CLAMPS FOR RAILING.
4. ALL DIMENSIONS ARE IN mm.



NOTE:—

1. THE MINIMUM INTERNAL DIMENSION OF THE J.B. SHALL BE 152 X 152 X 152.
2. THE FRONT DOOR SHALL BE HINGED & LOCKABLE TYPE.
3. THE CONNECTION OF FUSE TO THE PHASE 'R' IS TYPICAL ONE THE EXACT PHASE TO WHICH CONNECTION SHALL BE MADE SHALL BE DECIDED AT SITE.
4. FOR HAZARDOUS AREA'S THESE JUNCTION BOXES SHALL BE INCREASED SAFETY TYPE AND THE FUSE NEED NOT BE PROVIDED.
5. FOR POLE MOUNTED JUNCTION BOXED THE CABLE GLAND SHALL BE SIDE MOUNTED.
6. ALL DIMENSIONS ARE IN mm.

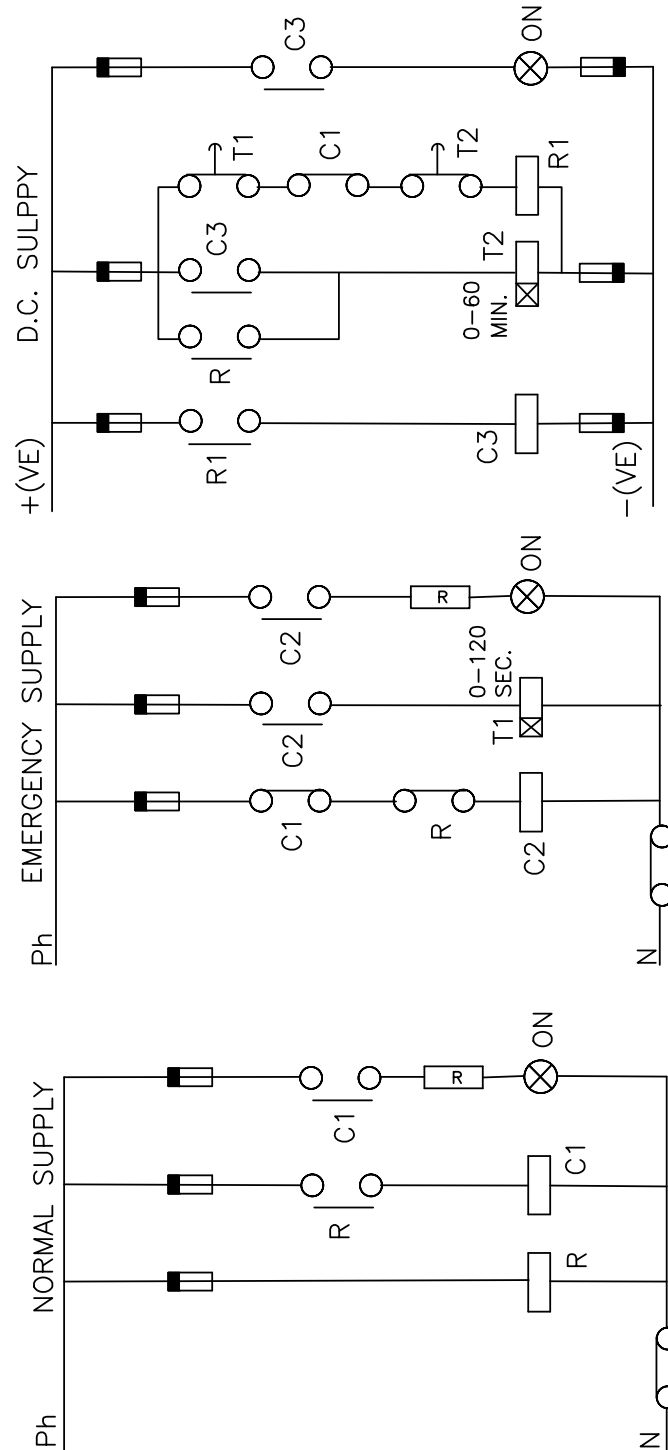
## TYPICAL STREET LIGHTING POLE



NOTE :-

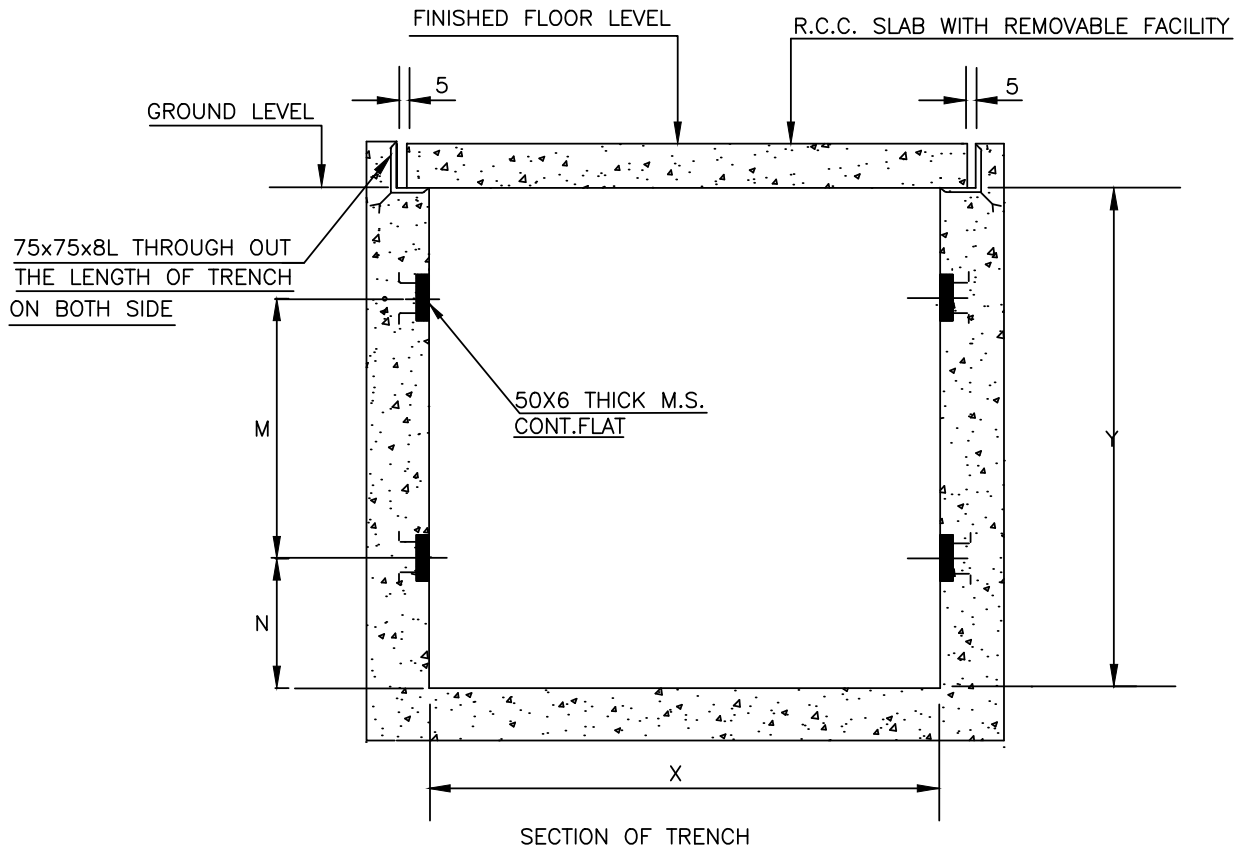
1. CONCRETING AND APPROVED MOUNTING HARDWARE FOR LIGHTING FIXTURES ARE INCLUDING IN SCOPE OF SUPPLY.
2. CONCRETE FOUNDATION OF GRADE M15 SHALL BE PROVIDED.

ALL DIMENSIONS ARE IN mm.



NOTE:-

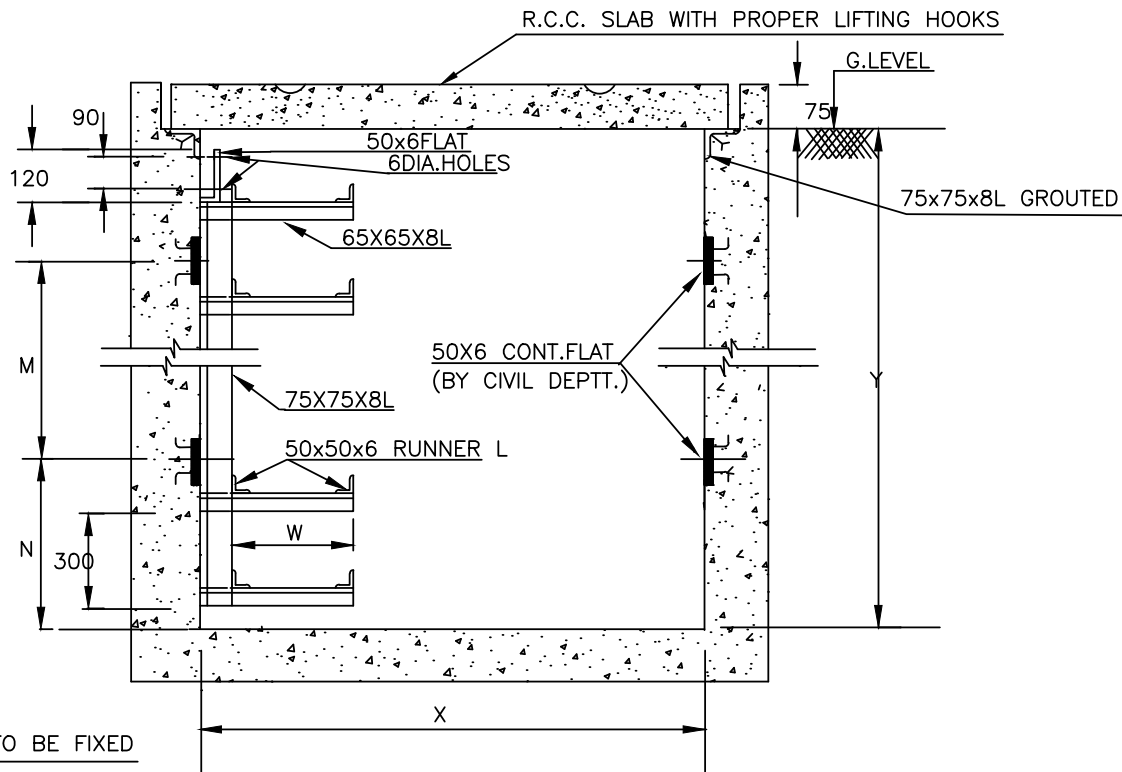
CONTACTORS C1,C2 AND C3 CONTROLS THE LIGHTING FEEDERS FOR NORMAL,EMERGENCY AND D.C. SUPPLY RESPECTIVELY.



DESIGN TYPE	X	Y	N	M
5T 350DS.	1400	1500	400	650
4T 350DS.	1400	1200	250	650
3T 350DS.	1400	900	250	300
5T 350SS.	1000	1500	400	650
4T 350SS.	1000	1200	250	650
3T 350SS.	1000	900	250	300
5T 250DS.	1200	1500	400	650
4T 250DS.	1200	1200	250	650
3T 250DS.	1200	900	250	300
5T 250SS.	900	1500	400	650
4T 250SS.	900	1200	250	650
3T 250SS.	900	900	250	300

NOTES:—

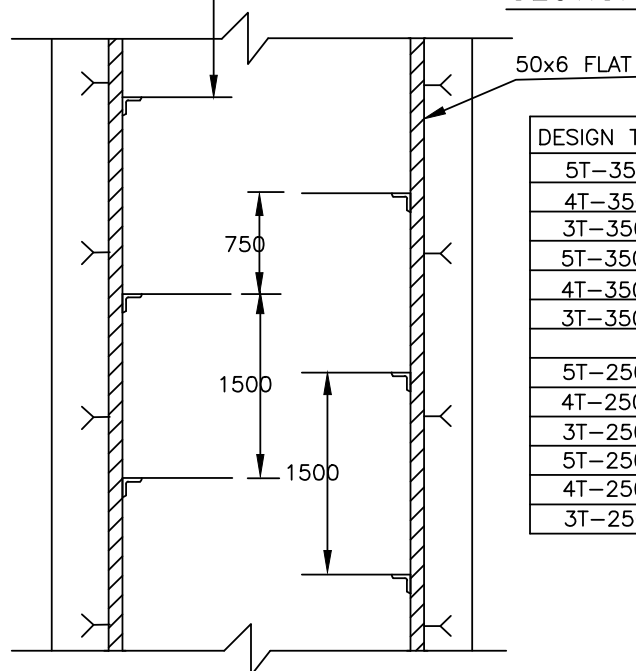
1. THE TOP OF TRENCH SHALL MATCH THE FLOOR LEVEL IN PLANT AREA.
2. IN INDOORS INSTEAD OF RCC SLAB, 20mm. THICK AL. EXTRUDED PLANK OR 10mm. THICK M.S. CHEQUERED PLATE SHALL BE USED AS PER PDS:E 507.
3. PROPER SLOPE TO BE GIVEN IN THE TRENCH FOR NATURAL DRAINAGE.
4. SS—SINGLE SIDE CABLE SUPPORTS.
5. DS—DOUBLE SIDE CABLE SUPPORTS.
6. ALL DIMENSIONS ARE IN mm.



SECTION OF TRENCH

CABLE SUPPORTS TO BE FIXED

@ 1500 INTERVAL

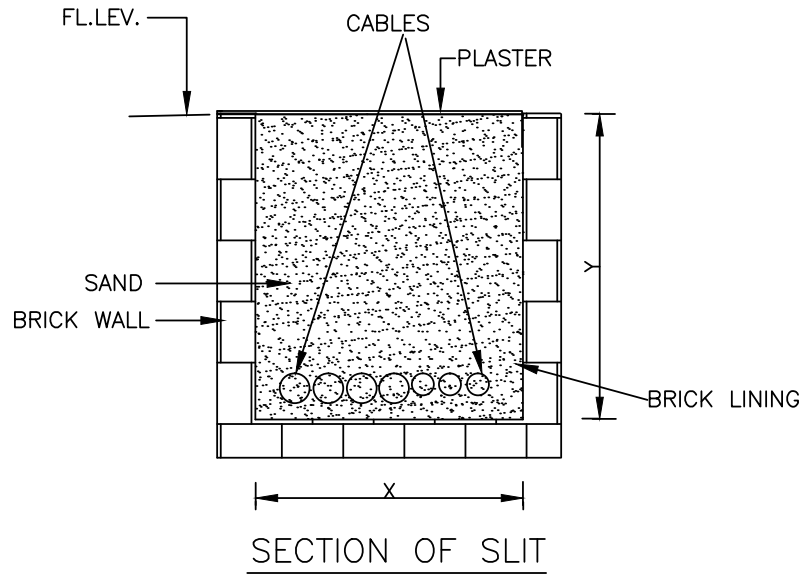


### TYPICAL PLAN OF TRENCH

DESIGN TYPE	X	Y	N	M	W
5T-350-DS.	1400	1500	400	650	350
4T-350-DS.	1400	1200	250	650	350
3T-350-DS.	1400	900	250	300	350
5T-350-SS.	1000	1500	400	650	350
4T-350-SS.	1000	1200	250	650	350
3T-350-SS.	1000	900	250	300	350
5T-250-DS.	1200	1500	400	650	250
4T-250-DS.	1200	1200	250	650	250
3T-250-DS.	1200	900	250	300	250
5T-250-SS.	900	1500	400	650	250
4T-250-SS.	900	1200	250	650	250
3T-250-SS.	900	900	250	300	250

- NOTES:—1. SS—SINGLE SIDE CABLE SUPPORT.  
2. DS—DOUBLE SIDE CABLE SUPPORT.  
3. ALL DIMENSIONS ARE IN mm.

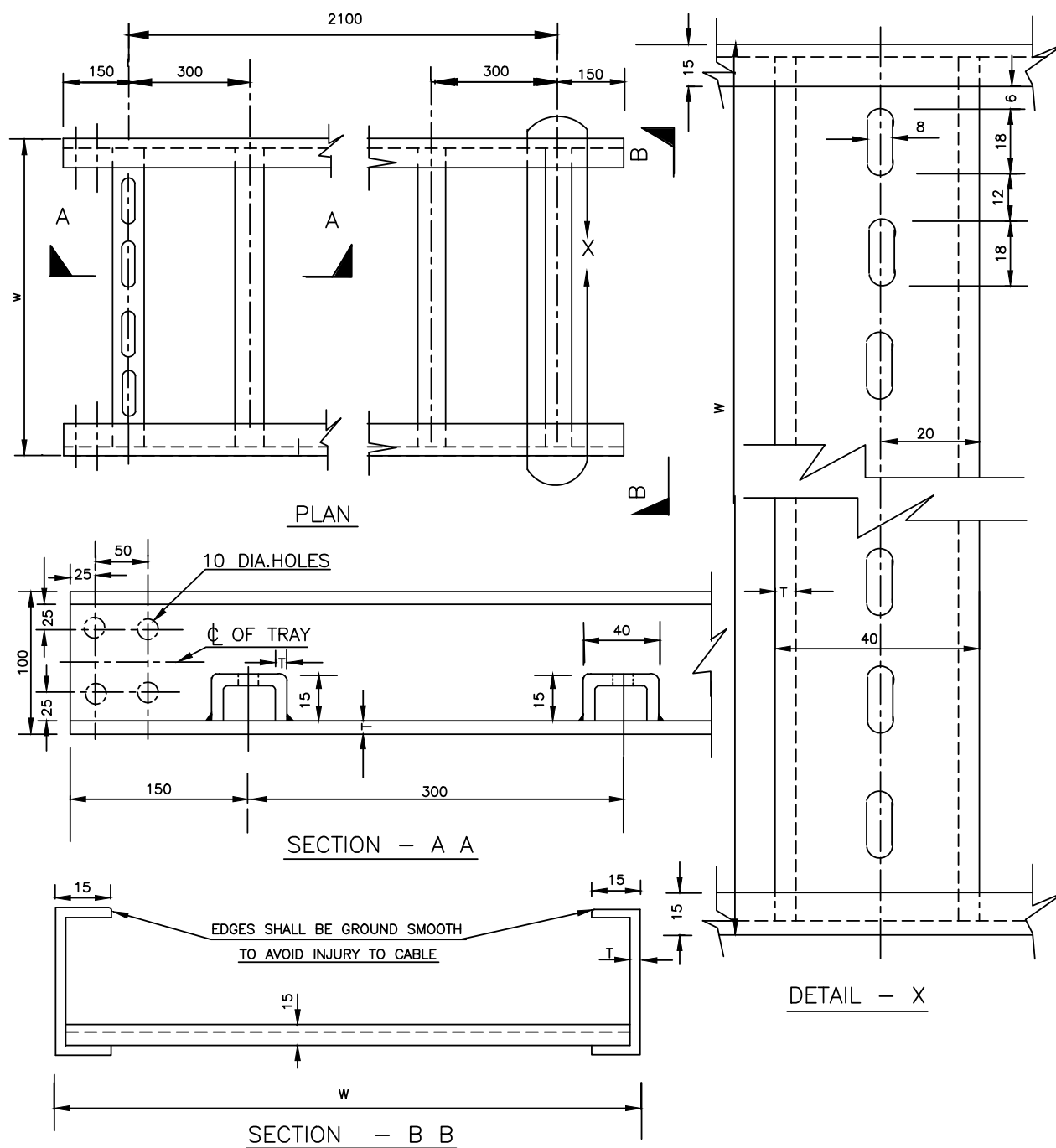




DESIGN TYPE	X	Y
S 300	300	300
S 200	200	200

NOTE:—

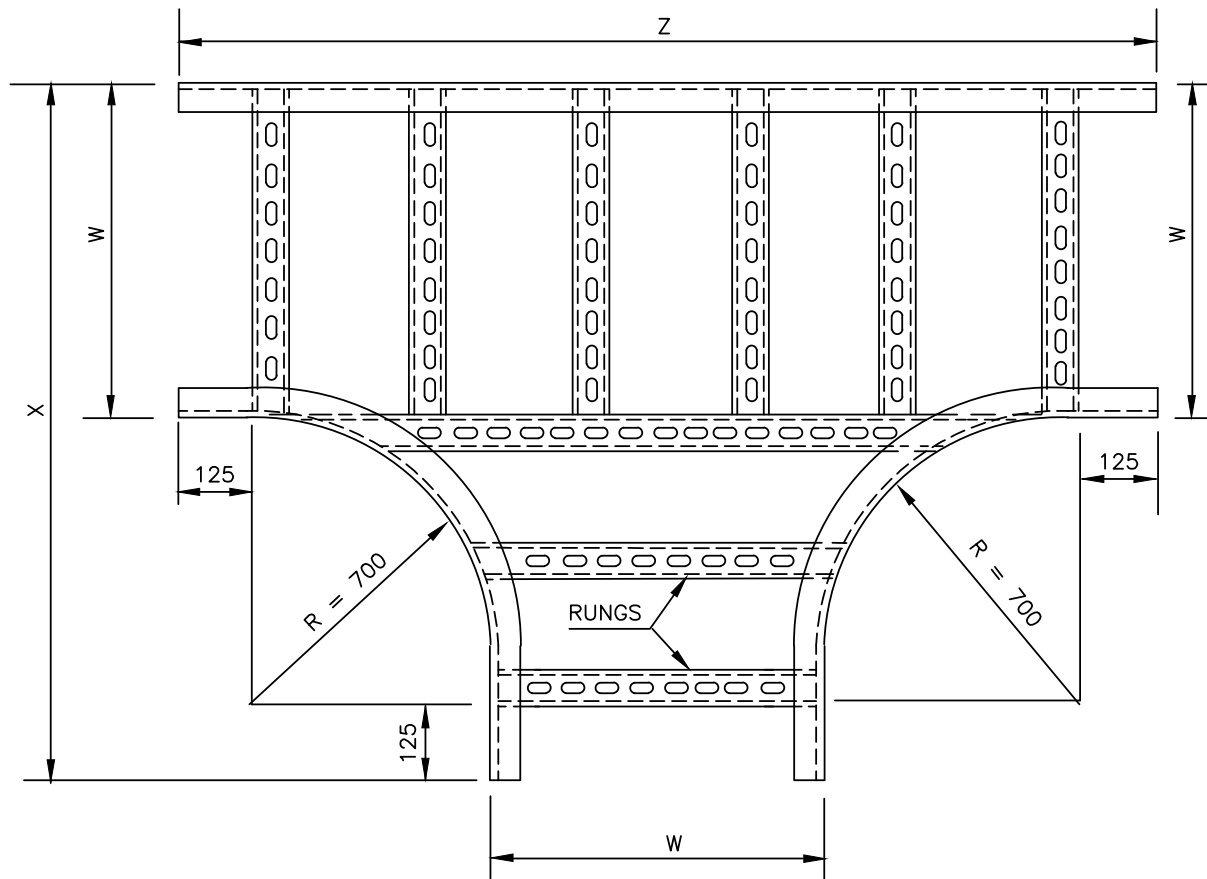
1. CABLE SLITS SHALL BE FILLED WITH SAND AND PROPERLY PLASTERED WITH LEAN CONCRETE AFTER LAYING OF CABLES.
2. WHEREVER CABLES ARE COMING OUT OF THE SLIT, SUITABLE MECH.PROTECTION TO BE PROVIDED.



DESIGN TYPE (WIDTH)	MAX.SUPPORTING SPAN		WEIGHT/METER APPROX. IN Kg.	
	G. I.	A. L	G. I.	A. L
SR 900	2000	2000	10.5	3.6
SR 600	2000	2000	8.9	3.05
SR 450	2000	2000	8.0	2.75
SR 300	2000	2000	7.6	2.6
SR 150	2000	2000	6.8	2.33

NOTE:—

THICKNESS " T " SHALL BE 3mm FOR G.I  
AND 4mm.FOR AL.

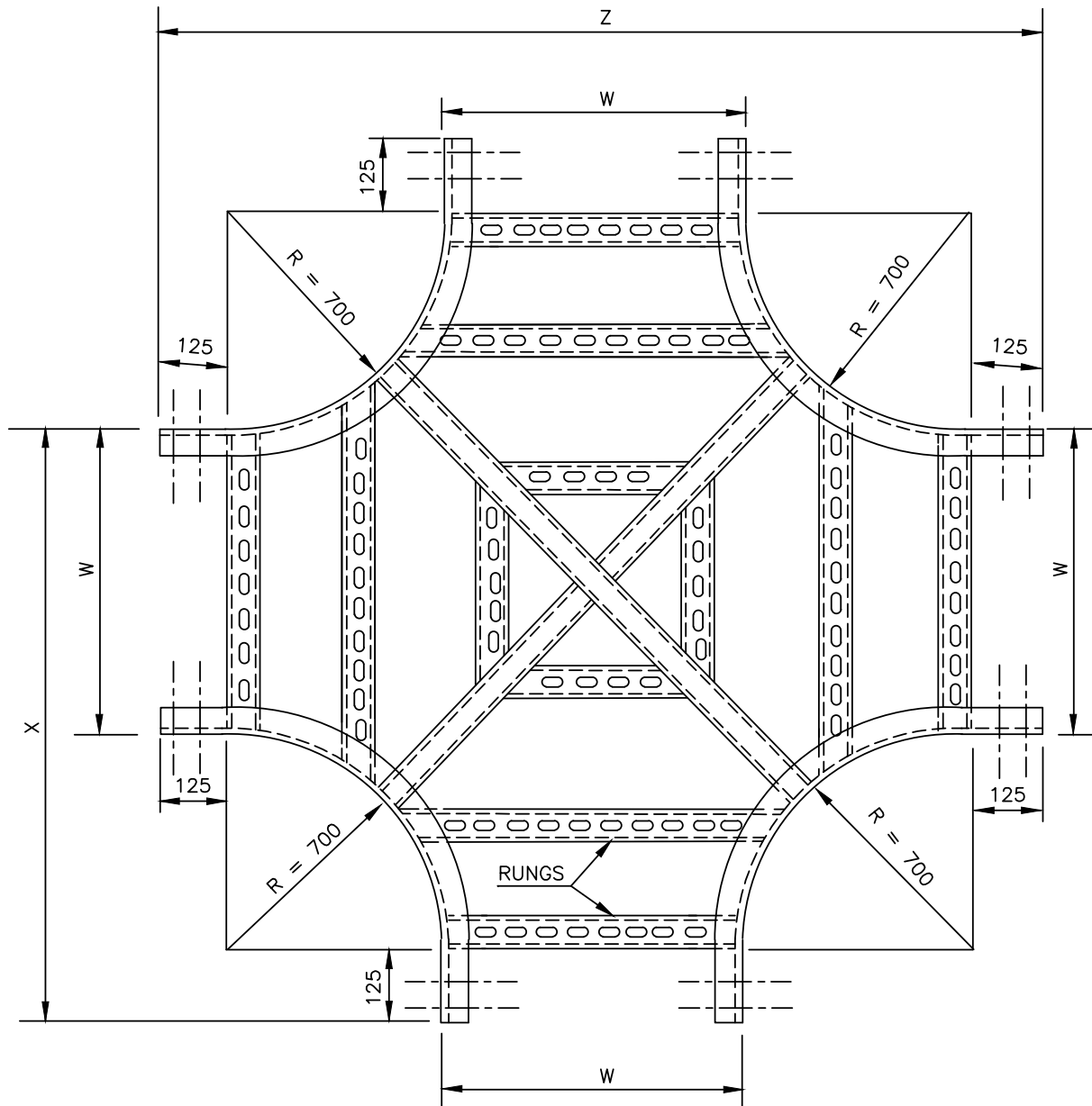


PLAN

DESIGN TYPE	W	$X=R+W+125$	$Z=2R+W+250$
HT 900	900	1725	2550
HT 600	600	1425	2250
HT 450	450	1275	2100
HT 300	300	1125	1950

NOTES :-

1. DISTANCE BETWEEN TWO RUNGS SHOULD BE APPROX. 300mm.
2. ALL DIMENSIONS ARE IN mm.

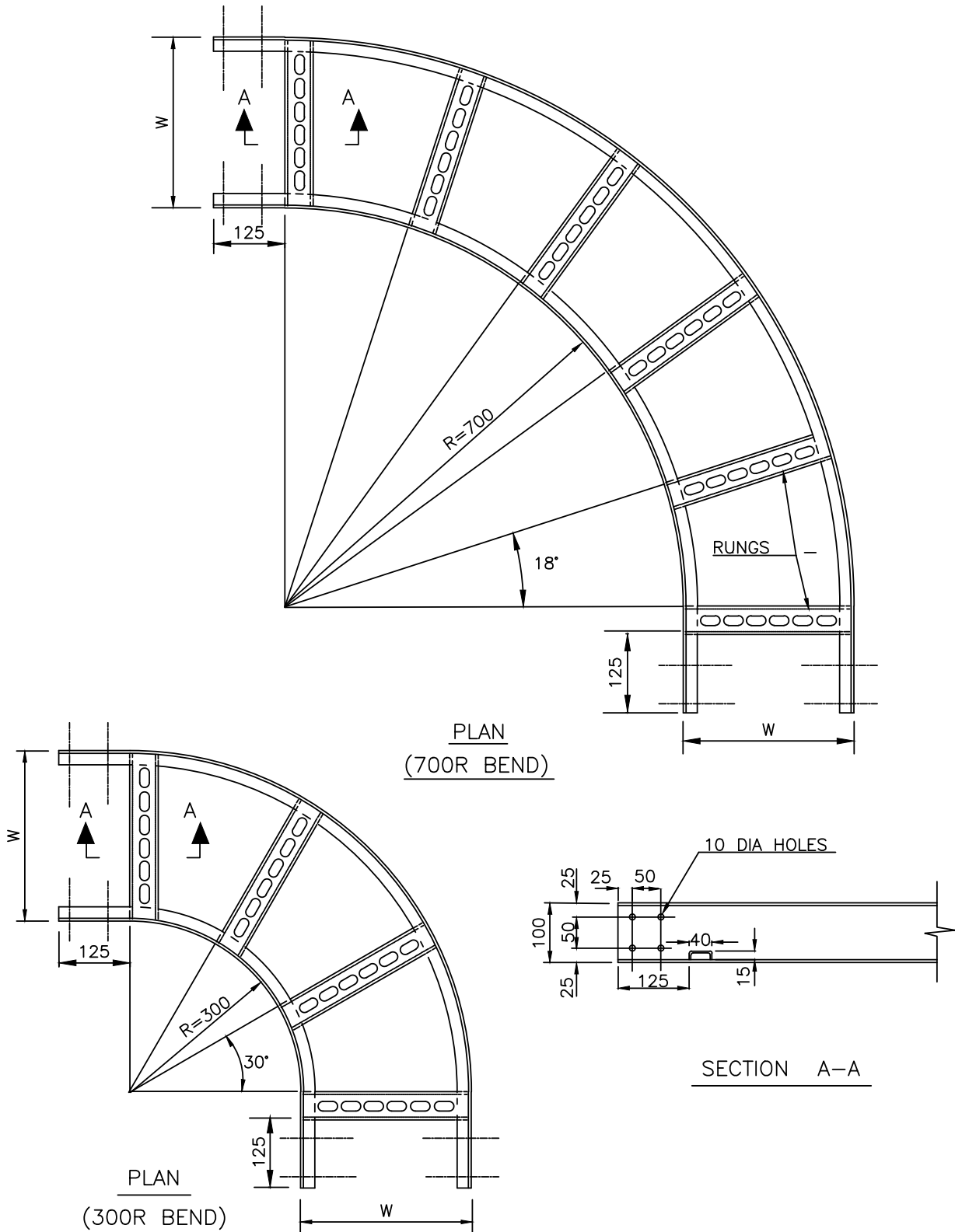


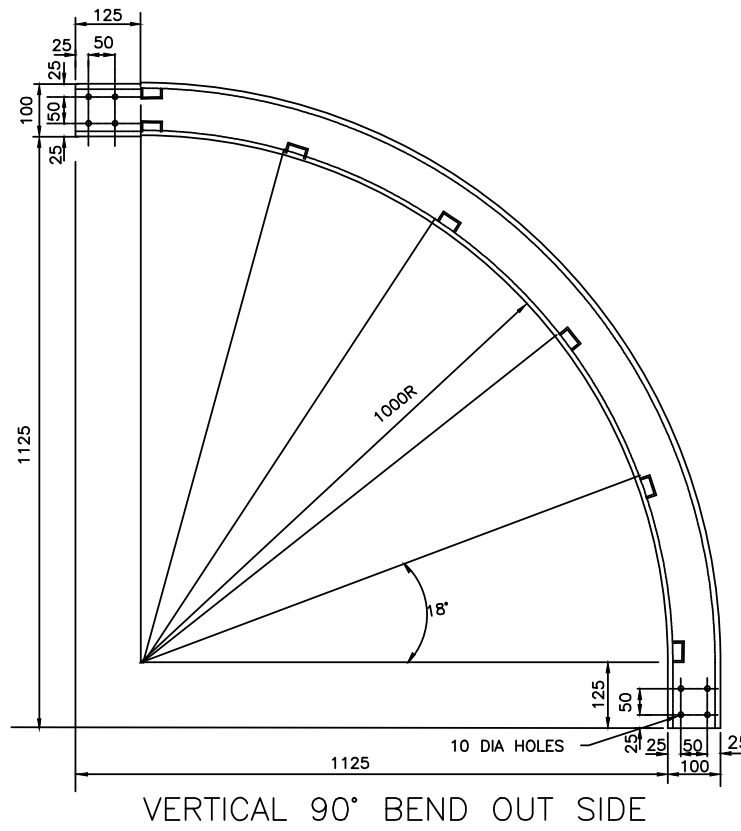
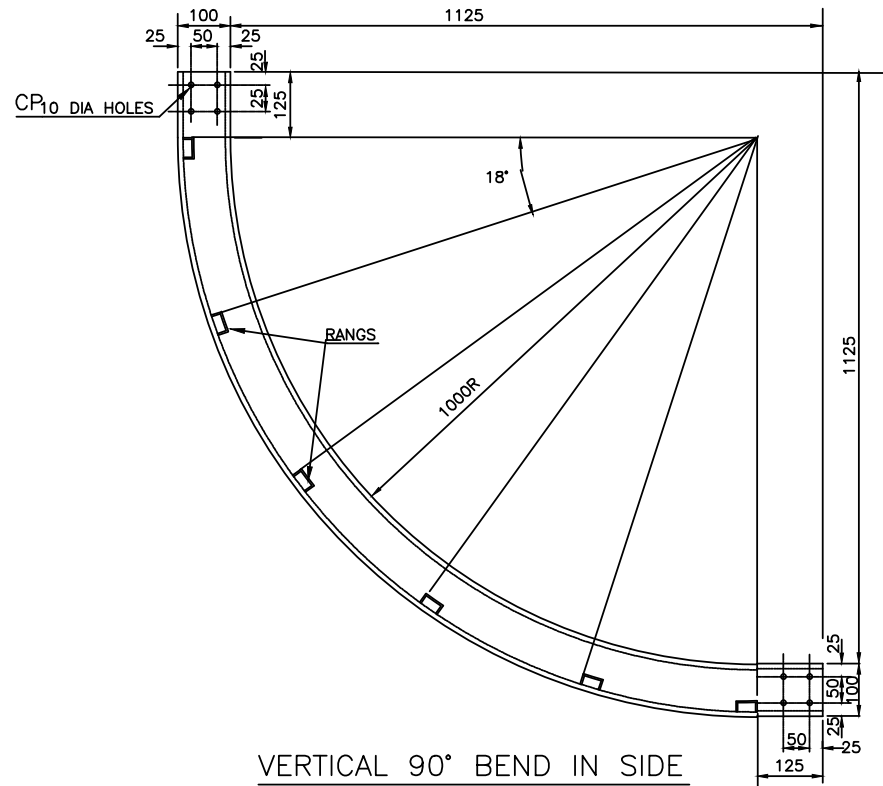
PLAN

DESIGN TYPE	W	$X=R+W+125$	$Z=2R+W+250$
HC 900	900	1725	2550
HC 600	600	1425	2250
HC 450	450	1275	2100
HC 300	300	1125	1950

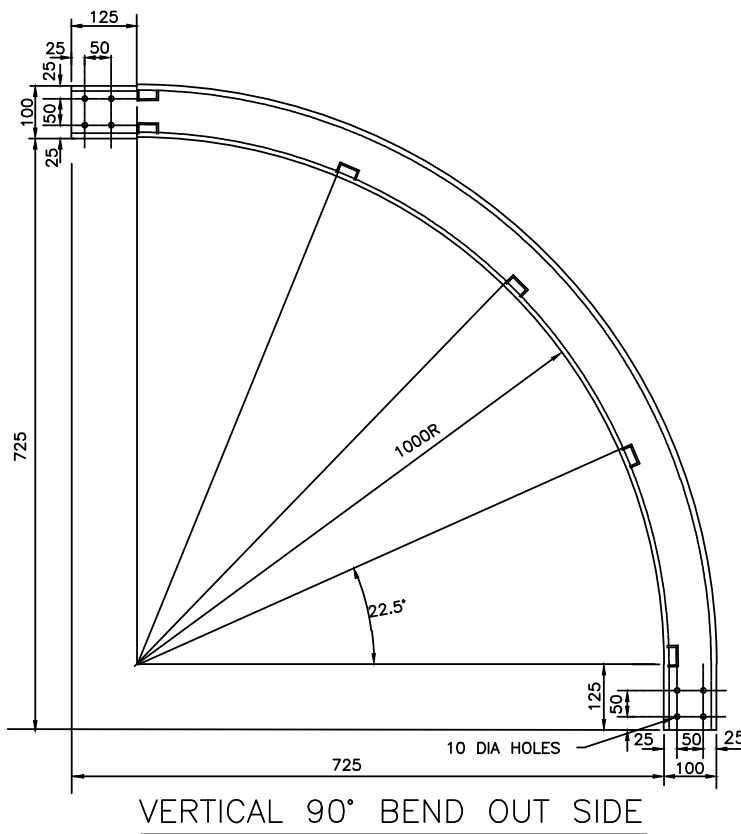
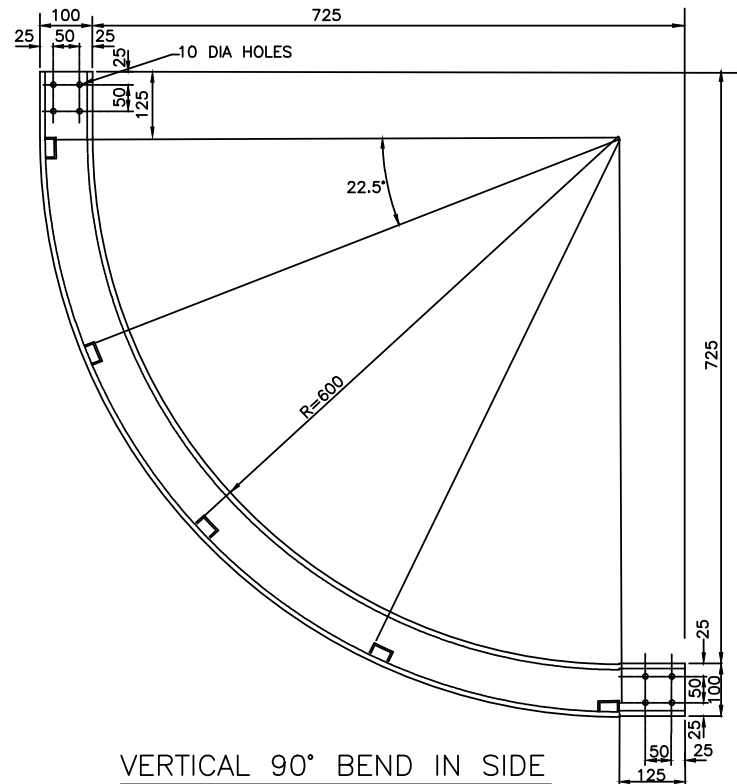
NOTES :-

1. DISTANCE BETWEEN TWO RUNGS SHOULD BE APPROX. 300mm.
2. ALL DIMENSIONS ARE IN mm.

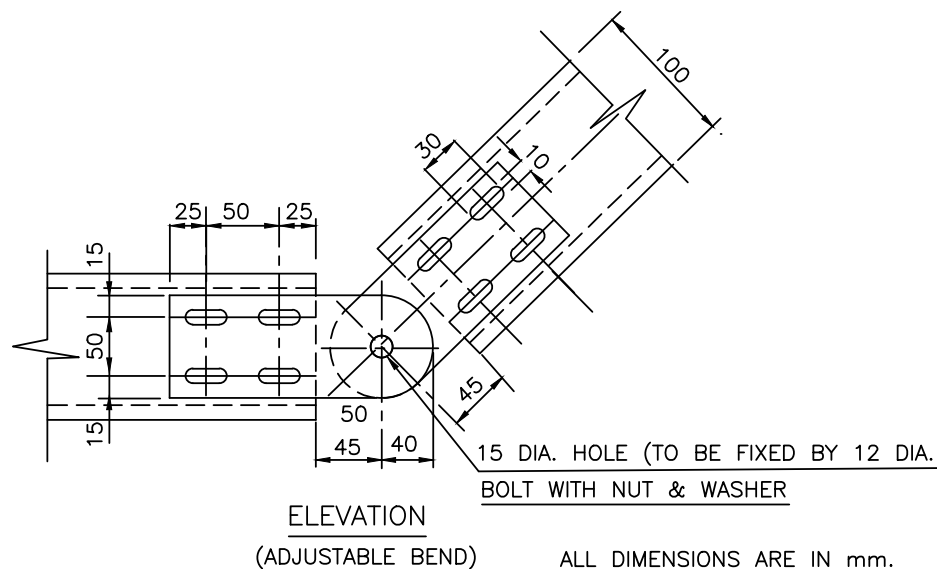




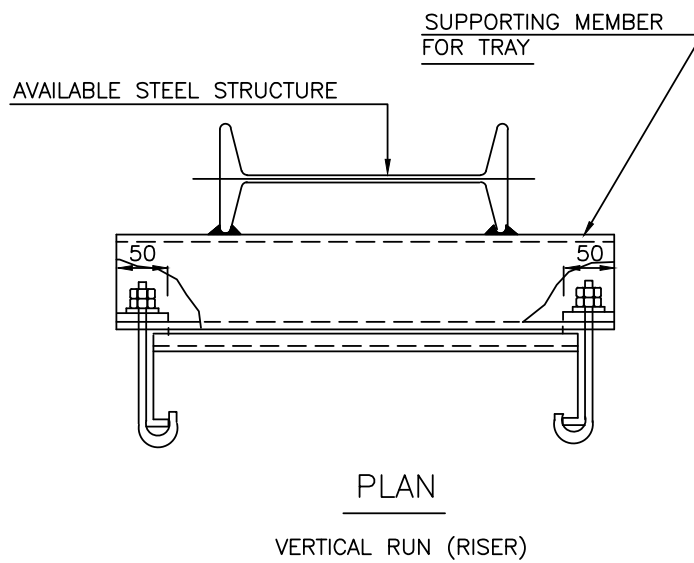
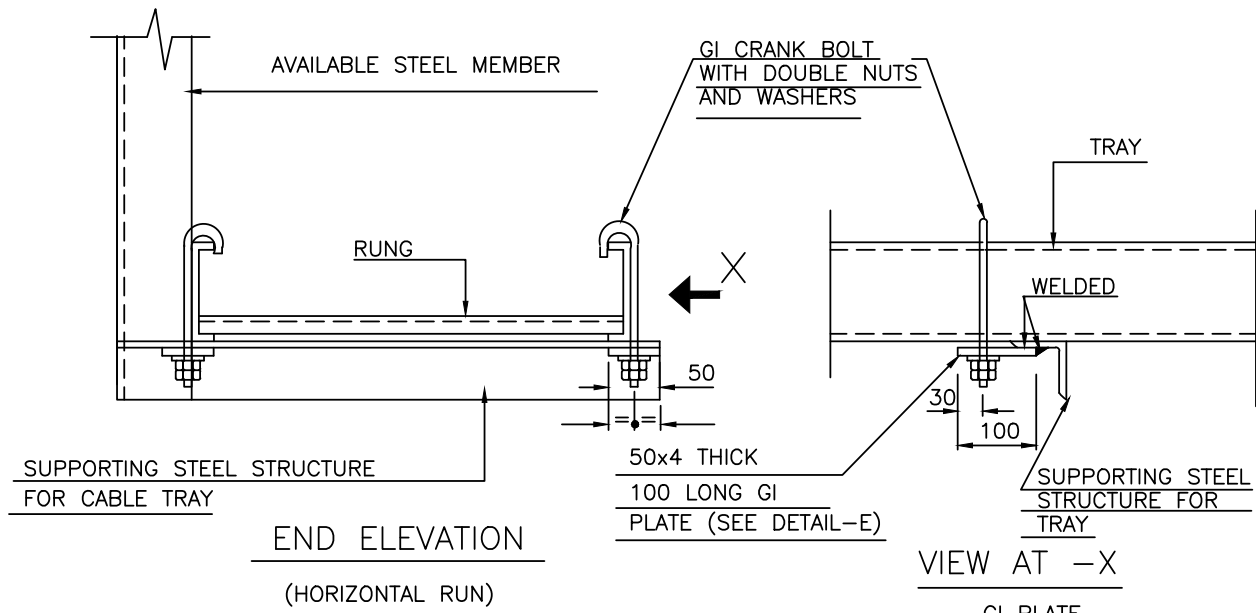
DIMENSIONS ARE IN mm.



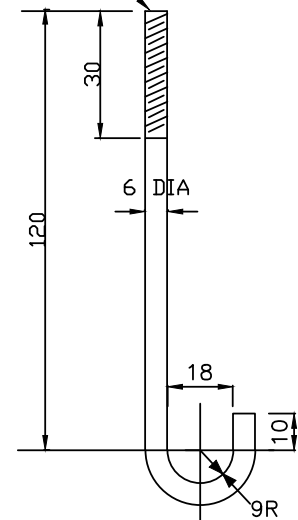
ALL DIMENSIONS ARE IN mm.





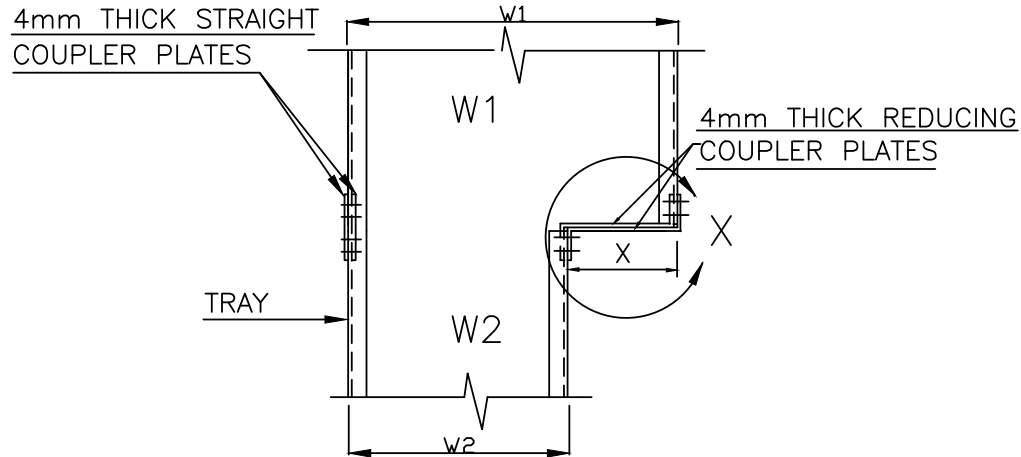


GI CRANK BOLT  
WITH DOUBLE NUTS  
& WASHERS.

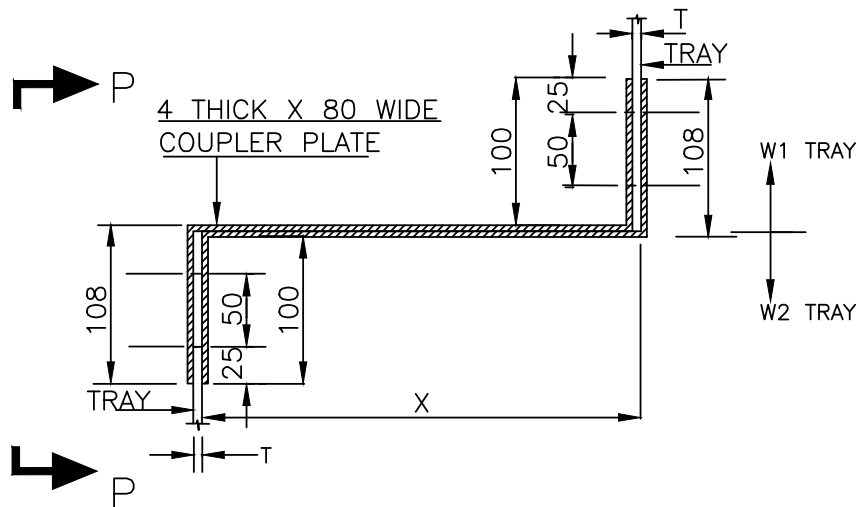


NOTES:-

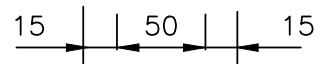
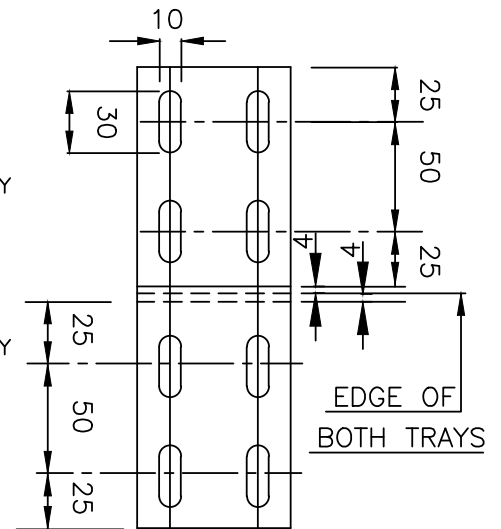
1. HORIZONTAL RUN TO BE CLAMPED WITH EVERY SUPPORT AS PER LAYOUT
2. VERTICAL RUN/ RISER TO BE CLAMPED WITH EVERY SUPPORT AS PER LAYOUT
3. EACH CRANK HOOK SHALL BE SUPPLIED WITH ONE PLAIN WASHER, ONE SPRING WASHER AND TWO DOUBLE CHAMFERED HEX NUTS. THESE SHALL BE GALVANISED ITEMS.
4. ALL DIMENSIONS ARE IN mm.



PLAN  
(REDUCING TRAY JOINT)



DETAIL - X  
DETAIL OF REDUCING  
COUPLER PLATE (4 THICK)



VIEW - P-P

ALL DIMENSIONS ARE IN mm.

SL. NO.	W1	W2	X
1	900	600 450 300	300 450 600
2	600	450 300	150 300
3	450	300 150	150 300



# GENERAL NOTES ON EARTHING AND LIGHTNING PROTECTION

PDSE: 601

0

DOCUMENT NO.

REV

SHEET 1 OF 2

## A. GENERAL

1. EARTHING AND LIGHTNING PROTECTION SHALL BE CARRIED OUT IN ACCORDANCE WITH IS : 3043 AND IS : 2309 RESPECTIVELY AND SHALL ALSO CONFORM TO THE REQUIREMENTS OF INDIAN ELECTRICITY RULES.
2. THESE NOTES SHALL BE READ IN CONJUNCTION WITH EARTHING & LIGHTNING PROTECTION LAYOUT DRGS. AND RELEVANT EARTHING STANDARDS (PDSE)
3. THE SIZE OF EARTH CONDUCTORS & SYMBOLS SHOWN IN THE LAYOUT DRGS. SHALL AS PER PDSE: 602
4. AS FAR AS POSSIBLE, THE EARTH CONDUCTORS SHALL BE TAKEN ALONG POWER & CONTROL CABLE ROUTES.
5. EARTHING CONDUCTORS BURIED UNDER THE GROUND SHALL BE LAID ATLEAST 500 MM BELOW THE GROUND LEVEL UNLESS REQUIRED OTHERWISE, e.g FOR CROSSING ANY UNDER GROUND PIPE OR TRENCH ETC. WHERE THE EARTHING CONDUCTORS SHALL RUN AT A MINIMUM DEPTH 300 MM BELOW THE BOTTOM OF THE PIPE/TRENCH.
6. BARE ALUMINIUM CONDUCTORS SHALL NOT BE BURIED DIRECTLY UNDER THE GROUND.
7. TAPPING FROM THE UNDER GROUND EARTH GRID SHALL BE TAKEN ONLY FROM EARTH PIT OR A PIT WITHOUT ELECTRODE PROVIDED FOR THIS PURPOSE.
8. JOINTING OF UNDERGROUND EARTHING STRIPS SHALL BE AVOIDED TO THE EXTENT POSSIBLE. HOWEVER, IF JOINTING IS TO BE DONE DUE TO UNAVOIDABLE REASONS, THIS SHALL BE DONE BY ELECTRIC ARC WELDING.
9. TERMINAL JOINTING & CLAMPING ARRANGEMENT SHALL BE AS SHOWN IN PDSE:603. ALL WELDED OR BOLTED JOINTS SHALL BE PAINTED WITH EPOXY RESIN PAINT OR BITUMINOUS PAINT.
10. EARTH BUSES, AS PER CONVENIENCE, SHALL BE PROVIDED IN PLANTS FOR EARTHING GROUPS OF EQUIPMENT TO EARTHING GRID. THESE EARTH BUSES, SHALL BE AS SHOWN IN PDSE: 615.
11. DETAILS OF EARTH PIT CONNECTIONS & ACCESSORIES FOR EARTH ELECTRODES SHALL BE AS SHOWN IN PDSE :604, 605 , 610 AND 611.
12. EARTH PITS FOR EQUIPMENT EARTHING, SYSTEM NEUTRAL EARTHING & LIGHTNING PROTECTION SHALL BE SEPARATE. HOWEVER, THESE PITS SHALL BE INTERCONNECTED.
13. SPACING BETWEEN TWO EARTH PITS SHALL NOT BE LESS THAN 10 M & THESE MAY BE LOCATED ABOUT 4M AWAY FROM THE BUILDING / STRUCTURE.
14. TYPICAL ARRANGEMENT OF NEUTRAL & EQUIPMENT EARTHING SHALL BE AS SHOWN IN PDSE: 617.

## B. SYSTEM NEUTRAL EARTHING

1. THE NEUTRALS OF H.T & L.T SYSTEMS SHALL BE EARTHED BY USING 2 NOS. 150 SQ. MM ALUMINIUM CABLE OF RESPECTIVE VOLTAGE GRADE. EACH EARTH CONNECTION SHALL BE TERMINATED ON SEPERATE EARTH PITS. HOWEVER, FOR ECONOMY REASONS, 2 EARTH CONNECTIONS OF 2 DIFFERENT EQUIPMENT CAN BE TERMINATED ON THE SAME EARTH PIT AS SHOWN IN PDSE: 617.
2. THE NEUTRAL OF H.T. SYSTEM SHALL BE CONNECTED TO EARTH PIT AS ABOVE THROUGH THE NEUTRAL EARTHING RESISTOR (N.E.R.) AS REQUIRED, WHERE AS THE NEUTRAL OF L.T. SYSTEM SHALL BE SOLIDLY EARTHED THROUGH RESPECTIVE L.T. SWITCH BOARD.
3. FOR D.C. SYSTEM, POSITIVE POLE SHALL BE EARTHED THROUGH HIGH IMPEDANCE IN BATTERY CHARGER.

## C. ELECTRICAL EQUIPMENT EARTHING

1. ALL EQUIPMENT RATED ABOVE 250V SHALL HAVE TWO EXTERNAL EARTH CONNECTIONS & THOSE RATED 250V & BELOW SHALL HAVE ONE EXTERNAL EARTH CONNECTION.  
FLAME PROOF EQUIPMENT, IN ADDITION, SHALL HAVE ONE INTERNAL EARTH CONNECTION THROUGH ADDITIONAL CORE OF POWER / CONTROL CABLE.

0	03.01.07	15.01.07	ISSUED FOR IMPLEMENTATION			
REV	REV.DATE	EFF.DATE	PURPOSE	PREPD	REVWD	APPD



# GENERAL NOTES ON EARTHING AND LIGHTNING PROTECTION

PDSE: 601	0
DOCUMENT NO.	REV
SHEET 2 OF 2	

- EARTHING CONNECTION TO INDIVIDUAL EQUIPMENT SHALL BE TAPPED ONLY FROM THE EARTHING GRID / RING OR EARTH BUS EXCEPT FOR EQUIPMENT RATED 250V & BELOW, FOR WHICH THE CONNECTION MAY BE TAKEN FROM THE NEAR BY EARTH CONDUCTOR OF A LARGER EQUIPMENT OR FROM THE BODY OF THE LARGER EQPT.
- EARTHING ARRANGEMENT OF MOTOR AND ASSOCIATED LOCAL CONTROL STATION SHALL BE AS SHOWN IN PDSE: 608.
- EARTHING ARRANGEMENT OF RAILS SHALL BE AS SHOWN IN PDSE: 609 WITH BOTH ENDS EARTHED.
- CABLES RACKS/RISERS/TRAYS SHALL BE ELECTRICALLY CONTINUOUS BY BONDING THE JOINTS BETWEEN THE RUNNER MEMBERS OF THE ADJACENT SECTIONS. THE CABLE RACKS SHALL BE CONNECTED TO THE EARTHING GRID AT SUITABLE INTERVALS.
- EARTHING ARRANGEMENT OF LIGHTING FIXTURES & PLUG SOCKETS RATED 250V AND BELOW SHALL NOT BE SHOWN IN THE EARTHING LAYOUT DRGS. HOWEVER, PLUG SOCKETS SHALL BE EARTHED BY 10 SWG SIZE G.I./AL. CONDUCTOR TAKEN FROM THE NEAREST EARTHING GRID/CONDUCTOR AND LIGHTING FIXTURES SHALL BE PROVIDED EARTHING THROUGH CABLE ARMOURS.
- IN SWITCH YARD AND GENERATING STATIONS SUITABLE EARTHING MAT SHALL BE PROVIDED TO REDUCE THE VALUE OF STEP/TOUCH POTENTIAL TO PERMISSIBLE VALUE.
- SWITCH YARD FENCE SHALL BE CONNECTED TO EARTH AT A REGULAR INTERVAL, NOT EXCEEDING 10 M.






















## D. STATIC EARTHING









- ALL PROCESS EQUIPMENT WHICH ARE LIKELY TO GET STATICALLY CHARGED, e.g. STORAGE TANKS, HIGH PRESSURE & MEDIUM PRESSURE VESSELS/PIPES, HIGH PRESSURE COMPRESSORS, HIGH PRESSURE STEAM EJECTORS ETC. SHALL BE EARTHED AGAINST STATIC CHARGE ACCUMULATION.
- EARTHING ARRANGEMENT ACROSS PIPE JOINTS/VALVES SHALL BE AS SHOWN IN PDSE: 612.
- DETAILS OF EARTHING OF VESSELS SHALL BE AS SHOWN IN PDSE: 613.
- MOBILE EQUIPMENT, REQUIRING EARTHING AGAINST STATIC CHARGE, SHALL BE TEMPORARILY EARTHED AS SHOWN IN PDSE: 608.
- PIPE TRESTLE CARRYING PIPES WITH HYDRO CARBONS SHALL BE CONNECTED TO EARTH GRID AT REGULAR INTERVALS, NOT EXCEEDING 25 M.
- WHEREVER PROCESS EQUIPMENT ARE MOUNTED ON STEEL STRUCTURE, THE BASE OF THE STRUCTURES SHALL BE EARTHED INSTEAD OF EARTHING THE INDIVIDUAL EQUIPMENT.

## E. LIGHTNING PROTECTION


- FIXING ARRANGEMENT ON AIR TERMINATION AND ROOF/DOWN CONDUCTOR FOR LIGHTNING PROTECTION SYSTEM SHALL BE AS SHOWN IN PDSE: 614.
- FOR LIGHTNING PROTECTION OF TALL STEEL STRUCTURES/VESSELS/TANKS, DOWN CONDUCTOR SHALL BE TAKEN FROM THE BASE AND CONNECTED TO EARTH PITS. AIR TERMINATION ROD SHALL NOT BE REQUIRED.
- LIFT SHAFT SHALL NOT BE USED FOR FIXING THE DOWN CONDUCTOR.
- IN CASE EARTH PITS FOR CONNECTING THE DOWN CONDUCTORS ARE NOT AVAILABLE IN THE BEGINNING OF FABRICATION/ERECTION OF SUCH STRUCTURES/VESSELS / TANKS. THEIR BASES SHALL TEMPORARILY BE CONNECTED TO NEAR BY STEEL COLUMN. ELECTRICAL CONTINUITY OF THE STRUCTURES, HOWEVER, SHALL BE CHECKED AND ENSURED.
- FOR ALL HIGH RISE CONCRETE STRUCTURES, TEMPORARY LIGHTNING PROTECTION NEED BE PROVIDED DURING CONSTRUCTION AND MAINTAINED TILL PERMANENT LIGHTNING PROTECTION IS INSTALLED. FOR THIS PURPOSE THE VERTICAL REINFORCEMENT, PROJECTING OVER EACH LIFT, SHALL BE CONNECTED TO EARTH PITS BY MEANS OF 2 NOS. FLEXIBLE COPPER CONDUCTOR CABLES. EACH OF THE FLEXIBLE CABLE SHALL BE OF 95 Sq. mm SIZE HAVING ONE END PERMANENTLY CONNECTED TO EARTH PIT AND OTHER END PROVIDED WITH A CLAMP FOR CONNECTING TO THE EXPOSED REINFORCEMENT.

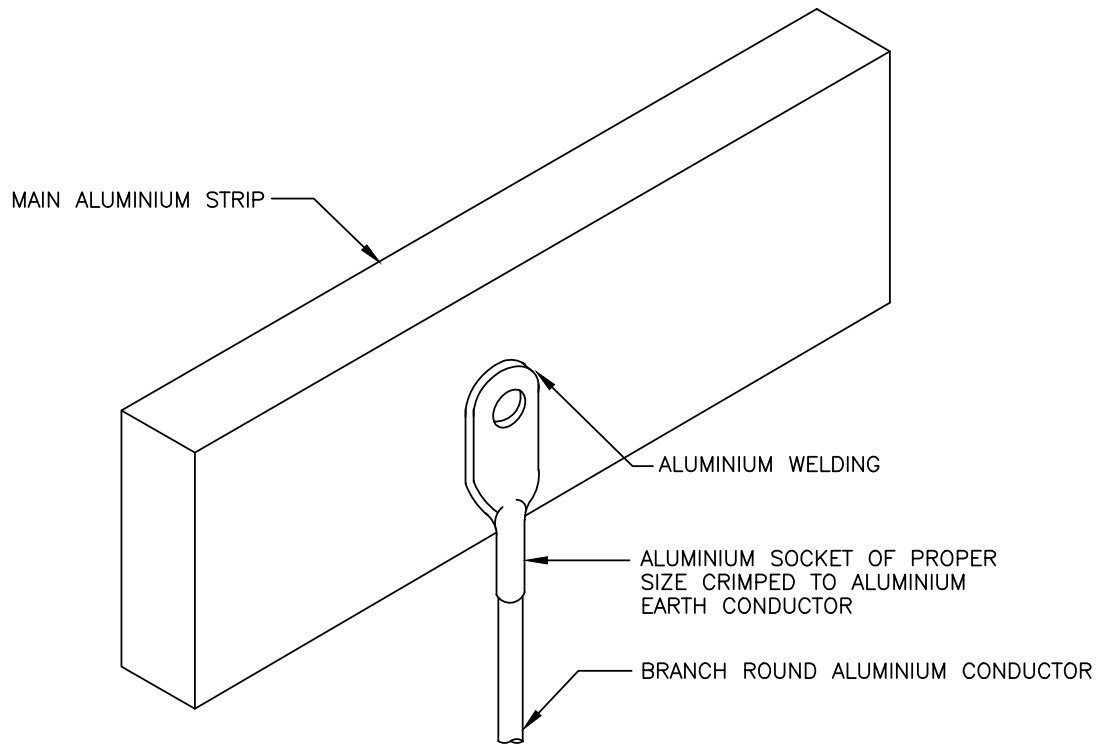
0	03.01.07	15.01.07	ISSUED FOR IMPLEMENTATION			
REV	REV.DATE	EFF.DATE	PURPOSE	PREPD	REVWD	APPD

SL. No.	EQUIPMENT TO BE EARTHED	FAULT LEVEL (MVA)	G.I. STRIPS/WIRES			ALUMINIUM			REMARKS
			MIN. SIZE (mm <sup>2</sup> )	SIZE TO BE USED (mm <sup>2</sup> )	SYMBOL	MIN. SIZE (mm <sup>2</sup> )	STRIPS/WIRES SIZE TO BE USED (mm <sup>2</sup> )	SYMBOL	
1A.	FOR PLANTS HAVING SWITCHYARDS/ GENERATING STATION								
I.	SWITCH YARD EQUIPMENT, GENERATORS, H.T. SWITCH BOARDS, TRANSFORMERS, MAIN EARTHING GRID, CONNECTION FROM EARTH BUS TO EARTHING GRID.	750 AT 11KV	706	2-50x8		491	2-38.1x6.35=484		AS PER CLAUSE 17.3.2 OF IS:3043
II.	SWITCH YARD EQUIPMENT, GENERATORS, H.T. SWITCH BOARDS, TRANSFORMERS, MAIN EARTHING GRID, CONNECTION FROM EARTH BUS TO EARTHING GRID.	500 AT 11KV 300 AT 6.6KV 150 AT 3.3KV	471	60x8		328	50.8x6.35=323		-DO-
III.	SWITCH YARD EQUIPMENT, GENERATORS, H.T. SWITCH BOARDS, TRANSFORMERS, MAIN EARTHING GRID, CONNECTION FROM EARTH BUS TO EARTHING GRID.	250 AT 6.6KV 125 AT 3.3KV	392	50x8		272	50.8x6.35=323		-DO-
IV.	SWITCH YARD EQUIPMENT, GENERATORS, H.T. SWITCH BOARDS, TRANSFORMERS, MAIN EARTHING GRID, CONNECTION FROM EARTH BUS TO EARTHING GRID.	350 AT 11KV 200 AT 6.6KV 100 AT 3.3KV	330 314 314	50x8		229 218 218	38.1x6.35=242		-DO-
V.	SWITCH YARD EQUIPMENT, GENERATORS, H.T. SWITCH BOARDS, TRANSFORMERS, MAIN EARTHING GRID, CONNECTION FROM EARTH BUS TO EARTHING GRID.	250 AT 11KV 150 AT 6.6KV 75 AT 3.3KV	235	50x6		163	31.75x4.78=152		-DO-
1B	FOR PLANTS WITHOUT SW. YARD/GENERATING STN. H.T. SWITCH BOARDS, TRANSFORMERS, MAIN EARTHING GRID, CONNECTION FROM EARTH BUS TO EARTHING GRID.	ANY FAULT LEVEL AT ANY VOLTAGE	210	50x6		120	38.1x3.18=121		AS PER CLAUSE 12.3.2 OF IS:3043
1C	ALL M.V. SWITCH BOARDS		210	50x6		120	38.1x3.18=121		AS PER CLAUSE 12.3.2 OF IS:3043
2	H.V. MOTORS		210	50x6		120	38.1x3.18=121		-DO-
3	TRANSFORMER NEUTRALS		-	-	-	120	-		-
4	M.V. MOTORS RATED 75KW & ABOVE		210	50x6		120	38.1x3.18=121		AS PER CLAUSE 12.3.2 OF IS:3043
5	M.V. MOTORS ABOVE 30KW & LESS THAN 75KW		175	35x6		93	31.75x3.18=101		-DO-

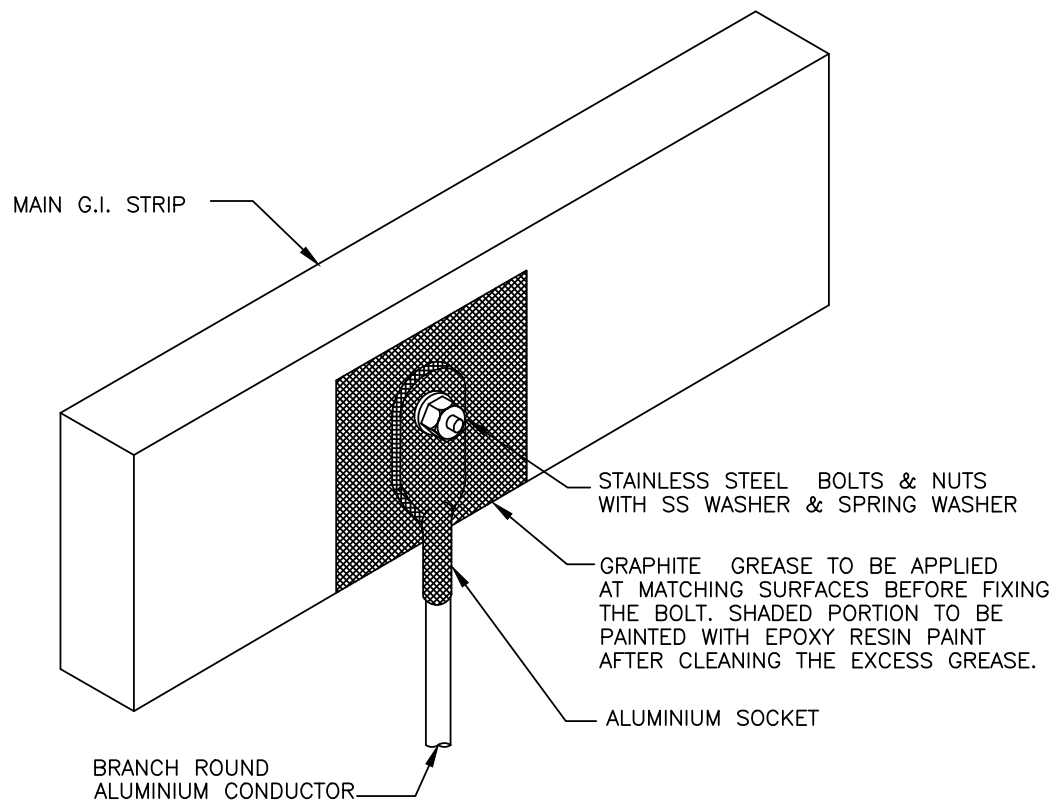
SL. No.	EQUIPMENT TO BE EARTHED	FAULT LEVEL (MVA)	G.I. STRIPS/WIRES		ALUMINIUM STRIPS/WIRES			1.1kv PVC SINGLE CORE CABLE		REMARKS
			MIN. SIZE (mm <sup>2</sup> )	SIZE TO BE USED (mm <sup>2</sup> )	SYMBOL	MIN. SIZE (mm <sup>2</sup> )	SIZE TO BE USED (mm <sup>2</sup> )	SYMBOL	SIZE (mm <sup>2</sup> )	
6	M.V.MOTORS ABOVE 5.5KW & LESS THAN 30KW 63A SW.SOCKETS,BATTERY CHARGERS,LIGHTING SUB-DIST.BDS.,D.C.BDS.		44	25x6		25	2 SWG=38.6		25	AS PER CLAUSE 12.3.2 OF IS:3043
7	M.V.MOTORS RATED 5.5KW & BELOW		7	8 SWG=13		5	10 SWG=8.3		6	-DO-
8	ALL MINOR EQUIPMENT RATED FOR 250V & BELOW		-	10 SWG=8.3		-	10 SWG=8.3		6	
9	NON ELECTRICAL EQUIPMENT,SUCH AS VESSELS STRUCTURES IN HAZARDOUS AREA & LIGHTNING PROTECTION CONDUCTORS		32x6	35x6		-	25.4x3.18=81		-	AS PER IS:2309

NOTE :—EARTHING CONDUCTOR SIZES FOR ITEMS AT SL.No.4,5,6 & 7 SHOULD BE CHOSEN AS HALF THE POWER CABLE SIZES ACTUALLY USED.

<div>  <p>पी डी आई एल <b>PDIL</b></p> </div>	ARRANGEMENT OF CONNECTIONS OF EARTH CONDUCTORS (T-JOINT AL STRIP & GI STRIP TO ROUND AL CONDUCTOR)		PC288-PDS:E 603	0
			DOCUMENT NO.	REV.
			SHEET 1 OF 6	

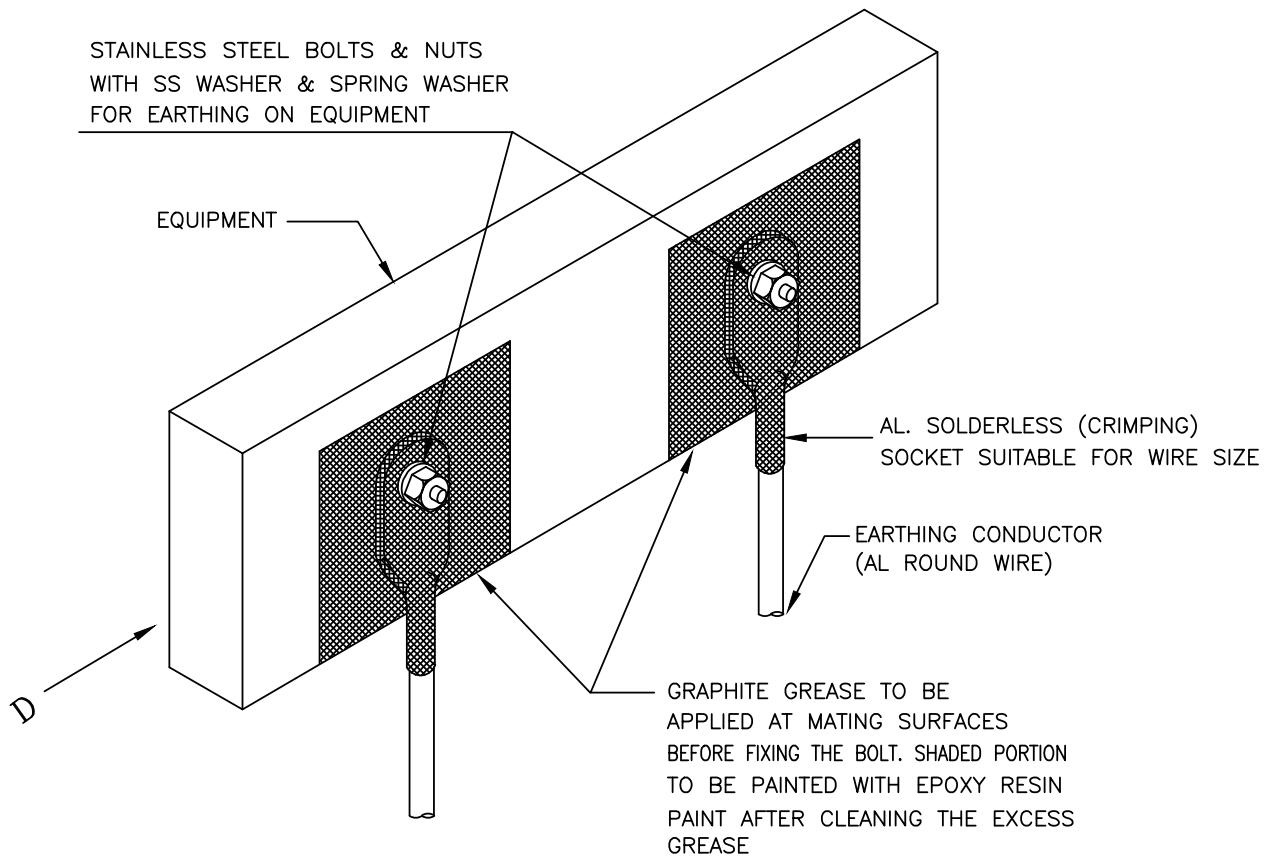


' T ' JOINT ALUMINIUM STRIP TO ROUND ALUMINIUM CONDUCTOR

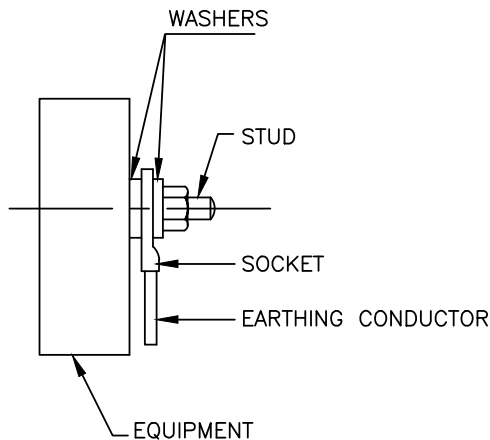


' T ' JOINT G.I. STRIP TO ROUND ALUMINIUM CONDUCTOR



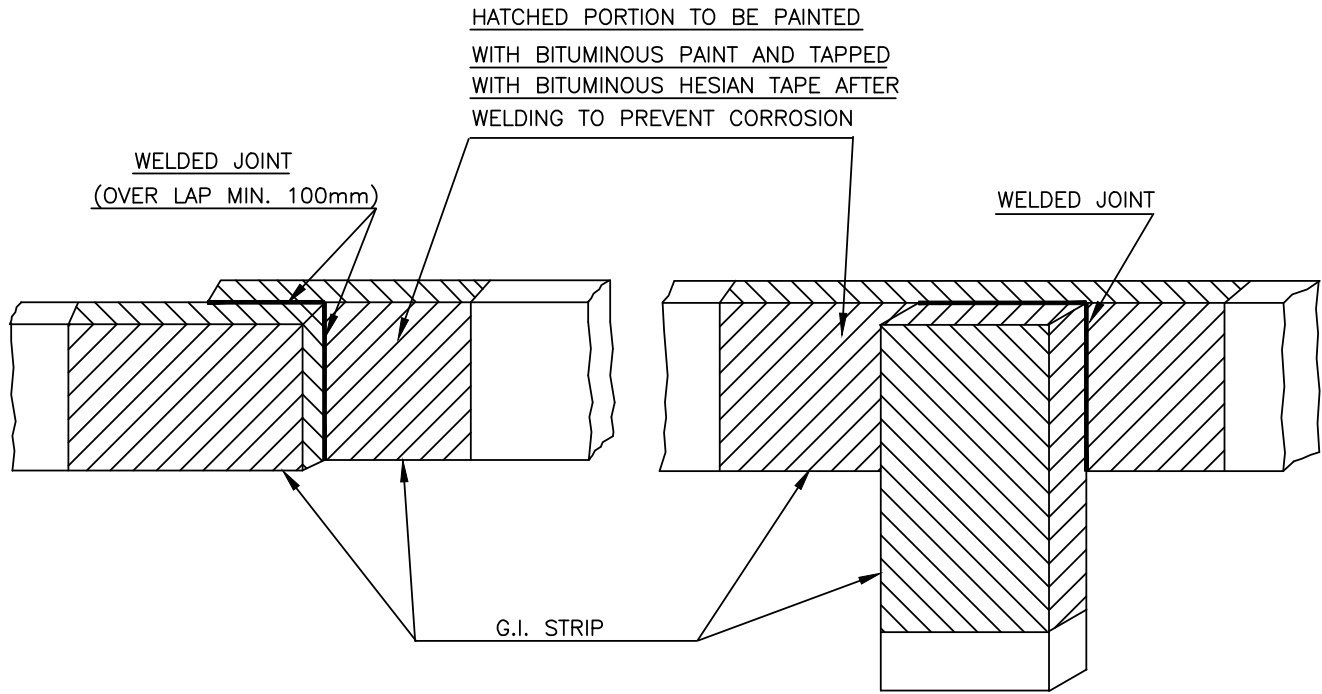


### ARRANGEMENT OF DOUBLE EARTH CONNECTIONS TO EQUIPMENT



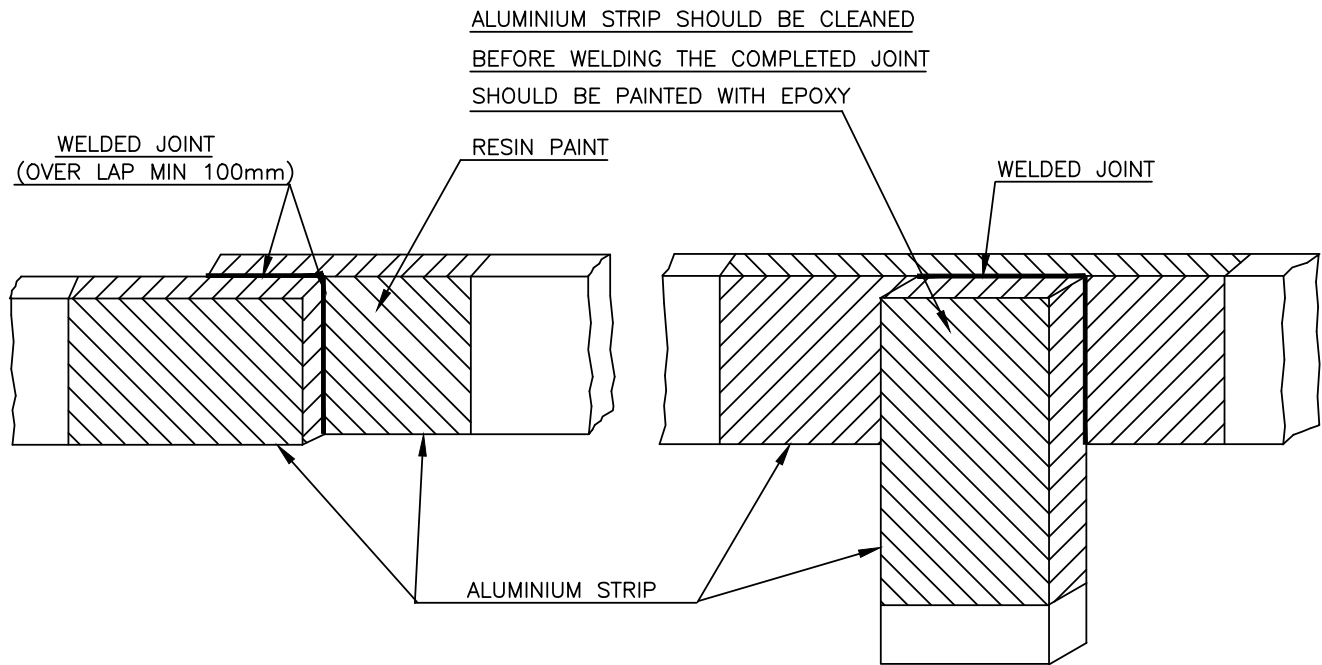
V I E W F R O M - D





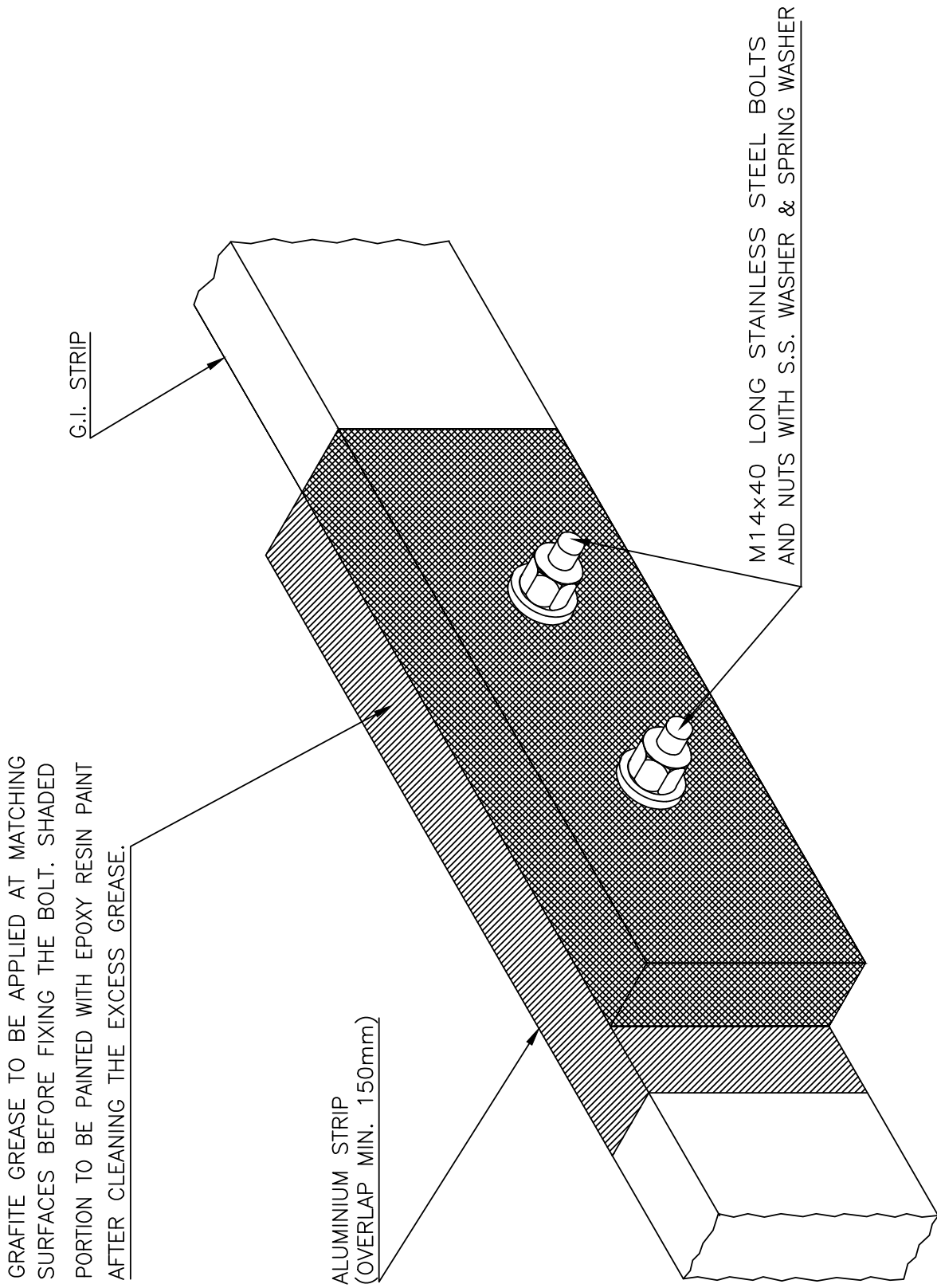
STRAIGHT JOINT G.I TO G.I. STRIP

" T " JOINT G.I. TO G.I. STRIP

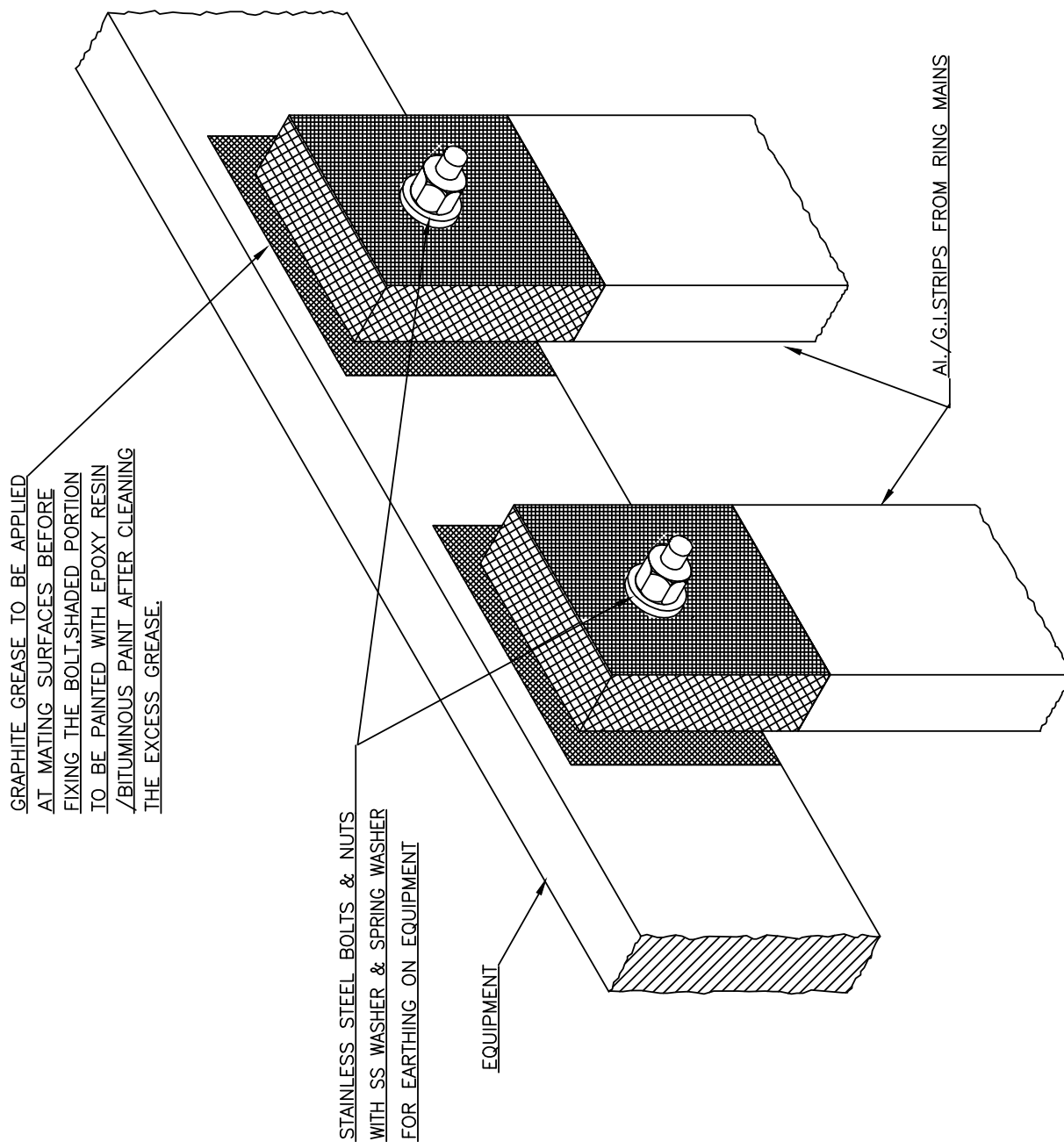


STRAIGHT JOINT AL. TO AL. STRIP

" T " JOINT AL TO AL STRIP



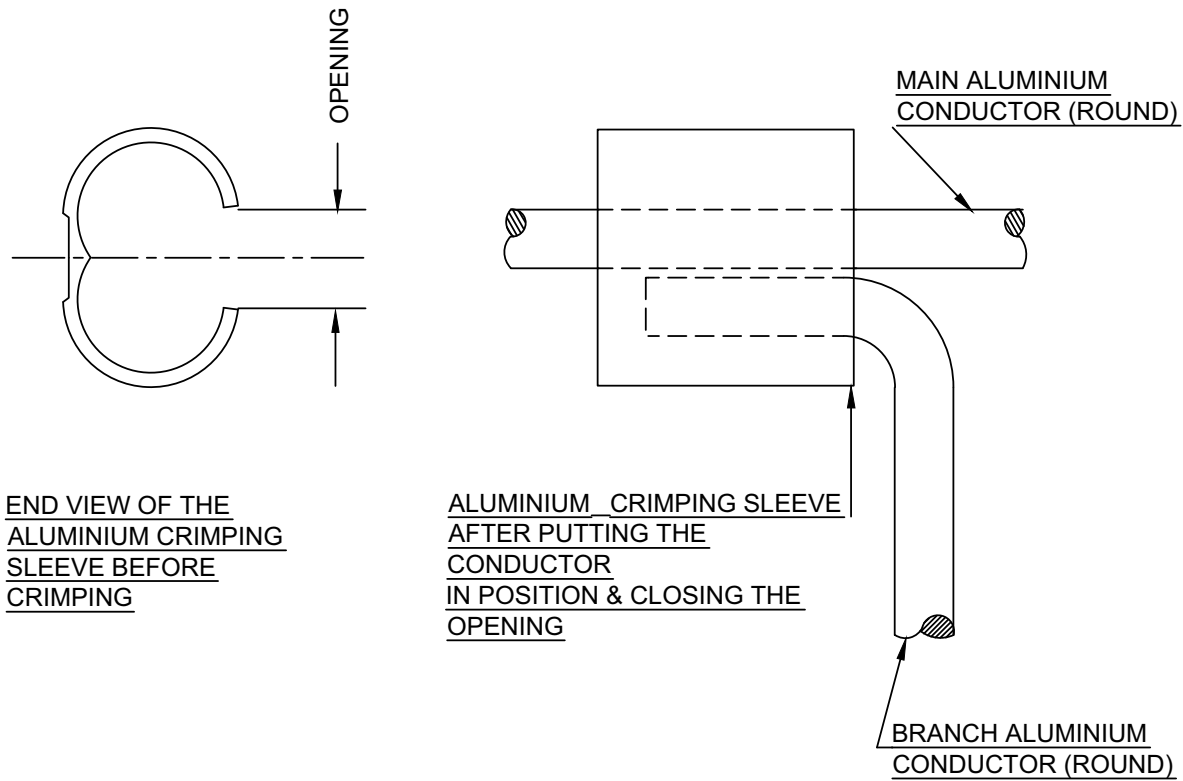
ARRANGEMENT OF LAP JOINT BETWEEN  
 AL. EARTH STRIP TO G.I. EARTH STRIP



ARRANGEMENT OF DOUBLE EARTH CONNECTION ON EQUIPMENT

NOTE:-

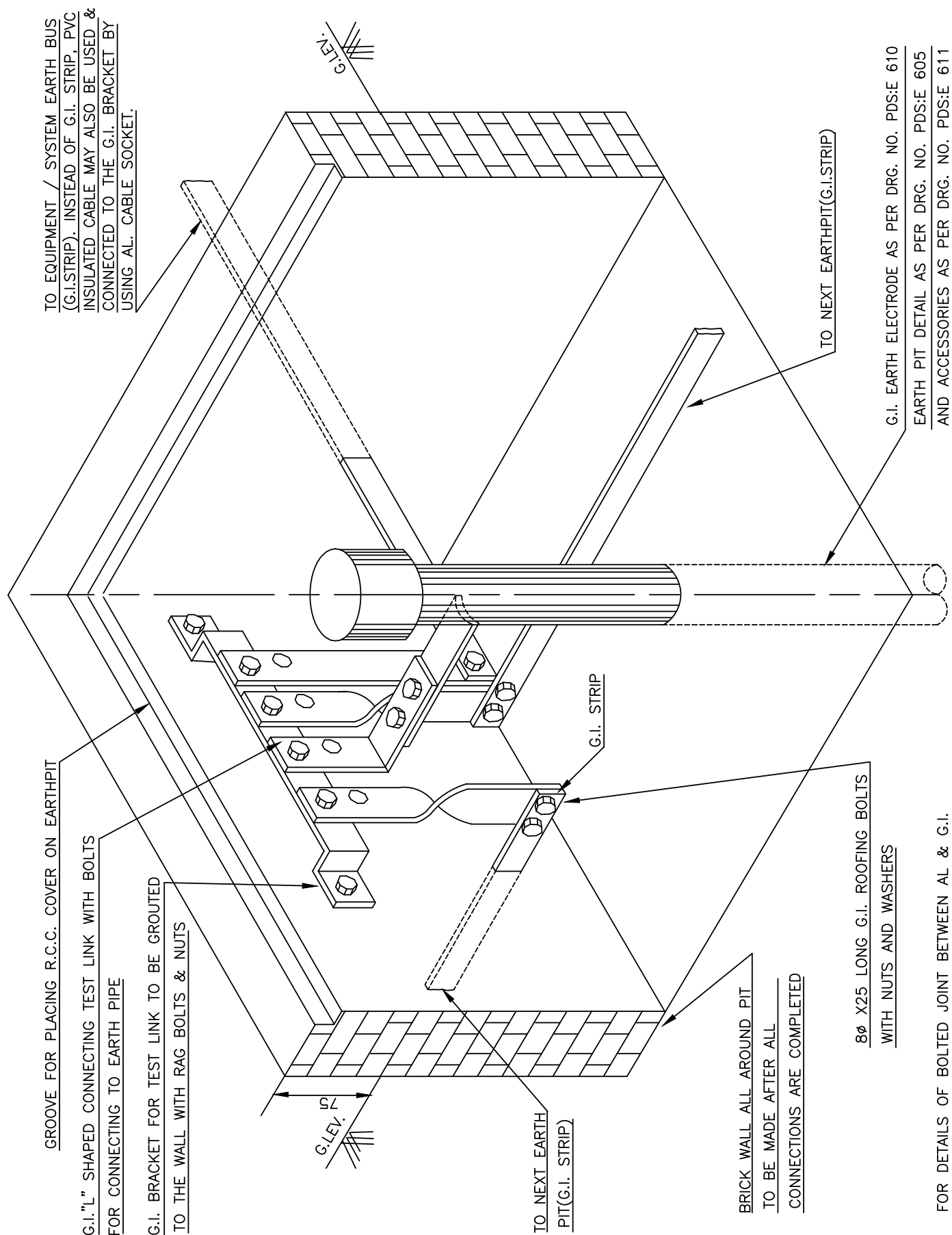
EPOXY RESIN PAINT SHALL BE USED FOR AL STRIP AND BITUMINOUS PAINT FOR G.I. STRIP.



"T" JOINT ROUND ALUMINIUM CONDUCTOR TO ROUND ALUMINIUM CONDUCTOR ( CRIMPING TYPE )

NOTE :-

USE CORRECT SIZE OF COMPRESSION DIES.

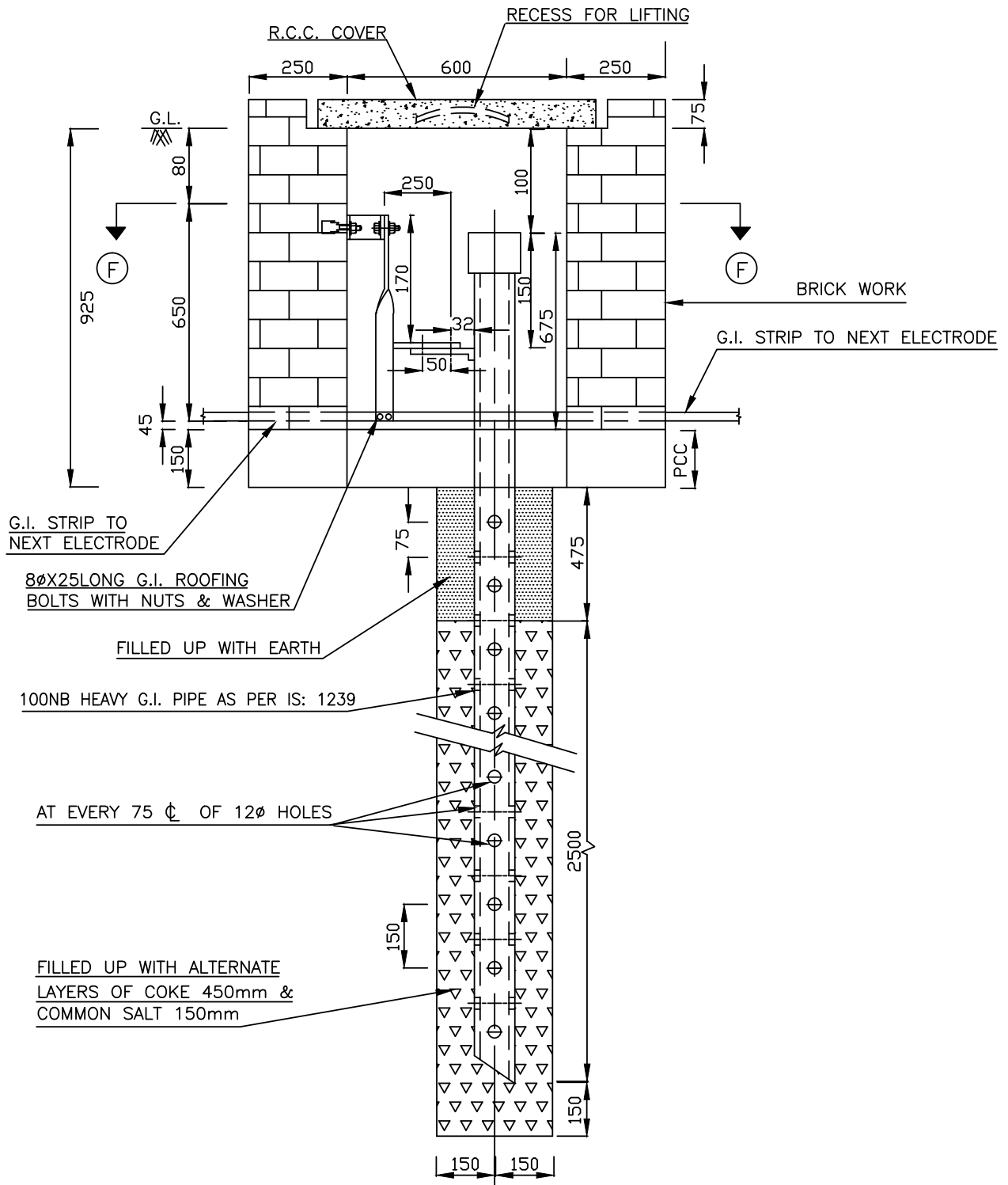


8Ø X25 LONG G.I. ROOFING BOLTS  
WITH NUTS AND WASHERS

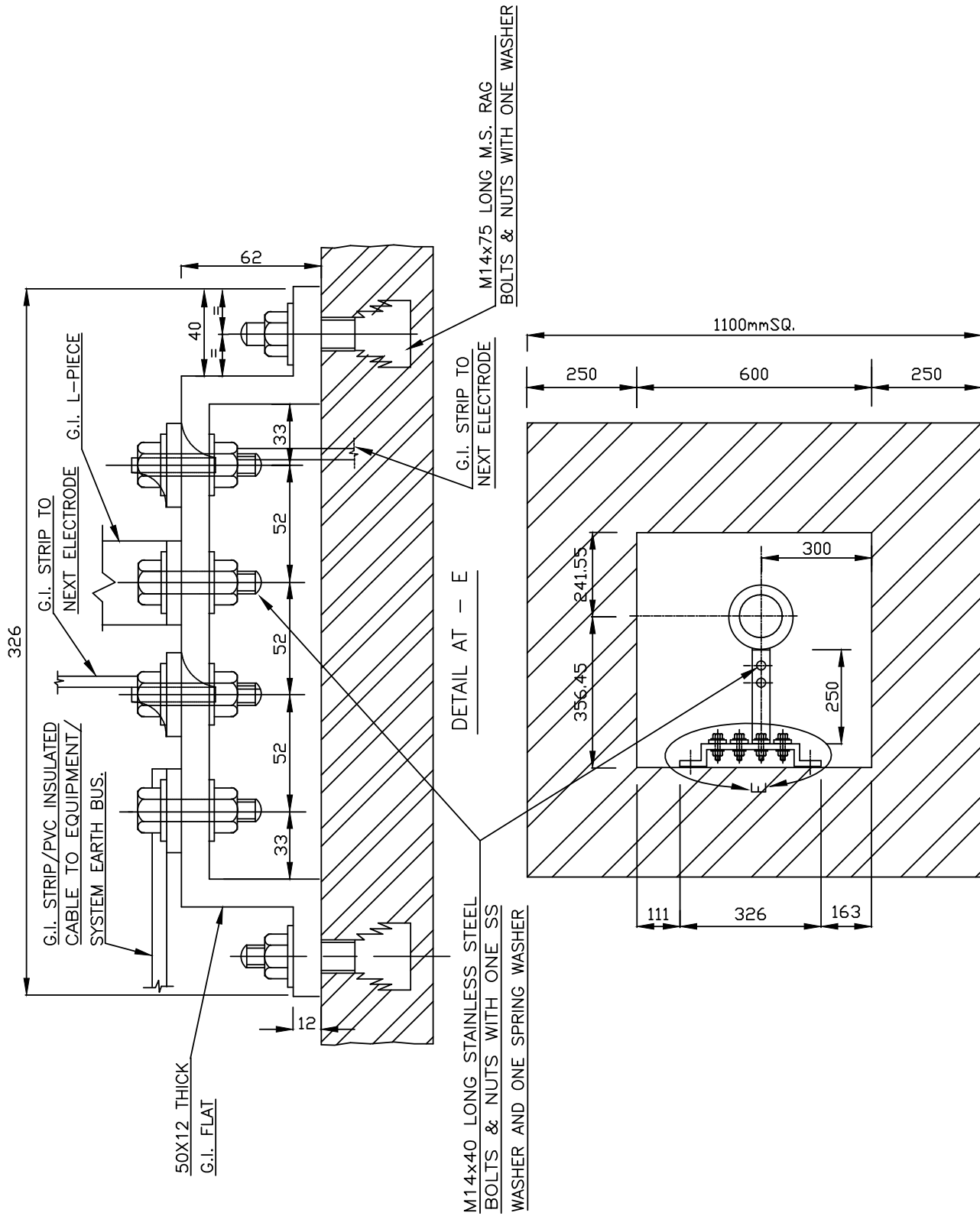
FOR DETAILS OF BOLTED JOINT BETWEEN AL & G.I.

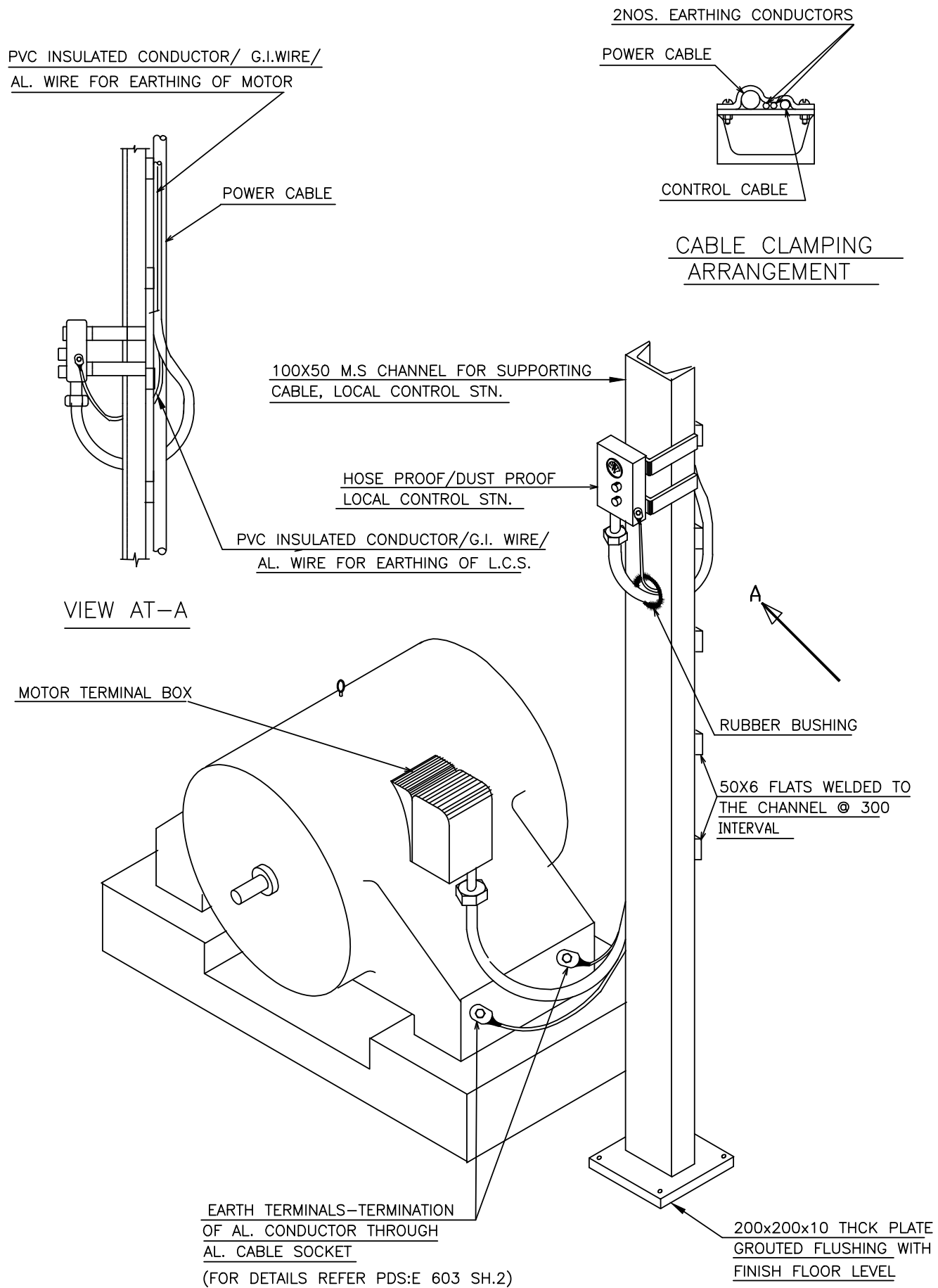
REFER PDS:E 603 (SHEET 4 OF 6 )

## EARTH PIT DETAILS

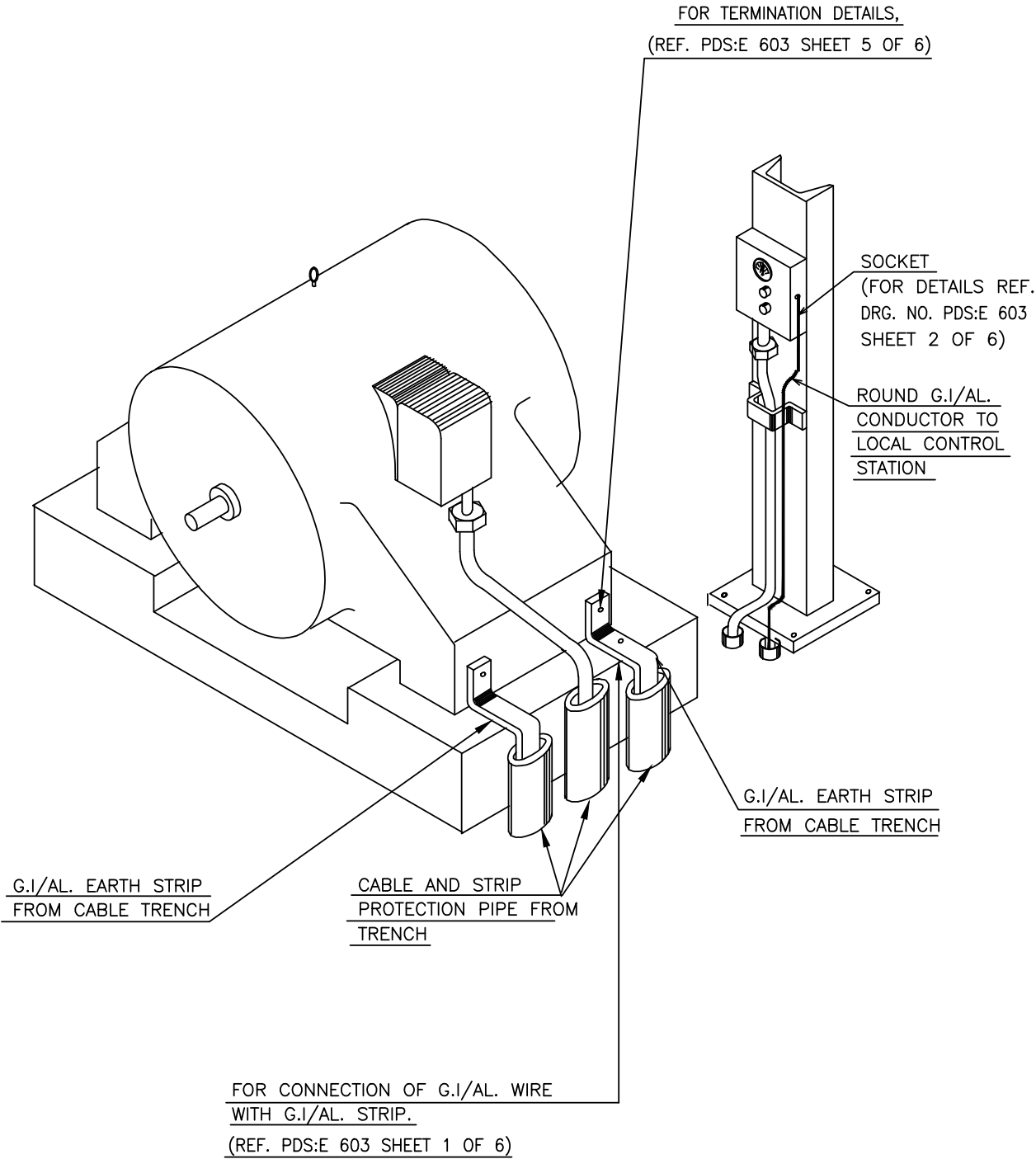


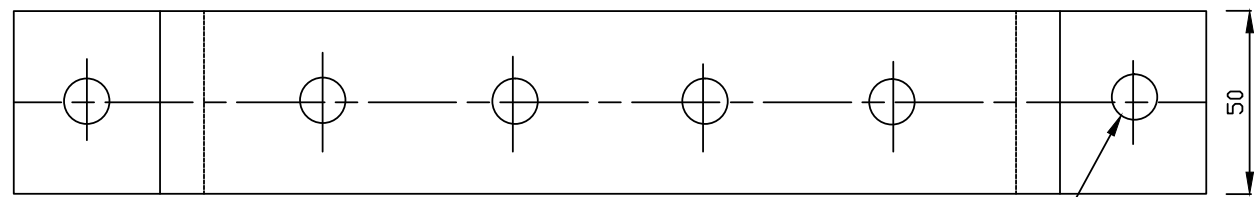
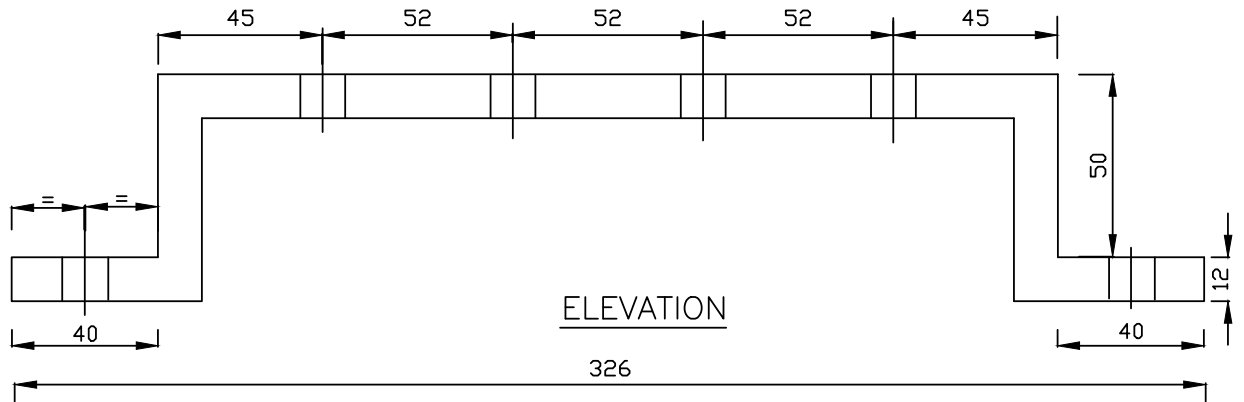
SECTIONAL ELEVATION OF EARTH PIT





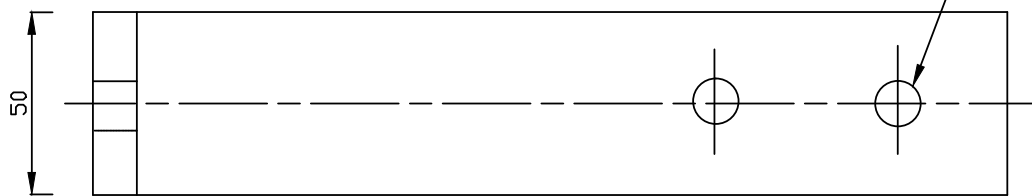




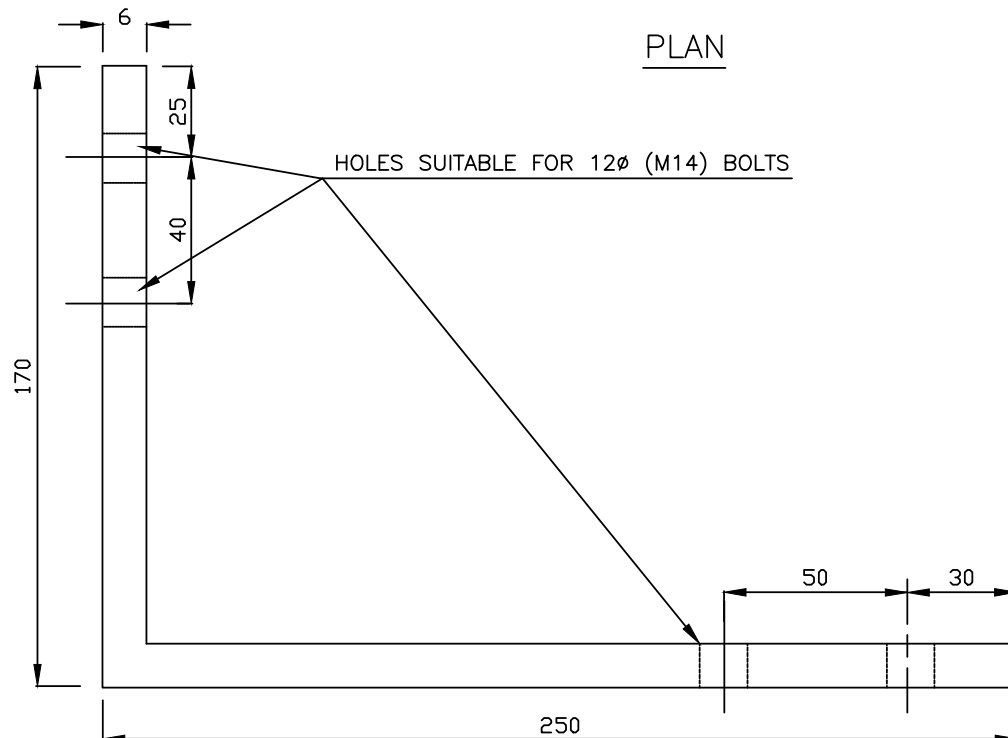


G.I. TEST LINK

HOLES SUITABLE FOR 12 $\phi$  (M14) BOLTS



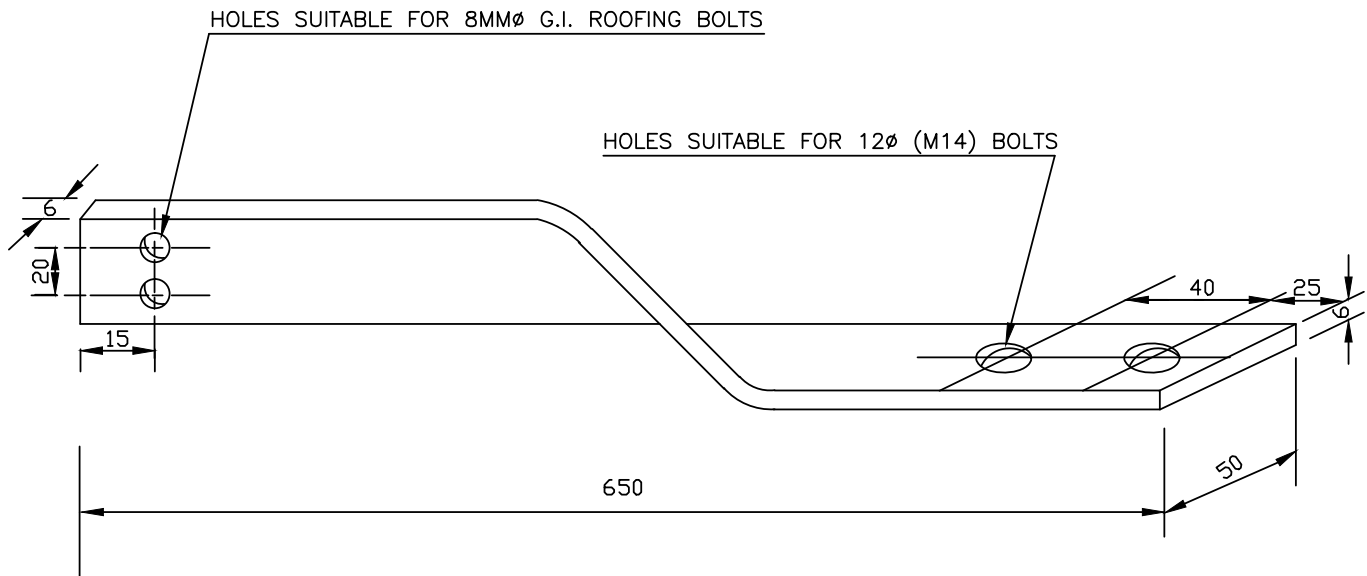
PLAN



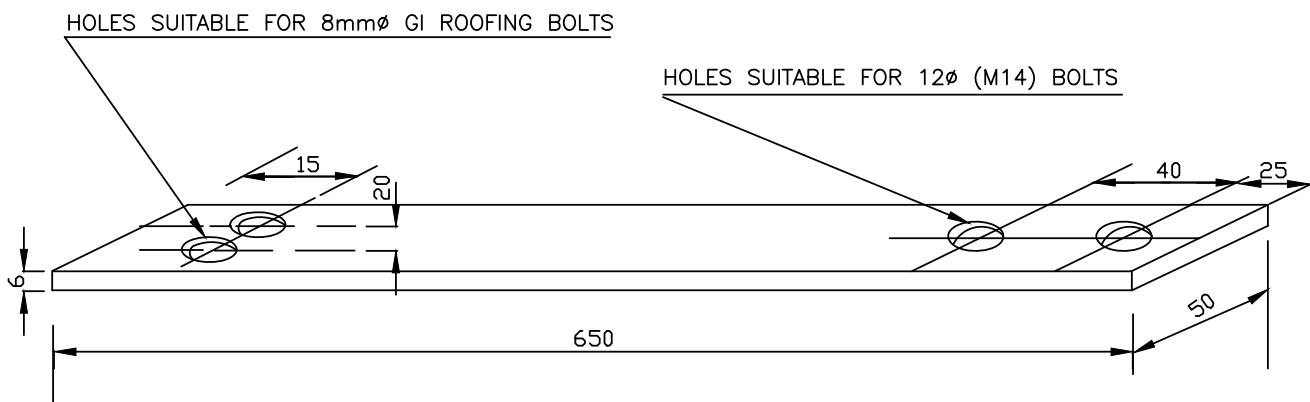
ELEVATION

G.I. 'L' PIECE

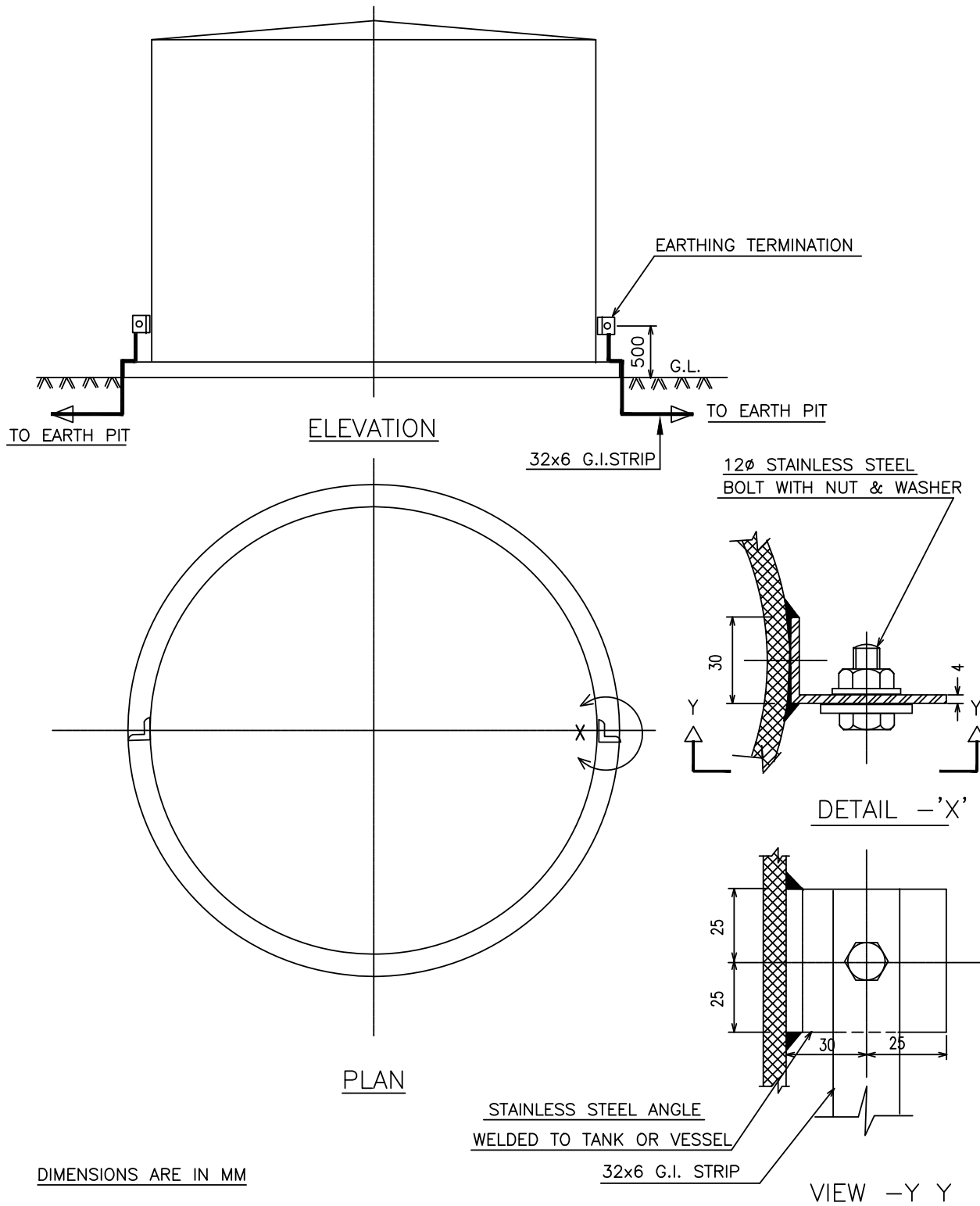
HOLES SUITABLE FOR 12 $\phi$  (M14) BOLTS



CONNECTING TWISTED ALUMINIUM FLAT PIECE

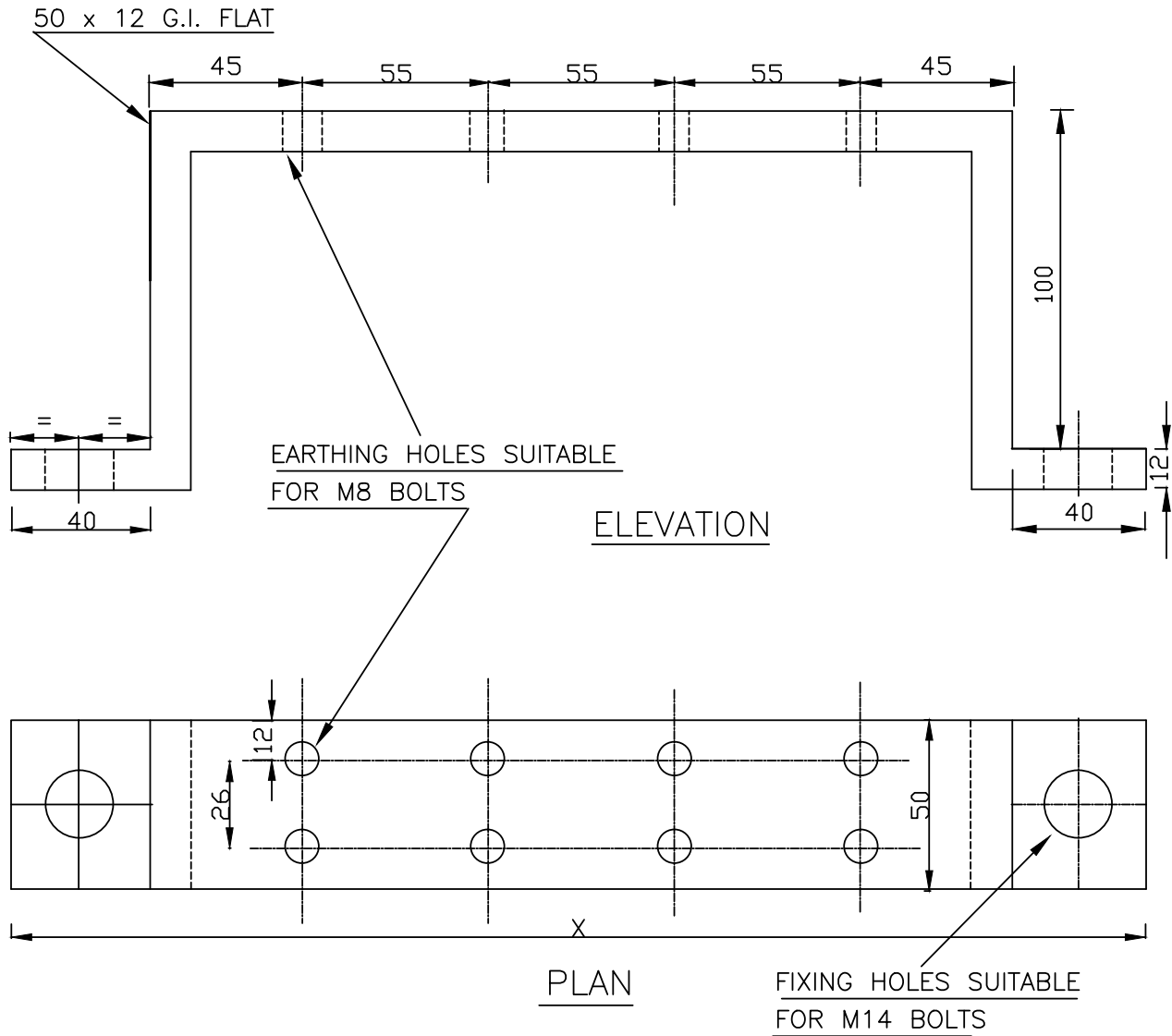


CONNECTING ALUMINIUM / G.I. FLAT PIECE



THE NO. OF EARTH CONDUCTOR SHALL BE AS FOLLOWS

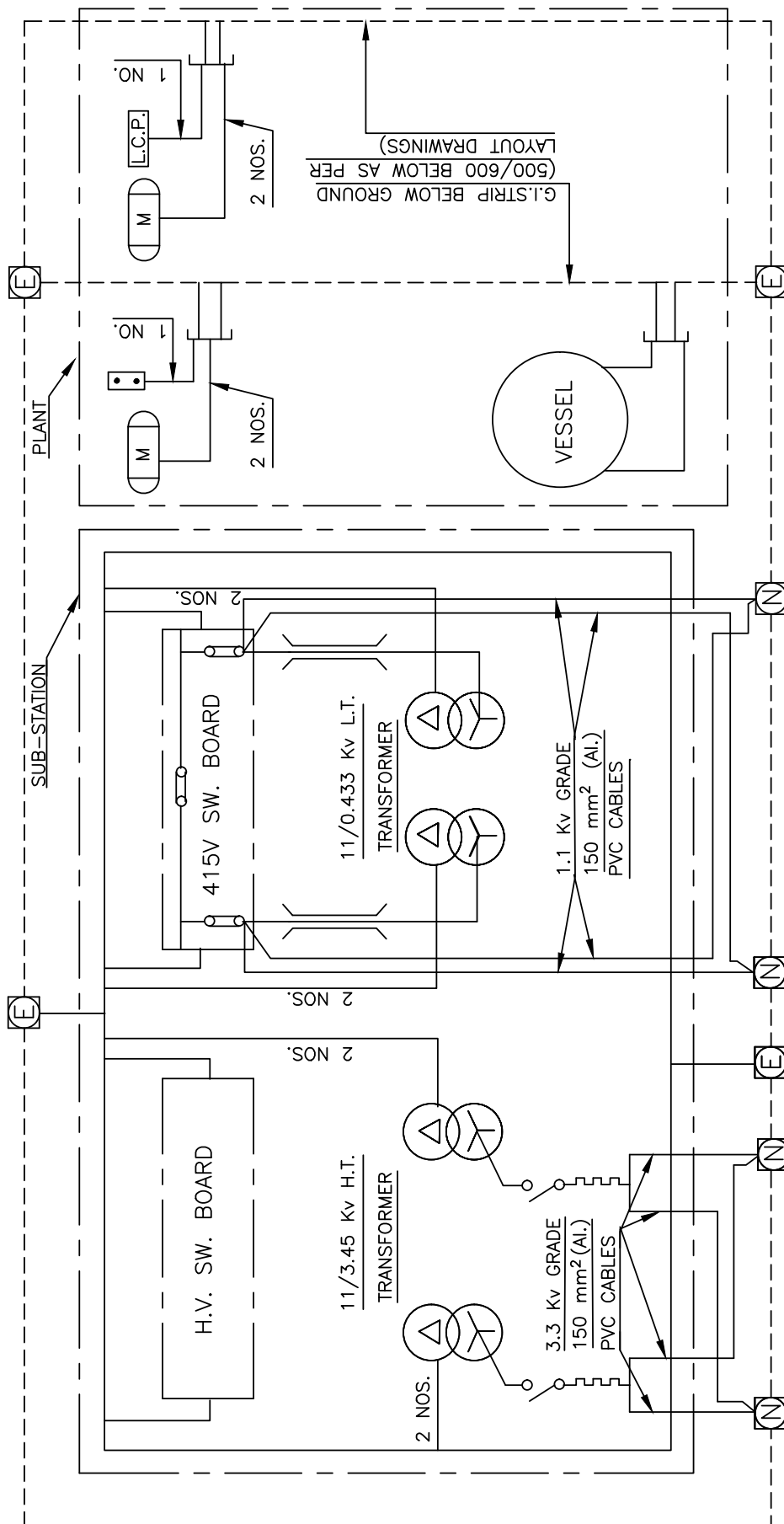
EQUIPMENT WITH ANY DIMENSION	HAZARDOUS AREA	NON-HAZARDOUS AREA
≤ 3 Mts.	1	1
> 3 Mts. ≤ 30 Mts.	2	1
> 30 Mts.	3	2



TYPE OF EARTH BUS	NO.OF EARTHING HOLES	OVERALL LENGTH x (mm)
1	8	335
2	10	390

NOTES:-

1. LOCATION OF EARTH BUS TO BE DECIDED AS PER EQUIPMENT POSITION AT SITE.
2. EARTH BUSES SHALL BE LOCATED ON STRUCTURES/COLUMNS WALLS/EQUIPMENT FOUNDATION ETC.
3. MOUNTING HEIGHT OF EARTH BUS SHALL NOT BE LESS THAN 500mm FROM FINISHED FLOOR LEVEL
4. ALL DIMENSIONS ARE IN mm



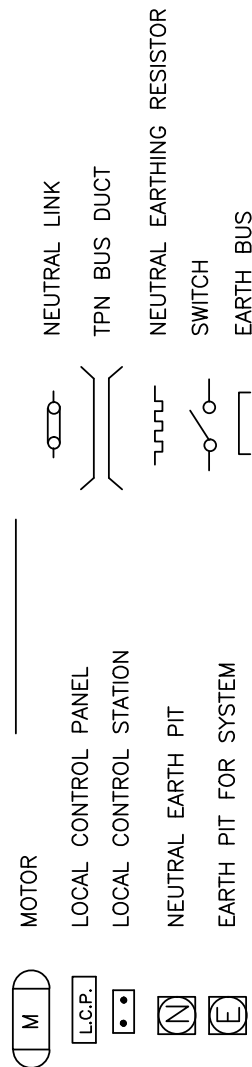
REF. DRGS.

1. EARTH PIT DETAILS - PDS:E 605
2. EARTH CONDUCTOR SIZES - PDS:E 602 (2 SHEETS)

NOTE :-

EARTH BUS SHALL BE 500 ABOVE FROM FLOOR LEVEL

L E G E N D



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		Document No.	Rev	
		Sheet 1 of 242		



## SECTION – 5.5

### DESIGN PHILOSOPHY - CIVIL & STRUCTURAL WORKS

**PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT**

**PROJECT: HIGH ASH COAL-TO-AMMONIUM NITRATE PLANT BASED ON INDIGENOUS COAL GASIFICATION TECHNOLOGY**



0	10.05.2024	10.05.2024	Issued for Tender	AR	BK	RNS
P	28.02.2024	28.02.2024	Issued for Review	AR	BK	RNS
<b>REV</b>	<b>REV DATE</b>	<b>EFF DATE</b>	<b>PURPOSE</b>	<b>PREPD</b>	<b>REVWD</b>	<b>APPD</b>

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 बी एच ई लि. <b>BHEL</b>
		Document No.	Rev	
		Sheet 2 of 242		

## **CONTENTS**



<b>SL.NO.</b>	<b>DESCRIPTION</b>	<b>DOCUMENT NO.</b>
1	DESIGN PHILOSOPHY FOR CIVIL & STRUCTURAL WORK	PC288/E/001/P-II/5.5
	<b>ANNEXURES</b>	
2	DESIGN PHILOSOPHY - ARCHITECTURAL	(Annexure-I)
3	DESIGN PHILOSOPHY - GENERAL CIVIL & DESIGN BASIS	(Annexure-II)
4	CIVIL ENGINEERING DESIGN BASIS ( STRUCTURAL)	(Annexure-III)
5	GENERAL DESCRIPTION OF STRUCTURES / FACILITIES	(Annexure-IV)
6	ES -2516 : TECHNICAL SPECIFICATION FOR CIVIL, STRUCTURAL & ALLIED WORKS	(Annexure-V)
7	ES-2517 : TECHNICAL SPECIFICATION FOR WATER SUPPLY, DRAINAGE & SANITATION	(Annexure-VI)
8	ES: 2518 TECHNICAL SPECIFICATIONS FOR BORED CAST-IN-SITU CONCRETE VERTICAL PILES	(Annexure-VII)
9	ES-2519 : TECHNICAL SPECIFICATION FOR ROADS,CULVERTS & STORM WATER DRAIN	(Annexure-VIII)
10	QUALITY ASSURANCE PLAN	(Annexure-IX)





<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div> <div>OWNER: Bharat Coal Gasification and Chemicals Limited</div> <div>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</div>	PC288/E/001/P-II/5.5	P	<div><div>बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 3 of 242		

## INDEX

Sl.No.	DESCRIPTION
<b>1.0.1</b>	<b>DETAILED SCOPE OF WORK</b>
1.1	Soil Investigation
1.2	Topographical / Contour Survey
1.3	Grading
1.4	Disposal of Surplus Earth
1.5	Site Cleaning
1.6	Roads
1.7	Surface Drainage
1.8	Contaminated Rain Water Sewer (CRWS) System and oily water sewer system (OWS)
1.9	Sewage Disposal Scheme
1.10	Paving
1.11	Structures, Buildings etc.
1.12	Surface Finishing
1.13	Acid / Alkali Proof Lining
1.14	Anti-termite Treatment / Damp Proof Course / Water Proofing
1.15	Miscellaneous
1.16	Engineering and Construction
1.17	Removal of underground and above ground structures
1.18	Transfer of Benchmark
1.19	Sizing of Various Facilities
1.20	Scope of Work in Outside Battery Limit (OSBL) Area
1.21	Rules and Regulations
<b>2.0</b>	<b>DETAILED ENGINEERING</b>
2.1	General
2.2	Design Calculations
2.3	Drawings
<b>3.0</b>	<b>CONSTRUCTION</b>

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 4 of 242		

Sl.No.	DESCRIPTION
3.1	General
<b>4.0</b>	<b>QUALITY ASSURANCE PLAN</b>
<b>5.0</b>	<b>COMPLETENESS OF WORK CONTRACT</b>

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसिफिकेशन और केमिकल्स लिमिटेड <b>BHEL</b>
		Document No.	Rev	
		Sheet 5 of 242		



## 1.0 GENERAL DESCRIPTION OF SCOPE

This section of the Tender Documents deals mainly with the Scope and Technical Specifications needed for the design, preparation of detailed Drawings and getting the design/ drawings approved by Owner/Consultant, execution and construction of complete Civil, Structural and other Allied Works on turnkey basis.

The scope of Civil Structural and Architectural Works under this Contract shall include carrying out Grading & Leveling, Detailed Design, Drawings, Supply, Procurement of all materials, Construction, Demolitions, Supervision of all relevant Civil and Structural Works including providing all labour, supervision, material, scaffolding, construction equipment, tools, tackles and plants, supplies, transportation, all incidental items though not indicated or specified but reasonably implied or necessary for successful completion of the project.

The tentative sizes of various process units, utilities and storage facilities are provided in the Plot Plan. Scope of the CONTRACTOR shall include but not limited to the following:-

- a) Engineering related to site leveling & preparation.
- b) Soil Investigation.
- c) Preparation of concept notes for design, engineering & construction.
- d) Structural Analysis and design calculations as per specifications laid down in Civil Engineering Design Basis, enclosed in the tender. for all Civil works including but not limited to pile, pile-cap, foundation, plinth beam, RC superstructure, steel super structure, trenches, drains, pits etc.
- e) Architectural design and drawings including details for doors, windows, partitions, false floor, false ceiling, toilet, finishes etc.
- f) General Arrangement and detail design drawings for pile, pile-cap, foundations, plinth beams etc, based on the soil investigation carried out by the bidder for the proposed site.
- g) General Arrangement and structural drawings at grade level showing foundations, extent of paving, trenches, drains, pits etc.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 6 of 242		

- h) General Arrangement and detail design drawings for superstructure (RCC and structural steel) at all levels.
- i) RCC drawings showing all necessary details for all foundations and structures.
- j) Structural steel detail drawings for all steel structures.
- k) General Arrangement and detail drawings for access roads, storm water drains, effluent drains, cable trenches, sewerage, manholes, pits, sumps with all necessary details.
- l) Effluent Treatment Plant (having zero liquid discharge) and Sewage treatment plant within battery limit.
- m) Bar Bending Schedules for all RCC works.
- n) Fabrication drawings with all details for steel structures.
- o) Coordination with OWNER / PMC for various activities including approvals of design basis, concept note, drawings, material samples, laboratory test results etc.
- p) Procurement of all items necessary for completion of scope of work.
- q) Construction of all units / structures, items of work included in scope of work.
- r) Preparation of as built drawings & final documentation.
- s) Obtaining Statutory Approvals.
- t) Adherence to Quality Assurance Plan

## 1.0.1 DETAILED SCOPE OF WORK

### 1.1. Soil Investigation

- 1.1.1 The CONTRACTOR shall carryout detailed soil investigation for the proposed plant afresh.
- 1.1.2 The CONTRACTOR shall adopt pile foundation, open type isolated, raft foundations as per foundation requirements of structure, loads, settlement & other design criteria.
- 1.1.3 The CONTRACTOR shall design and construct all foundations as per requirements with no extra cost to OWNER / Project Management Consultant (PMC).

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसिफिकेशन और केमिकल्स लिमिटेड <b>BHEL</b>
		Document No.	Rev	
		Sheet 7 of 242		

## 1.2 Topographical / Contour Survey

The CONTRACTOR may carry out his own Topographical investigation afresh if required.

Before commencement of work / Contour Survey, the CONTRACTOR shall clear the site from all the debris lying on the site.

At bidding stage, the CONTRACTOR shall visit the site and study the existing site conditions & existing structures if any.

### 1.2.1 Site Conditions

Levels like Finished Ground Level (FGL) and Highest Point of Paving (HPP) shall be finalized by the CONTRACTOR in consultation with OWNER / PMC based on contour survey of the unit, levels of adjacent units and levels of adjacent roads.

## 1.3 Grading

Fairly graded land site shall be provided to the CONTRACTOR. But to maintain proper and efficient drainage in the plant area, CONTRACTOR is required to study the existing site conditions like high flood level, etc & shall required to re-establish FGL around facilities/ buildings, etc., at no extra cost to OWNER / PMC. These grade levels shall be approved by the OWNER / PMC. Accordingly, micro grading works shall be in CONTRACTOR's scope.

Wherever filling / cutting is involved stone pitching should be provided as slope protection to protect the areas.



## 1.4 Disposal of surplus earth

The CONTRACTOR shall dispose-off all surplus and unserviceable earth (if any), outside the plant in accordance to local Governing authority, at his own cost.

Disposal shall be done at a place outside the plant, with the consent of the OWNER. Location of disposal area shall be decided by the CONTRACTOR and the required necessary approvals from the local bodies shall be the CONTRACTOR's responsibility.

Bidder may consider a disposal distance of approx. upto 2 KM initially for estimation purpose.

## 1.5 Site cleaning

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 8 of 242		

During construction and on completion of construction (inclusive all internal and external finishes), cleaning all the debris, waste materials scattered in and around the site and disposal of the same shall be in the scope of the CONTRACTOR with the consent of the OWNER.

## 1.6 **Roads**

The CONTRACTOR shall be responsible for complete planning and construction of the roads for access to all buildings and units of the plant (under his scope) from the existing roads including necessary tie-in connections. All works associated with shifting of Roads and related services (e.g. all type of drainages, culverts etc.) as required, for the proposed site, shall be in the scope of contractor.



## 1.7 **Surface Drainage**

The scope of work includes also providing all internal services such as water supply, sanitary sewerage, drainage and storm water drains etc. and connection to external prevailing facilities complete in all respects. All the above work shall be carried out strictly in accordance with the "Technical Specifications (ES- 2517)" enclosed with the tender.

The CONTRACTOR shall ensure proper drainage of all components of the Plant. For the purpose of drainage the Contractor's scope is not limited only up to the Unit Battery Limit but shall extend up to the adjacent drainage network around the unit. The CONTRACTOR shall provide proper drainage system for all roads mentioned in the above Para 1.6. Storm Water Drains shall be connected to the existing drainage system by providing suitable tie-in points.

The CONTRACTOR shall study the existing drainage system as per actual site conditions. Tie-in points for drainage & sewer shall be manhole / chamber (under bidder's scope) may be located at the outer boundary of bidders battery limit as per direction of Owner/PMC. The CONTRACTOR shall decide tie-in points for storm water drain based on existing drainage system in consultation with OWNER and PMC during detail engineering.

The drainage system shall be by gravity. Storm water drains shall be sized for the peak discharge arising discharge arising out of either rain water or fire fighting water.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 9 of 242		

### 1.8 **Contaminated Rain Water System and Oily Water Sewer (OWS) System**

The CONTRACTOR shall provide proper underground drainage system for contaminated rain-water and OWS. These shall be as per the philosophy mentioned in this tender document or in consultation with PMC/OWNER. The treated oily water shall be pumped to Owner's Guard Pond. Details of Tie-in points at battery limit shall be provided during detail design stage.

### 1.9 **Sewage Disposal Scheme**

The CONTRACTOR scope is to provide proper underground drainage system for sewage disposal and its connection to Common Sewage treatment plant for whole complex.

### 1.10 **Paving**

The CONTRACTOR shall provide RCC pavement for the complete area of the plant as job specific requirement. For the purpose of paving the Contractor's scope is not limited only up to Battery Limit, but shall extend up to the adjacent roads around the unit.

### 1.11 **Structures buildings etc.**

Contractor's scope shall include various technological structures steel & R.C.C. structures, pipe rack, buildings, equipment foundations, pits, cable trench, sheds, etc. as per the approved Plot Plan or mentioned in this tender document, required for the complete execution and commissioning of the plant.

### 1.12 **Surface Finishing's**



The CONTRACTOR shall be responsible for complete planning and detailing of all surfaces finishes viz. painting, flooring etc as per specifications given in the Tender.

### 1.13 **Acid / Alkali Proof Lining**

The CONTRACTOR shall be responsible for surface treatment of floors, exposed portion of foundations, pits and basins against acid / alkali as per process requirement.

### 1.14 **Anti-termite Treatment / Damp proof course / Water proofing**

The CONTRACTOR shall provide anti-termite treatment, damp proof course and water proofing as per design basis. Water proofing (for all open terraces) of all

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसीकरण और रासायनिक उद्योग <b>BHEL</b>
		Document No.	Rev	
		Sheet 10 of 242		

buildings shall be done by water proofing PU coating with treatment also, of approved Brand and make.

#### **1.15 Miscellaneous**

These shall include local platforms, pipe sleepers, local foundations, local supports, etc. as per requirement.

#### **1.16 Engineering and construction**

Preparation of detailed design, drawings, supply and construction of all civil, structural, architectural, plumbing & sanitary and building works shall be in the scope of contractors work.

#### **1.17 Removal of Underground and Above Ground Structures**

All above ground and underground structures will be demolished by the Owner. Underground facilities/structures, if any, demolished/ removed by the Contractor should ensure removal of former will not disturb the functions of existing plant, if any.

Demolition/Removal/Rerouting of cables / pipes, etc. encountered during excavation in the plot shall be in Bidder's scope of work. Existing piles if any, needs to be adjusted while making new piling/foundations.

#### **1.18 Transfer of benchmark**

The Benchmark will be made available inside plant premises. However, it may be verified by CONTRACTOR.

#### **1.19 Sizing of various facilities**



Sizing, nos., location etc. of various facilities viz. buildings, pipe rack, structures, equipments, etc. shall be in the scope of the bidder.

Any change of sizing, addition of any structure / facility, indicated by Owner/PMC during design stage, based on functional requirements and as well as local rules and regulations, etc, shall be in the Contractor's scope, at no extra cost to OWNER / PMC.

#### **1.20 Scope of work in outside battery limit (OSBL) Area**

Scope includes work in OSBL area, if required, such as pipe racks, local platforms, local supports, road crossings / culverts from tie-in points to new units.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 11 of 242		

## 1.21 Rules and regulations

All the facilities shall conform to all Local Rules and Regulations, Factory Inspector, Rules, TAC rules etc. whichever is more stringent.

Getting the approval of the various documents through the various authorities shall be in the Contractor's scope at no extra cost to OWNER / PMC.

## 2.0 DETAILED ENGINEERING

### 2.1 General

2.1.1 The CONTRACTOR shall carryout Analysis and Design of the structures required for this document and shall prepare all the required Architectural, Civil and Structural drawings needed for correct and accurate construction as per the Design Specifications given in this document.



2.1.2 The CONTRACTOR shall submit a Detailed Schedule for release of documents and drawings for review / approval to PMC/OWNER, within 2 weeks/or mutually period of date of award of the Contract. Such a schedule shall be made in line with the overall Project Schedule given in the document. The CONTRACTOR shall strictly adhere to the approved schedule.

The Format of Submission of the above mentioned schedule shall be mutually discussed and finalized after award of the job.

2.1.3 Construction of various structures / facilities, whose designs and / or drawings are specially identified in the Document Control Index or Project Schedule for approval by PMC/OWNER, shall not be taken up for construction at site till they are approved by PMC/OWNER and comments given are incorporated.

For other structures / facilities, the CONTRACTOR shall directly submit the Approved for Construction (AFC) drawings to PMC for information before, taking up construction.

2.1.4 It shall be the responsibility of the CONTRACTOR to accommodate all the functional requirements such as access, cutouts, clearances, interference etc. while designing / detailing of various structures / facilities.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 12 of 242		

2.1.5 Complete analysis, design and all drawings (including all soft files of drawings & design sheets) of each independent structure / facility shall be submitted in one lot so as to facilitate overall systematic review by PMC.

2.1.6 Only after the necessary architectural drawings are approved by the OWNER / PMC to their satisfaction, then the design drawings shall be reviewed and approved by PMC.

2.1.7 The CONTRACTOR shall keep the OWNER / PMC informed of any major design revisions simultaneously in progress.

## 2.2 Design calculations

The CONTRACTOR shall prepare the design calculations based on the standard accepted practice and guidelines from PMC / OWNER.

All design calculations shall be written systematically, legibly and submitted for approval as per standard accepted practice.

For structures, analysis and design shall be done on latest version of **STAADPRO SOFTWARE**.



For other miscellaneous works Excel and Word shall be used. Design calculations shall be done on A4 size sheet only.

## 2.3 Drawings

The CONTRACTOR shall prepare

- Civil & structural design & construction drawings, architectural drawings based on the standard accepted practice and guidelines from PMC / OWNER.
- Bar bending schedules.
- Fabrication drawings.
- As-built drawings.
- Detailing / drafting shall be done on AUTOCAD Latest Version only. Drawing size used shall be preferably of A1 size only. For foundation layout, drainage plans and paving plans, A0 size drawings can be used if necessary.



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 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 13 of 242		

### 3.0 CONSTRUCTION

#### 3.1 General

- 3.1.1 Construction of all civil and structural works including all material, labour, Supervision, tools and tackles etc. shall be carried out by the CONTRACTOR
- 3.1.2 Procurement and supply of all materials viz. cement, reinforcement, structural steel etc. shall be in the scope of CONTRACTOR.
- 3.1.3 All materials shall be procured in consultation with the Owner or as per the approved vendor list given elsewhere in this document. All materials of construction must be of ISI approved brand.
- 3.1.4 All materials and construction shall confirm to the specification given elsewhere in this document.
- 3.1.5 Materials of construction, construction methodology etc. shall be such, so as to protect the structures and foundations against the harmful effect of chemical, fumes etc. present in the plant, its vicinity, in ground and / or subsoil water.
- 3.1.6 The CONTRACTOR shall be responsible for obtaining the statutory approval from local authorities such as Inspector of Factories, Development Authorities, Municipal Corporation and other concerned authorities before starting the work.
- 3.1.7 The CONTRACTOR shall ensure that the facilities are constructed in accordance with the APPROVED FOR CONSTRUCTION drawings and specifications.
- 3.1.8 The CONTRACTOR shall maintain and operate an adequate system of control of availability of latest drawings and specifications, at all the places where work is performed.
- 3.1.9 Construction shall include excavation in all types of soils / rock inclusive of necessary dewatering as applicable.
- 3.1.10 The CONTRACTOR shall redo / repair all the existing facilities viz. roads, paving, drainage etc. which are damaged during transportation, construction and erection activities performed by him.
- 3.1.11 Rain water harvesting is mandatory for buildings like control room, operator room, view room, change room & check room, security building, maintenance building, canteen, laboratory building etc.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 14 of 242		

#### 4.0 Quality Assurance Plan

Contractor shall ensure the quality of civil works by engaging a third party supervision /inspection and provide test results to Owner/PMC for information. The Quality Assurance Plan is attached for reference as Annexure VIII and the contractor is obliged to follow it.



#### 5.0 COMPLETENESS OF WORK/CONTRACT

- 5.1 The scope of work mentioned in the contract/NIT is not the comprehensive one, but gives total idea/outline of the scope of work; however contractor shall be responsible for completeness of the job for the purpose indicated elsewhere to make the system fully functional and operational.
- 5.2 In case there is any conflict in the specifications appearing in different contractual documents then the specification whichever is stringent shall be applicable without any technical or commercial implications.
- 5.3 The work furnished shall be complete in every respect with all mounting, fittings, fixtures and standard accessories etc. normally provided for such item/equipment and or needed/required for erection, completion and safe operation of the item/equipment/system as required by applicable codes though they may not have been specifically detailed in the respective specifications, unless included in the list of exclusions.
- 5.4 Any additional items and materials which are not specifically mentioned but are required to complete the system offered, in every respect in accordance with the technical specifications and required for safe operation and guaranteed performance shall also be deemed as included in the scope of work of this tender. Contractor shall not be eligible for any extra payment in respect of such mountings, fittings, fixtures, accessories etc. which are needed/required for safe operation of the item/equipment/system, as required by applicable codes of the country though they may not have been explicitly spelt out in the NIT/Contract.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 15 of 242		

## ANNEXURE - I

### DESIGN PHILOSOPHY – ARCHITECTURAL

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 बी एच ई लि. <b>BHEL</b>
		Document No.	Rev	
		Sheet 16 of 242		

## **CONTENTS**

### **1.0 GENERAL**

- 1.1 SCOPE
- 1.2 UNITS OF MEASUREMENT
- 1.3 DEFINITION
- 1.4 CODES & STANDARDS

### **2.0 DESIGN PHILOSOPHY / CRITERIA - GENERAL**

- 2.1 ARCHITECTURAL DESIGN
- 2.2 BUILDING REQUIREMENT
- 2.3 BUILDING SERVICES
- 2.4 AESTHETICS
- 2.5 BUILDING ELEMENTS



### **3.0 BUILDING STRUCTURE**

### **4.0 ARCHITECTURAL TRADES**

- 4.1 EXTERNAL FINISHES
- 4.2 INTERNAL FINISHES
- 4.3 DOORS, WINDOWS & VENTILATORS
- 4.4 SANITARY FITTINGS & FIXTURES

### **5.0 MISCELLANEOUS**

- 5.1 DRAWING
- 5.2 DESIGN
- 5.3 BUILDING REQUIREMENTS

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 17 of 242		

## 1.0 GENERAL

### 1.1 SCOPE



The design philosophy defines the minimum design requirements and procedures for carrying out architectural design and engineering of buildings covered under this project. Relevant criteria shall be taken into consideration to achieve satisfactory and trouble free performance of the facilities.

### 1.2 UNITS OF MEASUREMENT

Units of measurement in design shall be in metric system.

### 1.3 DEFINITIONS

Owner	Bharat Coal Gasification and Chemicals Limited (JV of CIL & BHEL)
PMC	To be selected
LSTK Contractor	Successful LSTK bidder of the tender (To be selected)
CCE	Chief Controller of Explosives
TAC	Tariff Advisory Committee
NFPA	National Fire Protection Association
IS	Bureau of Indian Standards

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></p><p><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></p></div>	PC288/E/001/P-II/5.5	P	<div><p>भारत कोयला गैसिफिकेशन लिमिटेड <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 18 of 242		

## 1.4 CODES AND STANDARDS

The design shall be in accordance with established codes, sound engineering practices and shall conform to the applicable statutory regulations.

The main codes, standards and statutory regulations considered as minimum requirements are as follows. Latest revision of these shall be followed.

- 1.0 National Building Code of India
- 2.0 Factories Act of State
- 3.0 Local Municipality or any other Authority's Bye-laws as applicable.
- 4.0 Bye-Laws applicable of Town & Country Planning Organization.
- 5.0 Code of practice for building bye-laws IS : 1256
- 6.0 TAC (Tariff Advisory Committee) Rules
- 7.0 Indian Electricity Rules
- 8.0 Bureau of Indian Standards



Note: The above list is suggestive and not exhaustive. Apart from the basic codes any other related codes shall also be followed wherever required.

### 1.4.1 Order of Precedence

In case of any conflict / deviations amongst various documents, the order of precedence shall be as follows:

- Statutory Regulations
- Job Specifications
- Engineering Design Basis
- Standard Specifications



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 19 of 242		

## 2.0 DESIGN PHILOSOPHY / CRITERIA – GENERAL

### 2.1 ARCHITECTURAL DESIGN

Architectural design of buildings / sheds shall be in accordance with this design basis and references as stated herein, to facilitate the intended functions. The various types of requirements to be considered are described further. In Plant Area no underground/ basement shall be provided in the building.

### 2.2 BUILDING REQUIREMENTS



#### 2.2.1 Spatial Requirements

Spatial requirements inside a building / shed shall be decided based on activities to be performed in the building and consequent occupancy pattern, equipment layout etc. Spaces can be generally classified as functional spaces, circulation spaces, amenity spaces, utility spaces. They are elaborated further.

##### 2.2.1.1 Functional Spaces

Functional areas of any building / shed is constituted by the main activity for which the building is required. Various spaces/rooms shall be judiciously sized and shall be integrated logically to generate the total building plan taking into account the following parameters :-

- Activities, group of activities and consequent work-flow pattern.
- Site conditions i.e., dimensions, contours etc.
- Climatic conditions vis-à-vis orientation.
- Safety regulations.
- Lighting and ventilation.
- Green building Concept for non plant buildings
- Acoustics
- Services
- Security

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 20 of 242		

- j) Economy
- k) Aesthetics
- l) Specific requirements pertaining to particular buildings, if any
- m) All other established architectural design parameters in practice.

The objective of spatial arrangement shall be to satisfy functional requirements and physical comfort and safety regulations as well as aesthetics which has significant role in creating a favourable working environment.

### 2.2.1.2 Circulation Spaces



Following spaces are classified as circulation spaces. These spaces shall be provided as per required building services, for integrating various types of spaces and as means of access / exit / escape.

- a) Corridors & passages.
- b) Staircases
- c) Elevator
- d) Entrance lobby / Foyer including Reception & waiting.
- e) Gangway / walkways.
- f) Equipment loading / unloading platforms
- g) Emergency Exits

### 2.2.1.3 Amenity Spaces

Following spaces are classified as amenity spaces:

- a) Toilet (Gents & Ladies).
- b) Drinking Water Facility.
- c) Locker & Change Room.
- d) Rest room / Lunch Room.
- e) First-Aid Room

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 21 of 242		

Out of the above mentioned areas, a) Toilet, b) Drinking water, c) First Aid enclosures shall be mandatory requirement for all buildings / sheds under bidder's scope. However, number of male, female & physically challenged person's toilets will be decided during detailed engineering as per building by-laws.

Other facilities shall be provided as required.

#### 2.2.1.4 Utility Spaces

Utility spaces are space requirements which materialize due to provision of services like air-conditioning, pressurization, fire fighting, electrical, telephone, **LAN** etc. Following are examples. These spaces shall be provided as per required building services.



- i) Air-conditioning plant room.
- ii) Air handling rooms.
- iii) Pressurization blower plant room.
- iv) Electrical distribution panels rooms.
- v) Service ducts
- vi) Firefighting equipment room.
- vii) Telephone exchange equipment room.
- viii) UPS room.
- ix) Battery room.

#### 2.2.1.5 Sizes of Spaces

Sizes of various type of spaces shall be decided based on occupancy / equipment / Panel / furniture layout, clearance, maintenance & safety requirements & ventilation requirements.

However, following are the limiting sizes / dimensions for various purposes, which shall be adhered to :

- a) Minimum area of any habitable room = 9.5 m<sup>2</sup> with minimum dimension restricted to 2.5 m

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसीकरण औद्योगिक रसायन सी. लि. <b>BHEL</b>
		Document No.	Rev	
		Sheet 22 of 242		

- b) Minimum ht of any habitable room = 3 m which may be reduced to 2.75 m for air-conditioned areas. Due provision / clearance may be made for AC ducts above false ceiling if any. Headroom below beams should be min. 2.4 m.
- c) Maximum ht of habitable rooms = As stipulated by the local bye-laws
- d) Scale of accommodation for industrial work spaces = @ 14 m<sup>3</sup> per occupants. Minimum clear height of such workspaces shall be 3.6 m. Heights above 4.25 m shall not be taken into account.

## 2.2.2 Day Lighting and Ventilation

### 2.2.2.1 Day Lighting



Established level of illumination shall be maintained for all parts of the buildings by means of windows, ventilators, skylights, etc. Following references shall be adhered to in this regard.

- National Building Code of India, Part-VIII, Section-1
- IS:2440: IS 3646 (Part-II) : IS:7662 (Part-I)
- State Factories Rules
- Any other relevant rules / code etc.

Following architectural norms shall be adopted:

- Direct solar illumination shall not be considered and only sky radiation shall be taken as contributing to illumination of the building.
- Openings shall be provided with shading devices to avoid glare.

For the purpose of illumination, day lighting shall also be supplemented by artificial illumination.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 23 of 242		

## 2.2.2.2 Ventilation

### A) Natural Ventilation

Established level of ventilation in terms of air changes per hour shall be maintained for all spaces. Following references shall be adhered to for the purpose.

- National Building Code of India, Part-III, Section-1
- IS:3101 (industrial buildings), IS:3362 (residential buildings); IS:7662(Part-I)
- State Factories Rules
- Any other relevant rules / Codes etc.

Natural ventilation shall also be supplemented by mechanical or electrical means of ventilation in all areas of habitation. Sufficient no of Glazed / Louvered windows / ventilators shall be provided and supplemented by exhaust fans.



### B) Mechanical Ventilation

In addition to natural ventilation, if required mechanical or electrical ventilation shall be provided depending on the type of building and its use. Other relevant design basis shall be referred for its requirement and applications.

## 2.2.3 Acoustics And Sound Insulation

Specified acceptable noise level and reverberation time shall be maintained inside a building / shed. Following references shall be referred to for the purpose.

- National Building Code of India.
- State Factory Rules.
- Limitations on decibel level stated elsewhere, if any, in the bid document

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 24 of 242		

Required noise level in any space shall be maintained by means of

- Segregating noise sources by buffer zones
- Dampening of noise levels by damping devices
- Providing Acoustic treatment with acoustic material (on walls, ceilings, floors, as required).

## 2.2.4 Safety Requirements



Safety from fire and like emergencies shall be taken into account in building / shed design. Buildings / sheds meant for human occupancy shall be provided with exits sufficient to permit safe escape of occupants in case of an emergency. The exits shall be in terms of doorway, corridors, and passage ways to internal / external staircase or to areas having access to the outside. Following references shall be adhered to this regard. Max distance to an exit from any point in a building shall not exceed 30 m. Control Room building shall be provided with emergency exit on the other side of entrance.

A minimum of two staircases and two exits per floor shall be provided in each building. Width of passage / corridor shall not be less than 1500 mm. Following references shall be referred to for the purpose design of Control Room building.

- National Building Code of India, Part-IV
- State Factories Rules.
- Any other relevant rules / codes.

## 2.2.5 Site Planning & Landscaping

Site planning of building shall take into account aspects like inter-relationship of the buildings with the whole system, movement pattern, traffic and road net-work, safety regulations, service network, fire safety, climatic and environmental aspects.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 25 of 242		

Main and service / maintenance entrances of buildings shall be provided with vehicular access. All exit points shall also be provided with footpath / vehicular access. Truck movement space in accordance with traffic pattern shall be provided for the building as per the location of hoisting bay / loading, unloading platform. Road network and open space around the buildings shall be designed considering movement and functioning of fire tenders and cranes, etc.

Landscaping to be done for areas around control room and technical lab building within bidder's battery area excluding hard paved area. Such treatment shall generally consist of lawns, road side plantation and beautification of building entrance areas. Standard landscape elements such as earth contours, paving, flower beds, hedges, shrubs, ground cover and ornamental trees shall be incorporated in landscape treatment. Necessary water supply / sprinklers shall also be provided. Wherever required, Grass for landscaping shall be "Selection Grass".

## 2.3 BUILDING SERVICES



Following services shall be provided for all building / sheds as essential services.

### 2.3.1 Water supply, Distribution and Drainage, Sanitary Services.

The service is essential for all habitable buildings / sheds. All buildings with human occupancy shall have toilet and drinking water facility and accordingly water supply, distribution and drainage, sanitary services as per following references.

- National Building Code of India, Part-IX, Section 1 & 2
- State Factories Rules.

Drinking water provisions, including one number water cooler per area (of approx 20 m x 20 m) shall be provided within an enclosure separated from the toilets.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 26 of 242		

Space for janitor shall be provided in the toilets. All service pipes showing on the external wall shall be suitably concealed or shall be provided within a shaft.

Each building shall be equipped with approved PVC overhead water tanks of capacity not less than 2000 litres.

### 2.3.2 Electrical Services

This service shall be provided as essential service for all building / sheds. Electrical services for buildings shall consist of electrical supply and distributions, electrical lighting installations, telephone network, fans, exhaust fans, lighting protection system etc. including all accessories, cabling etc. including emergency power supply, all as per requirement. All electrical switches / sockets shall be of modular type as per the approved makes given separately.

### Air conditioning and Heating



Areas of control room, spaces housing equipment / machinery / panels etc. which required conditioned environment and certain specified areas like offices, specific office accommodation shall be suitably air-conditioned by window / split / package / centrally air-conditioned type units, as per requirement with respect to other relevant Design Basis.

Accordingly, AC Plant / AHU etc. of the required capacity, whenever required, shall be provided and housed, suitably.

## 2.4 AESTHETICS

Apart from the fulfillment of functional & safety requirement, aesthetic requirement of the buildings / sheds shall be taken care of in the design. As specific guidelines for achieving required aesthetics are difficult to establish, following guidelines shall be followed:



<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></p><p><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></p></div>	PC288/E/001/P-II/5.5	P	<div><p>भारत कोयला गैसीकरण और रासायनिक उद्योग लि. <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 27 of 242		

- a) Preliminary Drawings including perspective views indicating architectural treatment minimum three different alternative proposals shall be submitted for Owner's approval.
- b) Following elements shall be considered as contributory elements to aesthetics and their design etc. shall be subjected to the Owner's approval. Any change / modifications sought for aesthetics improvements with regards to these elements shall be carried out. Any incidental elements like brickwork, RCC work etc. required for such changes / modifications shall also be added.
- i) Building / shed shape and features
  - ii) Canopies, overhangs & shading devices
  - iii) Gutters
  - iv) Entrance / exit steps, door
  - v) Window / Ventilator composition
  - vi) External wall location with respect to columns
  - vii) Colour scheme, grooves in plaster
  - viii) Spatial arrangement
  - ix) Aesthetic of the buildings should match with the surrounding existing facilities at the site.

## 2.5 BUILDING ELEMENTS

### 2.5.1 Plinth protection

All the buildings & sheds shall be provided with minimum 1000 mm wide plinth protection around the building / shed. Level wise, it shall be 100 mm high above top of approach road level. In order to avoid accumulation of water outside the buildings, requirement of surface drains shall be examined on case to case basis for individual building and provided if necessary.



### 2.5.2 Finished Floor Level (Plinth FFL)

In general, Plinth FFL of the buildings, sheds shall be determined with respect to top of approach road or pavement. Unless noted otherwise on the reference drawings, following schedule shall be adhered to for FFL of various buildings & sheds.

a)	Sub Station Building		
	> Cable cellar floor	-	Top level of approach road + 450 mm/or as specified in Electrical section of NIT
	> Transformer bay with pebbles	-	Top level of approach road + 150 mm /or as specified in Electrical section of NIT
	> Single storey substation with trenches	-	F.G.L. (+) approx. 1000 mm high from top of road /or as specified in Electrical section of NIT
b)	Transformer bay	-	Top level of approach road + 150 mm/ or as specified in Electrical section of NIT
c)	Vehicle, scooter, cycle shed including fire tender bays, repair shop	-	Top level of approach road + 300 mm
d)	False floor areas (Control Room)	-	As specified in the Instrumentation section of NIT
e)	Loading, Unloading bays, platforms	-	Top level of approach road + 1100 mm
f)	Electrical rooms	-	As specified in the Electrical section of NIT
g)	Other Buildings / Shed (Process Operator's Cabin)	-	Top level of approach road + 450 mm from surrounding ground level.

**Notes:**

- In case of approaches with different top levels, the highest top level of approach road / pavement shall be considered.
- FFL shall be same throughout in a building / shed. Split levels any be considered in exceptional cases due to ground terrain etc.
- FFL of external loading / unloading bays / platforms, toilet, pantry, kitchen shall be 6 – 12 mm lower than that of the building / shed's FFL to check ingress / spillage of rainwater.
- FFL of Warehouses, stores may be kept lower than loading / unloading bays / platforms where forklifts etc. are used for internal movement of items. Adequate arrangement for negotiating the level difference shall be provided in that case.
- Where applicable, existing levels of building / sheds shall be followed.

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></p><p><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></p></div>	PC288/E/001/P-II/5.5	P	<div><p>बी एच ई लि. <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 29 of 242		

### 2.5.3 Steps / Ramps

Steps / ramps shall be provided for access to the buildings / sheds for pedestrian /vehicular movement, equipment entry, etc. Minimum 1500 mm wide platform shall be provided in between entrance door and steps / ramps. Following dimensions of the steps / ramps shall be adhered to:



a)	Tread	:	300 mm minimum
b)	Riser	:	175 mm maximum
c)	Slope of ram	:	Not steeper than 1:10 slope
d)	Ratio of tread & riser	:	2 Riser + Tread = 600 to 650 mm
e)	Landing width	:	1500 mm minimum
f)	Flight width	:	1500 mm minimum

Edge of treads shall be provided with friction grip strips

### 2.5.4 Wall

Following schedule shall be adhered to for wall material and thickness

1	Blast Proof Wall	Min 230 mm thk.RCC wall
2	Rain water duct / shaft	Min. 230 mm thk. hollow/ solid concrete block work
3	External walls	230 mm thk. hollow/ solid concrete block work
4	Fire wall (Around transformers)	240 thk RCC or 355 mm (including plastering) thick hollow/ solid concrete block work wall / OR as per Electrical requirements. (IER/TAC)
5	Internal partition wall	230 / 115 mm thk. hollow/ solid concrete block work wall depending on the overall length and height of the wall (refer notes below)

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 30 of 242		

**Notes:**

- 115 mm thick partition walls shall be provided with RCC transoms and mullions for suitability.
- Wherever conduits or pipes are required to be concealed within partition wall, the local wall thickness shall be increased suitably.



### 2.5.5 Doors

Doors shall be provided for access, security and safety to all rooms, functional areas in a building. Air tight door shall be provided in pressurized area and in gaseous protection area. Emergency door shall be opened outwards. Sizes of the doors shall be determined on the basis of the following schedule:

a)	Equipment, Panel area	:	Maximum size of equipment including packing
b)	Other areas	:	Volume of movement through door
c)	Minimum door size at entrance	:	1500 mm x 2500 mm (masonry opening size)
d)	W.C. bath Cubicle door	:	800 mm x 2100 mm (masonry opening size)
e)	Minimum size of other doors	:	1000 mm x 2100 mm (masonry opening size)

**Notes:**

- Entrance doors shall be provided covering full width of the entrance lobby. In that case the door shall be of composite type consisting of openable shutters & fixed panels. Entrance lobby shall be provided with elaborate canopy.
- Rolling shutters min 2500 mm wide shall be provided for equipment entry for Switchgear room, Electrical room, A.C. Plant room etc. and also wherever size of opening exceeds 2500 mm x 2500 mm.
- Mechanically operated rolling shutters shall be provided for main equipment entry opening, and also where opening size exceeds 8 m<sup>2</sup>.
- Fireproof door shall be with two hours fire rating as per statutory requirements.
- Blast resistant Control room entry door shall be provided with blast resistant baffle wall in front of entry door and shall have 45 degree / 90 degree overlap on both sides as per relevant standard/codes.



<div> पी डी आई एल <b>PDIL</b></div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT OWNER: Bharat Coal Gasification and Chemicals Limited DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</div>	PC288/E/001/P-II/5.5	P	<div> भारत कोयला गैसीकरण और रासायनिक उद्योग <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 31 of 242		

### 2.5.6 Windows / Ventilators

Windows / ventilators shall be provided in all areas for natural lighting, ventilation, and visibility of working level. For the purpose of ventilation, total openable area of the windows / ventilators shall be as per Factories Act subject to a minimum of 15% of the floor area to be ventilated. However, for control room and in office areas, etc. where visibility from inside is also important, increased window area (as per discussion with Owner/PMC) shall be provided. Areas accommodating panels / equipment shall be normally provided with ventilators at high level for uniformity distributed lighting.

Notes :

- Requirements of window / ventilation area as stipulated above is for maximum room height of 4000 mm. For heights more than 4000 mm, additional window / ventilator shall be provided in the same manner at every work area / platforms at all levels.
- Wherever due to limitation of external wall area or other reasons, stipulated area of window / ventilator cannot be provided, suitable mechanical / electrical system shall be employed.
- Fly mesh shutters shall be provided for windows / ventilators in Kitchen, Pantry, Dining hall etc.
- Ventilator shall be able to serve as smoke vents in the event of fire.
- For structures like workshop / warehouse / compressor shed with pre-coated or G.I. roof sheeting, suitable monitor may be added to provide proper ventilation.
- Fireproof windows shall be provided as per TAC, electrical, process, etc. statutory requirements.
- External windows shall have P.C.C. (1:3:6) sills, 100 thk.
- All glasses in windows & doors shall be toughened glass. Outside glasses shall be tinted toughened.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 32 of 242		

### 2.5.7 Canopy / Overhang

RCC Canopy / Overhangs shall be provided at all entrances for rain / sun protection, accentuation of the entrances, and pedestrian movement as per the following schedule:

- For all offices, control rooms, composite buildings / sheds accommodating offices, canopy shall be provided at all entrances. Size of the canopy shall be decided based on vehicle parking & pedestrian movement in addition to aesthetics of the building / shed. Bottom of canopy shall be minimum 2800 from top of drive way.
- Overhangs shall be provided over all exits. Size of the overhang shall be decided on the aesthetics of the building / shed subjected to minimum of 1000 mm.

Blast proof Control rooms shall not have any projections on outer face of its walls except with false treatment for aesthetics of the building.

### 2.5.8 Shading Devices



RCC Shading devices shall be provided over all windows, openable ventilators for rain & sun protection. These devices shall be in form of horizontal projections, vertical projected fins or combination of both as per building façade treatment. Minimum projection shall be 600 mm.

### 2.5.9 Parapet

Parapets shall be of RCC for all buildings with minimum 500 mm high for non-approachable roof and 1100 mm high for approachable roof.

### 2.5.10 Roof Gutter

Gutter with rainwater pipes shall be provided for all the buildings / sheds for roof water drainage. Sizing of the gutter shall be based on areas to be drained and number of outlets. Gutters shall be of RCC or sheet metal depending on type of structure.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 बी एच ई लिमिटेड <b>BHEL</b>
		Document No.	Rev	
		Sheet 33 of 242		

### 2.5.11 Rain Water Pipes Spouts

PVC rain water pipes shall be provided for roof water drainage. Number of rain water pipes shall be decided on the basis of roof area, slope and rainfall intensity as per NBC-IX, Section-2. Rain water pipes shall be concealed as far as possible. RCC or GI spouts may be used for drainage of chajja / small canopies of ground floor. Dia of rain water pipe shall be 150 mm minimum.

### 2.5.12 Entrance Lobby

Entrance lobby shall be provided as a common entrance for all buildings / sheds accommodating separate functional spaces integrated together. Individual entries to such functional spaces shall be from this lobby by means of passages / corridors. Apart from common entry lobby, separate independent entries to these functional spaces shall also be provided if functionally required. Size of the entrance lobby shall be decided on the basis of volume of movement. Air lock lobby shall be provided for all entries with centrally air-conditioned spaces, and pressurized.

### 2.5.13 Passage / corridors



Passage / corridors shall be provided to integrate various spaces. Width of the passage / corridors shall be as per statutory requirement, subject to a minimum width of 1500 mm.

### 2.5.14 Service Entry

Separate service entry shall be provided for service areas such as kitchen, air-condition / pressurization plant room, electrical rooms. A common service entry may be provided depending on spatial arrangement.

### 2.5.15 Emergency Exits

Emergency exits shall be provided for all the building / sheds as per statutory requirements. Emergency exits for individual function spaces such as console area, cable cellar, and switchgear hall shall also be provided. Emergency exits shall be

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 34 of 242		

located in such a manner that escape route is unobstructed & without passing through any other function areas. Corridors / staircases shall be provided as escape route.

### 2.5.16 Staircases

Staircases shall be provided in multi floor buildings for vertical circulation & emergency exits. Number of staircases shall be based on building / shed sizes, emergency exit requirements, and travel distances to exit points as per statutory regulations. More than 500 sq m ground covered area shall have at least two stairs in line with NBC-Part-IV. Emergency exit requirements shall be as per safety distance requirement. At least one staircase shall be provided for access to the flat roof tops for maintenance. Following dimensions for staircases shall be adhered to.

a)	Stairs width	:	1500 mm minimum, (1000 mm minimum for emergency exit)
b)	Tread	:	300 mm minimum
c)	Riser	:	150 mm maximum
d)	Ratio of tread & riser	:	2 Riser + Tread = 600 to 650 mm

### 2.5.17 Railings



Railings shall be provided in roofs, stairs and in all unprotected openings in slabs as a safety device. Railings in high level loading / unloading bay of substations shall be of removable type. Parapets shall be given precedence over railings in roofs.

All Hand Railings (in buildings only) shall be of SS-304 grade of design as per direction / approved by owner.

### 2.5.18 Toilets

Toilets shall be provided for all habitable buildings / sheds. Gents & ladies Toilet, drinking water enclosure & janitor space, all shall be provided as required. The fittings / fixtures provided for bath / toilet shall be of luxury / colored type.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 35 of 242		

### 2.5.19 Partitions

If required partitions shall be provided for flexible space arrangement in office spaces, Control room etc. The partitions shall be modular, dismantlable type of Godrej or approved equivalent make.

### 2.5.20 False Ceiling

False ceilings shall be provided for following purposes:-

- To reduce room volume and hide ducting etc. for air conditioned spaces.
- To maintain acoustic level inside any space.
- To reduce habitable room, corridor, lobby, toilet heights located in high ceiling building / shed to a reasonable and satisfactory height of minimum 3000 mm.
- In fire rated areas where walls and doors are required to be fire rated, false ceiling shall also have complementing fire rating. It is appreciated that false ceiling have limitations in their fire performance due to openings in them for lighting and air conditioning. Therefore alternative systems to prevent puncturing the ceiling must be employed.

### 2.5.21 Under deck Insulation

Under deck insulation below RCC roof and over false ceiling (both locations) shall be provided for air-conditioned office / space.



### 2.5.22 False / Cavity flooring

False / cavity flooring, consisting of cement filled flooring sheets with antistatic lamination on the top, of approved make / as directed by Engineer in charge, shall be provided to accommodate under floor cabling in all areas. Extent of false / cavity flooring shall be as per functional requirements.

False flooring shall be fire rated to the level of fire rating of the walls, doors and suspended ceiling in the compartment.

Cavity flooring for Control Room buildings, specifications given in Instrumentation section is to be followed.

### 2.5.23 Waterproofing on roofs

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 36 of 242		

Water proofing (for all open terraces) of all buildings shall be done by water proofing PU coating with treatment also, of approved Brand and make.

Wherever there is human/machine movement anticipated, it is preferable to use Brickbat waterproofing over roof.

#### **2.5.24 Dash fasteners, if used, shall be of approved make or as directed.**

### **3.0 BUILDING STRUCTURE**



The layout of the buildings shall be finalized within 3 months after the effective date of contract.

The design considerations, type of buildings and specifications of various buildings shall be as generally defined under this clause, unless stated otherwise as per plant Requirements:

S. No.	Building	Design Consideration	Type of Building
1	Operators & Maintenance/ Control Room building	Rack layout, occupancy	RCC blast resistance structure as per specifications/ relevant standard/codal requirements including Hollow /Solid Concrete Block work infill walls
2	Sub station	Equipment layout, occupancy	RCC frame, hollow/solid concrete block work/ masonry infill walls
3	Technological structures	Equipment layout, occupancy	Structural steel Framed Structure

### **4.0 ARCHITECTURAL TRADES (To be finalized in consultation of OWNER/PMC)**

All the buildings shall be provided with Architectural finishes such as floor finishes, plastering & painting on walls & ceilings, doors / windows / ventilators, roof treatment, plinth protection, etc. pertaining to approved make/brand and best quality for industrial usage.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 37 of 242		

#### 4.1 EXTERNAL FINISHES (To be finalized in consultation of OWNER/PMC)

##### 4.1.1 External Wall

- a) Substation Room, Operator & Maintenance building - Weather proof Exterior Acrylic Emulsion paint of approved brand, quality, make and shade as per direction of Owner.
- b) Control Room – Sand Stone Cladding



#### 4.2 INTERNAL FINISHES (To be finalized in consultation of OWNER/PMC)

##### 4.2.1 Floor Finishes

- a) Office area, & Sub station  
Vitrified tiles in glazed or matt finish / Marbo-granite tiles
- b) Toilet, Drinking Water area  
Granite flooring
- c) Circulation area (Corridor / Passage etc. except Entrance Lobby) of Substation - Kota stone flooring
- d) Circulation area (Corridor / Passage etc. except Entrance Lobby) of Control room –Complete flooring (except False flooring area) to be Granite or Vitrified tiles or combination of both as per direction of Owner. Selection of quality, shade etc. for Granite / Vitrified tiles shall be based on good engineering practices and done as per Owner's direction / approval.
- e) Switch Gear, Cable Cellar, A.C. Plant Room, storage area  
Switch gear Room for substation will have Kota Stone Flooring. Rest of the buildings wil has heavy Duty Decorative Ceramic Tiles. / Hardcrete Floor, as directed by E.I.C
- f) Battery Room  
Acid resistant epoxy coating over IPS-flooring & 2100 high dado.
- g) Entrance lobby, corridor lobby of main building- granite flooring

##### **Note:**

Skirting shall be provided in all areas, which shall be of same material as that of flooring. Glass strip panel shall be provided in cement concrete flooring.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 38 of 242		

#### 4.2.2 Internal Wall Finishes for applicable buildings/structures

- a) Entrance lobby, Corridor lobby:  
Granite stone cladding and plastic emulsion paint.
- b) Office areas of Buildings:  
Cement plaster, POP punning & plastic emulsion paint
- c) Circulation areas (Corridor / Passage etc. excepting Entrance lobby) of Buildings  
Cement plaster, POP punning & plastic emulsion paint
- d) Rack Room, Office Rooms, Operators Room  
Cement plaster, POP punning & plastic emulsion paint
- e) Switchgear Room / Electrical Room  
Cement plaster & Plastic Emulsion paint (Switchgear Room)
- f) Battery Room  
Acid resistant epoxy coating over cement plaster up to 2100 height. Plastic emulsion paint above 2100 height.
- g) Toilet, Drinking water area  
Granite stone cladding / Marble / Ceramic tiles as directed by E.I.C
- h) Inside surface of Prilling tower:  
Suitable Epoxy coating (like IPN epoxy phenolic coating) of approved Brand, Make and shade as per direction of owner.

#### 4.2.3 Internal Ceiling Finishes

- a) Toilet Electric Operator, Rack room, MCC panel room, UPS  
All false ceiling shall be either Gypsum board false ceiling or Armstrong false ceiling or combination of both as per direction of owner. Further, false ceiling shall also have fire rating complying with safety requirements.  
Also refer Instrumentation and Electrical specifications.
- b) Other areas which do not have false ceiling  
Cement plaster & white / color wash, plastic emulsion paint etc., as in the case of wall finish.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 39 of 242		

## 4.3 DOORS, WINDOWS & VENTILATORS

### 4.3.1 DOORS

All frame works shall be in Sal/chap wood in size 125 x 65 mm.

a) All doors in Toilet / WC / Bath

35 mm flush door laminated with 01mm laminate from both sides.

b) All doors of Electrical Room, A.C. Plant Room, Battery Room

Pressed steel frame with pressed steel shutter (or as specified in Electrical section).

c) Inside Control Room

Fire check door with 2 hours rating as required in perfect partition wall separating various fire zones (or as specified in Instrumentation section)

d) All other doors of Control Room / Satellite Rack Room / Sub station

Glazed, powder coated Aluminum door with decorative etching (or as specified in Instrumentation section).

### 4.3.2 WINDOWS & VENTILATORS

a) Windows / ventilators

Glazed, powder coated aluminum window / ventilator.

## 4.4 SANITARY FITTINGS (Make: Jaquar/Cera/Hindware/Perryware or equivalent)

a) Water Closet for Control Room

Wall hung type colored European designer type WC.

b) Water Closet for Sub Station.

Pedestal type white European designer type W.

c) Water Closet (Indian).



Orissa type (Indian) pan white WC.

d) Wash basins for Control Room.

Round wash basin white / colored housed in granite counter with electronic sensors for water control, approved quality mirror. Front portion below the counter shall be covered with shutters of laminated boards.

e) Wash basins for Sub Station / Satellite Control Room.

Wall hung wash basin with pedestal.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसीकरण औद्योगिक कंपनी लि. <b>BHEL</b>
		Document No.	Rev	
		Sheet 40 of 242		

f) Plumbing fixtures.

Stainless steel bib cock, stop cock etc. fittings.

g) Urinals of approved Brand, Make, size, shape and color shall be provided in Control Room with Electronic sensors for water control, along with Glass partitions of approved brand, make size and shape etc.

## 5.0 MISCELLANEOUS

### 5.1 ARCHITECTURAL DRAWING

5.1.1 Plant datum shall always be 100.00 meters and its correspondence to the reduced level with respect to the mean sea level shall be indicated in the “NOTES” (Unless it is already established).

5.1.2 Location co-ordinates shall be indicated on grids.

5.1.3 Reference drawings, notes, holds list, schedule of finishes including painting, door and window schedules, area statement, notes on plastering, key plan, were necessary, shall appear in the first drawing sheet of a building. Subsequent sheets can cover them by a reference to the first sheet.

5.1.4 Elevations shall show siography to highlight features, human figures for scale, automobiles for headroom, trees and foliage for appearance.

5.1.5 False ceiling area shall be shown by hatching suitably.



5.1.6 False flooring area shall be shown by hatching suitably.

5.1.7 Air-conditioned rooms shall be identified suitably.

### 5.2 DESIGN

5.2.1 Entrances shall be elaborate and well sheltered to accommodate pedestrians and vehicles.

5.2.2 Provision for future extension, vertical and horizontal shall reflect in the work.

<div> पी डी आई एल <b>PDIL</b></div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT OWNER: Bharat Coal Gasification and Chemicals Limited DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</div>	PC288/E/001/P-II/5.5	P	<div> भारत कोयला गैसिफिकेशन और रासायनिक उद्योग <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 41 of 242		

5.2.3 Toilet, kitchen and pantry floors with waterproofing and sloped for drainage. The finished floor level shall be 25 mm below the general finished floor level. Tile drops shall be indicated where required. For example from general floor to toilet floor, toilet floor to WC / Shower floor, general floor to pantry, general floor to entrance platforms and so on.

5.2.4 Plumbing works, external drainage, schematic, flow, shall be indicated.

5.2.5 Water tanks, AC plant, cooling tower, Chiller units etc., where required, shall be located on building roof as far as possible and it shall be positioned and supported to transfer its load on to beams and columns and not to the slab. Such facilities should not be visible from outside. Suitable side cladding shall be provided for this purpose.

5.2.6 Access to all roofs via steel ladder. In case of accessible roofs at least one staircase shall go up to the roof.

5.2.7 Plinth beams level shall clear trenches if any.



5.2.8 Vertical ducts for running services must be examined.

5.2.9 Ventilator arrangement shall be provided unless situations strongly prevent or make it unnecessary. In addition to ventilation requirements, ventilators shall have the capacity to vent smoke in the event of fire.

5.2.10 Layout shall take into account the type of air-conditioning and built-in provisions shall be made to accommodate the equipment.

5.2.11 Walls on steel beams shall be constructed after wall below and up to the steel beam is constructed. This shall appear in the 'Notes' if applicable.

5.2.12 Gaps in floor cut outs shall be sealed with fireproof material for fire safety.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 42 of 242		

5.2.13 Openings in wall / cladding for pipes and cables from pipe rack / trays shall be made water tight primarily by means of design features.

### 5.3 BUILDING REQUIREMENTS

5.3.1 All free edges of chajjas and slab projections shall have drip mould in plaster 50 mm wide and 20 mm drop, unless the need is resolved in some other manner.

5.3.2 Floor slab in WC areas shall be sunk by 500 mm and toilet, pantry, kitchen floor slabs shall be sunk by 200 mm at all levels (including terrace, where future extension is envisaged).

5.3.3 All partition walls within toilet kitchen areas shall be 115 mm thick and 2200 mm high.

5.3.4 All supporting framework members of partition walls within false ceiling areas shall go up to roof level, partitions shall go up to false ceiling level except where there are fire compartment wall where it shall be from floor to ceiling.

5.3.5 All windows and ventilators opening periphery shall have granite embedded in cement mortar 1:3.

5.3.6 Preferably all cut out in slab shall be provided with 200 mm high kerb.

5.3.7 Groove in plaster, 20 wide x 10 deep shall be provided aesthetically to break extensive areas of plaster.

5.3.8 Flooring shall be done in panels, preferably in 3000X3000 mm size with expansion joints provided at 25000 mm c/c.

5.3.9 Flooring contraction joint shall be provided as per design.



5.3.10 Parapet walls shall be at least 1100 mm high.

5.3.11 Roofs of RCC buildings should have mild slope towards rain water gutters.

5.3.12 All Instrument / Electrical cables at the junction of the building (outside) shall be covered with pre-cast RCC slab. Sleeve pipes should be provided for the cable in the masonry wall including its sealing.



5.3.13 All new buildings (except for Blast proof Control Room) shall be designed for vertical extension of one additional storey over and above bidder's plan to Accommodate requirement in future.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 43 of 242		



## ANNEXURE II

### DESIGN PHILOSOPHY – GENERAL CIVIL & DESIGN BASIS

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 44 of 242		

## TABLE OF CONTENTS

1.0	GENERAL
1.1	SCOPE
1.2	UNITS OF MEASUREMENT
1.3	DEFINITIONS
1.4	CODES AND STANDARDS
2.0	DESIGN CRITERIA – GENERAL
2.1	SURFACE TREATMENT
2.2	ROADS
2.3	CONCRETE PAVING (WITHIN PLANT AREAS)
2.4	SURFACE TREATMENT
2.5	STORM WATER DRAINAGE
2.6	WATER SUPPLY
2.7	SANITARY SEWERS
2.8	CONTAMINATED RAIN WATER SEWERS
2.9	OTHER PROCESS DRAINS
2.10	STORAGE TANK FOUNDATION AND DYKE WALLS
2.11	BARRICADE
2.12	TRENCHES
2.13	HARD SURFACES
3.1	REMOVAL / REROUTING OF CONSTRUCTIONS

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसीकरण औद्योगिक कमिशन <b>BHEL</b>
		Document No.	Rev	
		Sheet 45 of 242		

## 1.0 GENERAL

### 1.1 SCOPE

This engineering design basis defines the design criteria that shall form the basis for carrying out design and engineering of items under general civil, viz. roads, paving, drainage, etc.

### 1.2 UNITS OF MEASUREMENTS



Units of measurement in design shall be metric system.

### 1.3 DEFINITIONS

Owner	Bharat Coal Gasification and Chemicals Limited (JV of CIL & BHEL)
Consultant	To be selected
LSTK Contractor	Successful bidder of the tender
CCE	Chief Controller of Explosives
TAC	Tariff Advisory Committee
NFPA	National Fire Protection Association
IS	Indian Standards

### 1.4 CODES AND STANDARDS

The design shall be in accordance with established codes, sound engineering practices and shall conform to the statutory regulations applicable to the country.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसीकरण और रासायनिक उद्योग <b>BHEL</b>
		Document No.	Rev	
		Sheet 46 of 242		



1.4.1 The main codes, standards and statutory regulations considered as minimum requirements are as follows. Latest revision of these shall be followed.

IS: 456	Code of practice for plain and reinforced concrete
IS: 800	Code of practice for general construction in steel
IS: 875	Code of practice for design loads (Other than earthquake for buildings & Structures
IS: 1172	Code of basic requirements for water supply, drainage & sanitation
IS: 1742	Code of practice for building drainage
IS: 1905	Code of practice for structural use of unreinforced masonry
IS: 2065	Code of practice for water supply in buildings
IS: 2212	Code of practice for brick work
IS: 8835	Guidelines for design of surface drains.
IRC: 6	Code of practice for road bridges, Section-II Loads and stresses
IRC: 19	Standard Specifications and Code of Practice for Water Bound Macadam
IRC: 37	Design of flexible pavements
IRC: 58	Design of rigid pavements
	Factory Rules for State

Note: The above list is suggestive and not exhaustive. Apart from these basic codes, any other related codes shall be followed wherever required.

1.4.2 In case of any conflict / deviations amongst various documents, the order of precedence shall as follows –

- Statutory regulations
- Job specifications
- Engineering design basis
- Standard specification

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसिफिकेशन और केमिकल्स लिमिटेड <b>BHEL</b>
		Document No.	Rev	
		Sheet 47 of 242		

## 2.0 DESIGN CRITERIA –GENERAL

### 2.1 SITE GRADING

2.1.1 The work area shall be cleared and stripped completely of all bushes, roots, trees, Shrubs and other vegetation, organic matter and other objectionable materials. All these should be completely uprooted and removed, and not merely scraped at the surface.

**2.1.2 The grading of the area, if required, shall be done by cutting and filling with the following:**

- a. Cutting Area : Thoroughly rolled and compacted.
- b. Filling Area : Compacted in layers not exceeding 20cm to  
Achieve minimum 95% of maximum dry density.



**2.1.3 Site grading philosophy shall be based on following:**

FFL of the adjacent paved area is .....m above Mean Sea Level (To be decided later).

However, levels like Finished Ground Levels (FGL) and Highest Point of Paving (HPP) shall be finalised by the CONTRACTOR, in consultation with OWNER / PMC, based on contour survey of the Unit, levels of adjacent units and levels of adjacent Roads.

### 2.1.4 Slope in Graded Areas

a. General Site Grading	1 in 500 to 1 in 1000
b. Micro grading, after completion of major construction (for road corridors)	1 in 200
c. Tanks Farms	1 in 200 to 1 in 300

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></div>	PC288/E/001/P-II/5.5	P	<div> बी एच ई लि. <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 48 of 242		

## 2.2 ROADS

Contractor shall design cross section of roads, including roads for crane access, as per IRC 37. However, the minimum section to be adopted shall be as given in clause 2.2.7 Ruling gradient shall not exceed 1 in 20. If existing roads are to be used for erection purposes, the same should be strengthened to cater for erection loads. It should be ensured that use of existing roads does not hinder normal activities in existing plants.

### 2.2.1 ROAD WIDTH



Category	Width*	Carriageway Width
i. Road around unit and its Primary access	12.5 m	10.5 m (three lane road or width to suit crane type)
ii. Roads for high lifts crane	2.0 m+ c.w. width	3 m + outer width of crawlers of required Capacity crane.
iii. Plant approach road	9. 0m	7.0 m (two lane)
iv. Roads around tank farm	7.5 m	5.5 m
v. Patrolling roads (along boundary wall)	6.0 m	4.0 m
vi. Access to building	5.5 m	3.5 m
vii. Foot path	1.0 m	.....

\* Width of the road to be finalised as per site condition/Plot plan requirements in consultation with client / PMC.

### 2.2.2 Camber

1 in 50

**2.2.3 Radius of curve:** 12 m for 8 m wide carriage way roads, 8 m for 5.5 m wide Carriage way width & 15 m for roads of higher carriageway width.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसीकरण औद्योगिक रसायन औद्योगिक निगम <b>BHEL</b>
		Document No.	Rev	
		Sheet 49 of 242		

**2.2.4 Pavement Type:** Concrete pavement at all roads to be used for crane movement (Requirement of crane movement route and its specification to be finalised in consultation with client /PMC)

**2.2.5 Extents:** As per Plot Plan / Equipment Layout drawing / scope drawing.

**2.2.6 Clearance:** Minimum 8.0 m to underside of pipe racks or as per Design Philosophy (Piping).

### 2.2.7 Minimum Cross Section



- Sub base: The sub base shall be 300 mm layer of crushed / broken size stones on well compacted earth or approved fill.
- Base course: The base course shall be 225 mm stone size thick water bound macadam consisting of 3 layers of 75 mm each or Wet mix macadam roads.
- Bituminous wearing course / RCC: The wearing course shall be 75 mm thick for roads with crane duty and 50 mm thick for roads without crane duty. However, roads for crane movement, concrete pavements shall be provided.

### 2.2.8 Crossings

a. Pipe Ways under roads & rails	RCC Box Culverts
b. Storm Water Culverts Under road / rail.	RCC Box Culverts
c. Electric / Instruments Cable	RCC duct bank with PVC Pipe Class – 1 (IS 4985)

### 2.2.9 Finished Road Top Levels above FGL

When box culverts for pipe ways are provided	1.05 m (minimum)
Ways are provided	1.6 m at box culvert location with a slope from 1.05 m to 1.6

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 50 of 242		

	m above FGL
When overhead bridges are	1.05 m around hazardous units
Provided for pipe ways	0.40 m to 0.60 m for others areas
Other areas	0.40 m to 0.60 m

## 2.3 CONCRETE PAVING (WITHIN PLANT AREAS)

### 2.3.1 General

RCC paving to be done for entire battery limit and extend up to the adjacent roads around the unit. The contractor's scope is limited to units' peripheral roads. Heavy duty paving shall be designed for heavy vehicular traffic movement as per IRC Loading.

Concrete paving shall be laid in cast-in-situ panels of 3.0 meter X 3.0 meter size, with expansion joints spaced approximately 15.0 m c/c, each panel being cast in a single pour.



Hard stands should be designed and provided by contractor, based on required crane capacity, here called for by Owner, the same shall be demolished after erection, and surface made good.

Provision of trenches, drains, sealing of trench covers, inserts, thickening for pipe / equipment supports etc. shall be made while construction pavements, as detailed in drawings.

Acid / alkali / chemical resistant coating as required shall be applied in areas where such corrosive materials are likely to come in contact with concrete.

Suitable drainage arrangements will be provided within curbed areas around pumps, for drainage leaks. Similarly, suitable drainage arrangement shall be provided at streaming points also.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 51 of 242		

### 2.3.2 Joints

Expansion joint of 20 mm shall consist of 20 thick impregnated fibre boards. Filled at top with joint sealing compound 20 x 25.

Equipment / column pedestals will be separated from paving with 20 thick sand fill and Sealing compound 20 x 25.

Contraction joints will be sealed by sealing compound 10 x 40.

**2.3.3 Slope:** 1 in 100 (minimum)

### 2.3.4 Minimum requirements of paving in various areas

a. Paving within Process & Utility : Type – I (200 mm thick RCC)  
areas for maintenance compatible  
to crane movements / dropout  
/ Loading / Unloading areas /  
Vehicular movement areas

#### b. Non vehicular movement areas

i. Unit : Type –II (150 mm thick RCC)  
II. Offsite pump station : Type –II (150 mm thick RCC)  
II. Bullet Area : Type –II (150 mm thick RCC)  
II. Utilities : Type –II (150 mm thick RCC)

c. **Pipe rack** : PCC 1:3:6 (100 mm thick)

Paving and trenches including covers in process units shall be suitable for Hydra crane movement. Where movement of bigger cranes for maintenance is envisage paving and trenches including covers shall be designed for the loads arising from the same.

## 2.4 SURFACE TREATMENT

The surface treatment for the various areas shall be provided as enumerated in the table below.

AREA	RCC PAVING	ASPHALT PAVING	50 thick PCC 1:3:6 ON 115 thick brick soling	GRAVEL	100 THK PCC 1:3:6	ACID / ALKALI PROOF COATING
Operating Areas of Process units (including Roads for crane movement)	X (Type I /II Paving as per cl. 2.3.4)					
Around Transformers In substation						
Roads (excluding roads having crane movement )		X				
Approaches to units		X				
Tank farms			X			
Acid / alkali / storage / handling area						X
Parking		X				
Hardstands	X					
Pathways	X					
Pipe ways					X	
‘ X ’ Indicating applicable option						
Notes:						
1. Existing services where interfering with the new construction should be located and rerouted as instructed by Owner / Consultant.						
2. Micro-grading shall be carried out by the Contractor over graded areas to bring the FGL to indicated levels including provision of required slopes and finishes.						

## 2.5 STORM WATER DRAINAGE

2.5.1 Storm water drains shall be sized for the higher discharge arising out of either rain water or fire fighting water.

2.5.2 Rain water run-off shall be computed by the formula:-

$$Q = KIA / 360$$

K is run-off coefficient given below.

A is area (hectares) contributing to the drain

I is rain fall intensity (mm / hr.)

Q is the discharge.

2.5.3 Design of drains shall be based on Manning's formula:-

$$V = R^{2/3} S^{1/2} / n$$

V is velocity of flow m/s,

R is hydraulic radius,

S is slope,



n is roughness coefficient taken as 0.013 for plaster surface, 0.015 for cast-in-situ concrete, 0.017 for brick lined.

The following parameters are to be ensured to be within limits specified while sizing

Minimum velocity of drains	:	0.6 m/s
Maximum velocity of drains	:	2.4 m/s
Minimum depth of drains	:	300 mm
Minimum width of rectangular drains	:	300mm (for depth<500mm)
Minimum width of drains	:	500 mm (depth > 500mm)

Run off coefficient 'K'

a.	paved area	concrete	-	1.0
		Bituminous	-	0.9
b.	unpaved areas		-	0.7

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		Document No.	Rev	
		Sheet 54 of 242		

c. unusable areas like Green belt - 0.4

#### 2.5.4 Drains within Process Units

Rain water falling on such portion of paved areas of process unit where it is not likely to get contaminated, shall be collected in open rectangular RCC drains. These drains shall be covered by gratings, and shall be generally connected to periphery drains, which at battery limit shall have a double valve chamber. This will permit discharging the rain water either to storm water network, or to the battery limit CRWS manhole. Drains shall be designed for the maximum of rainwater / firewater on same principles as storm water drains.

#### 2.5.5 Culverts and Road/Rail Crossings



Road / Rail and storm water drain crossing shall by RCC box culverts, designed for the Relevant IRC loads for roads, and track loads for rail. The relevant lateral loads due to wheel / track loads on the soil adjacent to wall on crossing shall be considered on the walls. Approval from the rail authorities on culvert design shall be in the scope of LSTK contractor.

Drain to adjacent to roads / pavement where heavy crane movement is anticipated shall be Concrete drains, designed to resist the lateral thrust due to wheel loads.

Pipe culverts, if instructed to use by Owner/PMC, shall comprise of R.C.C. pipes (class NP-3, IS: 458) under roads; and R.C.C. pipes (class NP-4, IS: 458) under rail lines.

#### 2.5.6 Tank Farm Drainage

Tank farm drainage system should be provided in such a way that the storm water discharge shall be either sent to storm water open ditch or to the oily water sewer by providing valve pit outside the dyke wall depending on its contamination.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 बी एच ई लिमिटेड <b>BHEL</b>
		Document No.	Rev	
		Sheet 55 of 242		

### 2.5.7 Disposal of Storm Water

Storm water drains shall not be combined with oily waste sewer / CRWS/combined sewer system, etc. For disposal of storm water references shall be made to the 'scope' document.

### 2.5.8 Oil Catcher

An oil catcher with baffle wall type arrangement shall be provided a storm water ditch before it leaves the battery limit of the unit, & tank farm.

## 2.6 WATER SUPPLY

Existing drinking water piping shall be extended to new facilities. Adequacy of header branch line etc. shall be ensured; else additional lines shall be run.

## 2.7 SANITARY SEWERS

### 2.7.1 General



Sanitary sewerage will not be combined with storm water.

Building drainage shall be designed as a dual pipe system with separate soil & waste pipe.

Sewers shall be designed for discharging 3 times average flow flowing half full in case of lateral sewer, and flowing 2/3 full in case of Main sewer. The minimum and maximum clearing velocities shall be 0.75 m/s and velocity 2.4 m/s respectively. Velocity shall be calculated by Manning's formula with  $n=0.015$

Minimum pipe size shall be 100 mm and all pipes shall preferably be salt glazed stoneware unless abnormal soil conditions or high velocity dictates otherwise.

2.7.2 Sanitary sewer shall be led into the sewerage system leading to waste water treatment plant (WWTP). Where system is not available, septic tank/soak pit shall be provided.

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		Document No.	Rev	
		Sheet 56 of 242		

2.7.3 Cover for Sewer Line shall be minimum 600 mm.

Under road, sewer shall be protected by concrete encasement or minimum cushion shall be 1200 mm.

Under railway, the sewer shall be protected as per railway standards.

#### 2.7.4 Material of Construction

- a. Material of Construction for Manholes shall R.C.C. M30.
- b. Material of Construction for Sewer



##### Sanitary Sewer

- i. Toilet block to inspection - CI pipes as per IS: 3486/1729)  
chamber or UPVC, as directed.
- ii. Gravity main & lateral - Salt glazed stoneware / C.I. / R.C.C. Class  
P1 (as per IS: 458)
- iii. Pressure main - C.I. pipes (as per IS: 1536 and IS: 1537)
- iv. Offsite Pumping, if any - CPVC pipes/GI as per PMS J2A(as directed )
- v. Manholes - R.C.C. M30

## 2.8 CONTAMINATED RAIN WATER SEWERS

### 2.8.1 Process Unit

Contaminated rain water / floor wash / fine water shall be collected through catch basins located in the contaminated areas of the process unit and shall be send to the oil catcher / CRWS pit / CRWS header. The continuously contaminated area of all pumps shall be segregated by kerb wall; discharge from such kerbed areas shall be collected in OWS network and not in CRWS network.

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		Document No.	Rev	
		Sheet 57 of 242		

CRWS shall be designed for contaminated water due to rain water or Fire water, whichever is more.

The quantities of contaminated rain water shall be worked out based on the contaminated process area in the unit block.

Sewer shall be sized flowing full with peak flows taking future requirements or 2/3 full without future requirements.

CRWS manholes shall be R.C.C. (M30) construction. For trapping of gas or prevention of spread of fire through CRWS from one area to another, a liquid seal of minimum 150 mm shall be provided in manhole along with suitable vents. Location of sealed manholes should be decided accordingly. The vents on the manholes should extend minimum 2.0 m above the pipe rack or 1.0 m above buildings, or if in open areas extending min 3.0 m above FGL with frame arresters.



CRW sewers in process units and tankage areas shall be of mild steel /Carbon steel conforming to IS: 3589

## 2.8.2 Tank Farm Area

Tank farm areas, not containing tanks for corrosive materials, shall be drained by surface drains. Waste water shall be led to a sand trap and then to a valve chamber which shall either drain the water to storm water drain or oily water drain. Waste water from tank farm areas containing corrosive / hazardous materials shall be drained by chemical sewers to neutralization tank / ETP.

## 2.9 OTHER PROCESS DRAINS

Other process drains shall be oily water sewers, closed blow down sewers or chemical Sewers. Sizing, layout, material specification, corrosion protection etc will be as per u/g piping design Basis.

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></p><p><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></p></div>	PC288/E/001/P-II/5.5	P	<div><p>भारत कोयला गैसीकरण और रासायनिक उद्योग <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 58 of 242		

Oily water sewer convey water contaminated with oil, e.g. from reflux drums, separators, Cooling / quench water for compressor / pump, process wash water, floor and paving Drains in oily areas etc. These are conveyed either to WWTP or oil separator by means Of U/G steel pipes through sealed manholes.

Blow down are liquid streams containing water / oil / chemicals that are required to be drained from process equipment under different operating situations like start-up, shutdown etc. Blow down systems are closed piped systems in which streams are collected in underground blow down drums and then pumped to respective slop / field tanks.

Chemical sewers carry effluents containing chemicals which require separate treatment from oily water streams. These are generally corrosive and require pipe of materials resistant to corrosion or lined pipes.



Closed blow down sewers shall be closed piping systems as shown in piping drawings. These will lead to underground blow down drum / drums which shall be protected by a concrete pit as detailed in drawings. Before entering the blow down drum, a valve chamber shall be provided for the sewer .Sewer cleanouts will be provided at start / end charges in direction and at 45 m intervals on straight length.

Other aqueous blow downs within process areas will be collected by funnels and routed through oily water sewers to sealed manholes. A common oily water header will route these streams to the plant oily water sewer network leading to waste water treatment plant.

Small neutralization pits hall be provided near battery rooms to treat floor wash in battery rooms. Water from these pits will further be routed to storm water drains.

Dyked areas around emergency booths shall drain into a gully trap which shall be connected to the chemical sewer network.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 59 of 242		

Oily water & contaminated rain water catch pits / manholes shall be of reinforced concrete to the chemical sewer network with internal coal tar epoxy lining.

Manhole for acid / alkali sewer shall be of reinforced concrete (M30). Exposed steel work shall be provided with coal tar epoxy coating.

## 2.10 STORAGE TANK FOUNDATION AND DYKE WALLS

2.10.1 The storage tank foundations shall be designed to sustain the forces at the tank bottom within permissible settlement, under operating and hydro-test conditions.

Tanks less than 2.5m dia. may rest directly on a concrete pedestal with anti corrosive layer.



Tanks greater than 2.5m dia. but less than 10.0 m dia. may be supported on RCC ring all with sand / murrum fill.

For tanks greater than 10m dia, Tank Pad Foundations shall be provided as per relevant design Codes.

2.10.2 Anticorrosive layer shall be provided as per specifications for tank pads of 50 thick premix Carpet over 50 thick bitumen sand mixed with additions of kerosene / oil as required.

### 2.10.3 Storage tank Dyke Walls / Fire Walls

Dyke walls / Fire walls shall be provided. Walls shall be plastered brick work conforming to standard relevant Codes. DYKE walls shall be designed for retaining liquid in case of rupture of the largest tank in the farm. It shall be minimum 600mm thick to enable persons to walk on the wall top. If space permits, Dyke walls shall be provided with ramps on both sides at suitable places, for movement of vehicles for tank cleaning purpose. Fire walls shall only be 600 mm high (min.) or as shown in drawings / as instructed. They shall only retain spillages, to prevent fire spread.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 60 of 242		

## 2.11 BARRICADE

Contractor shall design a suitable barricading system for protection of existing facilities if required. Barricade shall be of G.I. sheet cladding with suitable supporting system of height and extent shown in drawings or as instructed by Owner / Consultant. Water spray system shall be incorporated where felt necessary by Owner / Consultant. Localized G.I. sheet barricading shall be provided from operational constraint requirements as directed by Owner / consultant.



## 2.12 TRENCHES

Trenches shall be of RCC with inserts or other suitable arrangement required to support Cables pipes etc. Pre-cast concrete covers with lifting arrangement shall be provided on top. In paved areas, the top will be flush with finished floor level. Covers shall overlap walls and joints with paving shall be sealed to prevent water entry. In unpaved areas, walls shall be raised above ground level by 100 mm. Trench floors shall be provided with a nominal slope to drain pits, where any water entering trenches can collect and be detained to the nearest contaminated rain water sewer / storm water sewer. Trench covers shall be designed for the vehicle load relevant to the area where the trench is located. Cable trench shall be of leak proof construction.

## 2.13 HARD SURFACES

Hard surface of PCC 1:3:6, (100 mm thick) over suitable bedding (brick / stone soling) Shall be provided below all new pipe tracks and / or extended portion of existing pipe Tracks (if any). This shall extend 600 mm on one side for track width less than 6 m, and 900mm On either side for pipe track having width 6 m or more, end it shall have approach @ 500 M c/c from nearest road.

Hard surface of PCC 1:3:6 (100 mm thick) over suitable bedding (brick / stone soling) of approximate size 1 m x 1 m shall be provided with proper approach near drain point of offsite piping, near drinking water installations, at washing facilities,

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></p><p><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></p></div>	PC288/E/001/P-II/5.5	P	<div><p>भारत कोयला गैसिफिकेशन लिमिटेड <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 61 of 242		



etc., with suitable curbing and drainage arrangements as required for the fluid being handled.

## 2.14 REMOVAL / REROUTING OF OBSTRUCTIONS

All underground or above ground structures / foundations which will cause obstruction to new structures / foundations, and which can be removed without disturbing any functions of the existing structures if any, shall be removed by the Contractor.



All existing underground or above ground facilities requiring rerouting due to fouling with new facilities shall be rerouted by the Contractor in such a manner that rerouted facilities keep on functioning as before.

Before finalizing the route connection to existing system, adequacies of existing system shall be checked by the contractor.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 62 of 242		



## ANNEXURE- III

### CIVIL ENGINEERING DESIGN BASIS (STRUCTURAL)

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></div>	PC288/E/001/P-II/5.5	P	<div><div>बी एच ई लि. <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 63 of 242		

## TABLE OF CONTENTS

<b>1.0</b>	<b>GENERAL</b>
1.1	SCOPE
1.2	UNITS OF MEASUREMENT
1.3	DEFINITIONS
1.4	CODES AND STANDARDS
<b>2.0</b>	<b>MATERIALS OF CONSTRUCTION</b>
<b>3.0</b>	<b>DESIGN LOADS</b>
3.1	DEAD LOADS
3.2	EQUIPMENT LOADS
3.3	LIVE LOADS
3.4	WIND LOADS
3.5	SEISMIC LOADS
3.6	IMPACT & VIBRATORY LOADS
3.7	BLAST FORCES
3.8	CONTINGENCY LOADS
3.9	MISCELLANEOUS LOADS
3.10	LOAD COMBINATIONS
<b>4.0</b>	<b>DESIGN CRITERIA FOR FOUNDATIONS</b>
4.1	GENERAL
4.2	TYPES OF FOUNDATIONS
4.3	SHALLOW FOUNDATIONS
4.4	PILED FOUNDATIONS
4.5	MACHINE FOUNDATIONS
4.6	CONCRETE GRADE
4.7	FOUNDATION BOLTS
4.8	PEDESTAL HEIGHTS
4.9	GROUTING
<b>5.0</b>	<b>DESIGN CRITERIA FOR REINFORCED CONCRETE STRUCTURES</b>
25.1	GENERAL
5.2	LIQUID RETAINING R.C.C. STRUCTURES AND BASEMENTS
5.3	STAIRCASE
5.4	CONCRETE GRADE
5.5	REINFORCEMENT BARS
5.6	MINIMUM THICKNESS OF STRUCTURAL CONCRETE ELEMENTS
5.7	MINIMUM COVER TO REINFORCEMENT
5.8	EXPANSION JOINT
5.9	DEFLECTIONS
5.10	MISCELLANEOUS APPLICATIONS

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div> <div>OWNER: Bharat Coal Gasification and Chemicals Limited</div> <div>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</div>	PC288/E/001/P-II/5.5	P	<div><div>बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 64 of 242		

## **6.0 DESIGN CRITERIA FOR STEEL STRUCTURES**



- 6.1 GENERAL / DESIGN METHOD
- 6.2 EXPANSION JOINTS
- 6.3 STEEL GRADE
- 6.4 FIRE PROOFING OF STEEL STRUCTURES
- 6.5 LIMITING PERMISSIBLE STRESSES
- 6.6 LIMITING DEFLECTION
- 6.7 MINIMUM THICKNESS
- 6.8 ELECTRICAL SWITCHYARD STRUCTURES AND TRANSMISSION TOWERS
- 6.9 PAINTING
- 6.10 GROUTING
- 6.11 CLADDING / RAINWATER FUTTERS

## **7.0 CRITERIA FOR MASONRY WORKS**

- 7.1 GENERAL
- 7.2 CEMENT MORTAR
- 7.3 FIRE WALLS

## **8.0 DESIGN REQUIREMENTS FOR SPECIFIC APPLICATIONS**

- 8.1 PIPERACK
- 8.2 RCC AND STEEL CHIMNEYS
- 8.3 CULVERTS

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 65 of 242		

## 1.0 GENERAL

### 1.1 SCOPE

This engineering design basis defines the minimum design criteria that shall form the basis for carrying out detailed structural design and engineering of all plant and non-plant structures and buildings. All data required in this regard shall be taken into consideration for acceptable, satisfactory and trouble-free engineering of the structures.



Compliance with this design basis and / or review of any of the contractor documents shall in no case relieve the contractor at the contractual obligations. All structures shall be designed for the satisfactory performance of the functions for which they are being constructed.

### 1.2 UNITS OF MEASUREMENT

Units of measurement in design shall be in metric system.

### 1.3 DEFINITIONS

Owner	Bharat Coal Gasification and Chemicals Limited (JV of CIL & BHEL)
Consultant	To be selected
LSTK Contractor	Successful LSTK bidder of the tender
CCE	Chief Controller of Explosives
TAC	Tariff Advisory Committee
NFPA	National Fire Protection Association
IS	Indian Standards

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 66 of 242		

## 1.4 CODES AND STANDARDS

The design shall be in accordance with established codes, sound engineering practices and shall conform to the statutory regulations applicable to the country.



1.4.1 The main codes and standards and statutory regulations considered as minimum requirements are as follows Latest revision of these shall be followed.

- 1) National Building Code of India : 2005
- 2) IS: 875 (Part 1) – Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures (Part 1 – Dead Loads).
- 3) IS: 875 (Part 2) - Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures (Part 2 – Imposed Loads).
- 4) IS: 875 (Part 3) - Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures (Part 3 – Wind Loads).
- 5) IS: 1893 (Part 1):2002 –Criteria for Earthquake Resistant Design of Structures (Part 1 – General Provisions and Building).
- 6) IS: 1893 (Part 4):2005 –Criteria for Earthquake Resistant Design of Structures (Part 4 – Industrial Structures including Stack-Like Structures).

### 1.4.2 STRUCTURAL STEEL

- 1) IS: 800 – Code of Practice for General Construction in Steel
- 2) IS: 802 – Code of Practice for use of structural steel in overhead transmission line towers.
- 3) IS: 1161 – Code of Practice for Circular hollow sections/pipes.
- 4) IS: 4923 – RHS & SHS sections.
- 5) IS: 2629 – Recommended practice for hot dipped galvanizing on iron and steel.
- 6) IS: 2633 – Methods for testing uniformity of coating of zinc coated articles.





 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 67 of 242		

- 7) IS: 6533 – Code of Practice for design and construction of steel chimney.
- 8) IS: 6745 – Method for Determination of mass of zinc coating.
- 9) IS: 814 – Covered Electrodes for manual metal arc welding of Carbon and carbon manganese steel.
- 10) IS: 816 – Code of Practice for use of Metal arc welding for General Construction in mild steel.
- 11) SP-06 – (Part 1 to Part 7) - Handbook for Structural Engineers.

### 1.4.3 REINFORCED CONCRETE AND MASONRY WORK

- 1) IS: 456 – Plain and Reinforced Concrete – Code of Practice
- 2) SP:16 - Design Aids for Reinforced Concrete to IS: 456
- 3) SP: 34 – Handbook of Concrete Reinforcement and Detailing.
- 4) SP:24 – Explanatory Handbook on Indian Standard Code of Practice for Plain and Reinforced
- 5) SP: 20(S & T) – Explanatory Handbook on Masonry Design and Construction.
- 6) IS: 2911 (Part 1 to Part 4) – Code of Practice for Design and Construction of Pile Foundation.
- 7) IS: 2950 (Part 1) – Code of Practice for design and construction of Raft foundation.
- 8) IS: 2974 (Part 1 to Part 5) – Code of Practice for design and construction of Pile Foundations.
- 9) IS: 3370 - Code of Practice for Concrete Structures for storage of liquids.
- 10) IS:4326 – Code of Practice for earthquake resistant design & construction of buildings
- 11) IS: 13920 – Code of Practice for ductile detailing of reinforced concrete structures subjected to seismic forces.
- 12) IS:1172 - Code of basic requirements for water supply, drainage & sanitation
- 13) IS:1742 - Code of practice for building drainage
- 14) IS:1905 - Code of practice for structural use of unreinforced masonry
- 15) IS: 2212 - Code of practice for brick work

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></p><p><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></p></div>	PC288/E/001/P-II/5.5	P	<div><p>बी एच ई लि. <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 68 of 242		

#### 1.4.4 ROADS AND SANITARY WORKS

- 1) IS: 2065 - Code of practice for water supply in buildings
- 2) IS: 8835 - Guidelines for design of surface drains.
- 3) IRC: 6 - Code of practice for road bridges, Section-II Loads and stresses
- 4) IRC: 19 - Standard Specifications And Code of Practice for Water Bound Macadam
- 5) IRC: 37 - Design of flexible pavements
- 6) IRC: 58 - Design of rigid pavements

Note: The above list is suggestive and not exhaustive. Apart from these basic codes any other related codes shall also be followed wherever required.

In case of any difference between Codes provision and this design basis, the stringent one should govern the design.

#### 1.4.5 In case of any conflict / deviations amongst various documents, the order of precedence shall be as follows.

- Statutory Regulations
- Job Specifications
- Engineering Design Basis
- Standard Specifications

## 2.0 MATERIALS OF CONSTRUCTION

Type of Structure	Materials of Construction
Piperacks	Structural Steel (unless required otherwise from process requirement or operation considerations)
Technological Structures/Platforms	-do-
Shed type structures (e.g. compressor	-do-

shed, Pump shed)	
Opening Platforms in steel structures	Steel gratings
Blast Proof Control Room	RCC
Substation	RCC framed with hollow/solid concrete blocks walls

### 3.0 DESIGN LOADS (DL)

The following design loadings shall be considered

- 1) Dead loads including self weight
- 2) Live load
- 3) Wind load
- 4) Seismic load
- 5) Equipment load
- 6) Dynamic load
- 7) Load from lifting appliances
- 8) Erection loads / maintenance loads
- 9) Thermal load
- 10) Earth pressure / Hydrostatic Loads
- 11) Any other load not mentioned above, but applicable



These loadings shall be applicable to all structures irrespective of the material employed for construction.

### 3.1 DEAD LOADS

Dead load shall comprise of the weight of all permanent construction including walls, fire proofing, floors, roofs, partitions, stairways and fixed services.

Unless noted otherwise following unit weights shall be adopted.

Reinforce Concrete	:	2500 kg/m <sup>3</sup>
Plain Concrete	:	2400 kg/m <sup>3</sup>
Structural steel	:	7850 kg/m <sup>3</sup>
Backfill Soil	:	1800 kg/m <sup>3</sup>
Operating floor with grating	:	100 kg/m <sup>2</sup>
Staircase (steel)	:	140 kg/m <sup>2</sup>

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		Document No.	Rev	
		Sheet 70 of 242		

Ladder	:	40 kg/m <sup>2</sup>
False ceiling	:	60 kg/m <sup>2</sup>
Heavy duty tar felting	:	30 kg/m <sup>2</sup>

## 3.2 EQUIPMENT LOADS

### • EQUIPMENT CATEGORY I

The weight of equipment category I such as pumps, compressors, motors etc., shall be derived as far as possible from Manufacturer's data and shall include controls, auxiliary machinery, piping etc. The equipment load shall be categorized if required for use in various loading combinations as empty and operating.

### • EQUIPMENT CATEGORY II

This category consists of loads from equipments such as vessels, columns, heat exchangers, condensers, settlers, filters and the like, complete with their piping. In accordance with the various load combinations for the category of equipment, the following weights/loads shall be included in the calculations.

#### a) EMPTY WEIGHT (EL<sub>e</sub>)



This is the dead weight of vessels, columns, etc. completely installed) including platforms and ladders, piping, insulation and fireproofing) and ready for operation, however, without liquid filling. Weights will be derived from manufacturer's data.

#### b) OPERATING LOAD (EL<sub>o</sub>)

This is the empty weight plus the maximum weight of contents of vessels, columns, etc. during normal operation of the plant, Weight of pipes full of product (liquid/gases) plus the weight of insulation and anchor loads if any.

#### c) HYDROSTATIC TEST LOAD (EL<sub>t</sub>)

When Hydrostatic pressure testing of equipment is required at site and is done after installation, the weight of equipment, completely filled with water shall be incorporated in the design of the supporting structure. Only one biggest system shall be considered to be tested at a given time.

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></p><p><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></p></div>	PC288/E/001/P-II/5.5	P	<div><p>बी एच ई लि. <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 71 of 242		

The empty / operating / test weight of process equipment including contents and all fixtures, platforms, ladders and attached piping etc, shall be considered. If piping weight is not indicated separately or not included in the weight of the equipment, the same shall be taken as 10% of the weight of the equipment.

### 3.2.1 Exchangers / Fabricated equipments

When exchangers are supported on structures, the supports shall be designed for vertical and horizontal forces (bundle pulling force or friction forces). The vertical loads shall be categorized into empty weight, operating weight and test weight. Weight distribution over two (2) saddles of an exchanger shall normally be as follows:

Exchanger Type	Channel Side	Shell Side
Floating head type	60%	40%
Fixed tube sheet type	50%	50%
Kettle type	45%	55%
U-tube and other type	67%	33%

#### 3.2.1.1 Special Considerations

##### a. Bundle Pull



Bundle pull forces for different types of exchangers shall be taken as under :-

Fixed type	-	Nil
Kettle type	-	0.30 x Bundle weight
All other types	-	0.86 x Bundle weight or 30 N/mm of diameter whichever is greater.

Total Bundles Pull shall be considered on fixed pedestal alone

##### b. Thermal Expansion

Horizontal force due to thermal expansion of horizontal vessels / exchangers shall be relieved by using slotted holes and slide plates and remaining force derived from the product of the sliding saddle 'gravity load' and the coefficient

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		Document No.	Rev	
		Sheet 72 of 242		

of friction shall be applied to each support. The coefficient of friction shall be as under:

a. Teflon to Teflon	:	0.08
b. stainless steel to Teflon	:	0.10
c. steel to steel	:	0.30
d. steel to concrete	:	0.45

#### c. Non-Static Loading



Foundations and structures supporting vessels subject to surge loading, such as De-aerators shall be designed with sufficient stiffness and rigidity to resist a notional horizontal forces of 10% of those derived from the Vessel's operating weight or the given surge load whichever is the greater. The forces shall be applied at the vessel's centre of gravity and act longitudinally OR transversely. Consideration shall be given to bracing these structures.

The design of foundations and structures supporting agitated vessels, centrifuges, reactors and other variable load equipment shall take full account of all the loading data provided by the equipment vendors. Where no loads are available, consideration shall be given to applying force at 10% of operating weight. In addition, for dynamic effect loads will be increased by 50% of steam agitated equipment and 25% for mechanical agitated vessels.

Where two or more similar items of such equipment are supported on a common foundation or structure, the design must be based on the assumption that these items will resonate in phase.

### 3.3.2 Rotating Equipment

Comprehensive loading data of mechanical equipment, such as, fans, blowers, pumps, compressors, D.G. Sets, turbines, motors engines etc., as furnished by the equipment vendor shall be considered.

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		Document No.	Rev	
		Sheet 73 of 242		

### 3.3 LIVE LOADS (LL)

Live loads shall, in general, be as per IS: 875. However, the following minimum live loads shall be considered in the design of structures to account for maintenance and erection phases; if equipment layout / vendor drawings indicate loads of greater magnitude, the same shall be adopted.

i. Process Building / Technological Structure (Open / Enclosed type)

Operating area	-	5.0 kN/m <sup>2</sup>
Maintenance area	-	7.5 kN/m <sup>2</sup>
Ground floor	-	10.0 kN/m <sup>2</sup>

ii. Compressor House/TG House

Operating area	-	10.0 kN/m <sup>2</sup>
Maintenance area	-	10.0 kN/m <sup>2</sup>
Ground floor	-	10.0 kN/m <sup>2</sup>

iii. Service Platform



Vessel / Tower	-	3.0 kN/m <sup>2</sup>
Isolated platform	-	2.5 kN/m <sup>2</sup>
(For valve operation)		
Access way	-	2.5 kN/m <sup>2</sup>
Cross over	-	2.0 kN/m <sup>2</sup>
Piperack walkways	-	2.5 kN/m <sup>2</sup>
Gantry girder walkway	-	3.0 kN/m <sup>2</sup>

iv. Substation / Control Room

Panel floor	-	10.0 kN/m <sup>2</sup>
Miscellaneous partition	-	1.0 kN/m <sup>2</sup>
Other areas	-	5.0 kN/m <sup>2</sup>

v. Office building

Office area	-	3.0 kN/m <sup>2</sup>
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		Document No.	Rev	
		Sheet 74 of 242		

	Entrance lobby	-	5.0 kN/m <sup>2</sup>
	Exit way	-	5.0 kN/m <sup>2</sup>
	Miscellaneous partition	-	1.0 kN/m <sup>2</sup>
	Document Storage area	-	10.0 kN/m <sup>2</sup>
vi.	Laboratory		
	Upper floors	-	4.0 kN/m <sup>2</sup>
	Ground floor	-	5.0 kN/m <sup>2</sup>
vii.	Cooling Tower		
	Operating platform /cover	-	3.0 kN/m <sup>2</sup>
	Slab of hot water basin & Sump		
viii.	GT Building / DM Plant /ETP		
	Operating platforms	-	3.0 kN/m <sup>2</sup>
	Ground floor	-	5.0 kN/m <sup>2</sup>
ix.	Staircase		
	Process Building	-	5.0 kN/m <sup>2</sup>
	Technological structure	-	5.0 kN/m <sup>2</sup>
	Office	-	5.0 kN/m <sup>2</sup>
	Substation/Control Room	-	3.0 kN/m <sup>2</sup>
	Laboratory	-	4.0 kN/m <sup>2</sup>
	Service platform	-	2.5 kN/m <sup>2</sup>

Loads on account of equipment and incidental loads shall be taken over and above the loads indicated in the table.

For all other buildings not covered in above Table as well as roofs of various structures, the imposed loads shall be taken as specified in IS: 875 (Part II)



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 75 of 242		

1 KN/m<sup>2</sup> allowance shall be made for services supported from below the floor.

Live load on various types of roofs shall be as per the requirements given in IS: 875.

### 3.4 WIND LOADS (WL)

Wind loads shall generally be as per IS-875 (Part-3) except for switchyard structures and transmission towers for which IS: 802 shall be applicable. Basic wind speed shall be as per the Code. As per IS:875 (Part-3), definition of basic wind speed shall be peak gust velocity averaged over 3 second time interval at 10 m height above mean ground level with 50 years mean return period . The design life span of all structures, except temporary structures, and boundary wall shall be taken as per IS 875. Life span of temporary structures and boundary wall can be lesser and shall be as per IS: 875.

Design wind speed and pressure shall be worked as per the latest revision of IS 875 Part-3.

To account for surface area of piping, platforms and other attachments fixed to the equipment, the surface area of the equipment (vessel/column) exposed to wind shall be increased by 20% or as specified in the mechanical data sheets of the equipment.



Wind force on structural elements shall be calculated using design wind pressure multiplied by elements frontal area, normal to wind direction multiplied by force coefficient as per Table 29, IS 875 Part-3.

In calculation of wind force frictional drag shall be considered where applicable.

### 3.5 SEISMIC LOADS(SL)

Seismic loads shall be as per IS: 1893 (latest version).

### 3.6 IMPACT AND VIBRATORY LOADS

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></p><p><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></p></div>	PC288/E/001/P-II/5.5	P	<div><p>भारत कोयला गैसीकरण और रासायनिक उद्योग लि. <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 76 of 242		

Structures subjected to impact or vibratory loads shall be designed as per the provision of IS: 875 & IS: 2974. Requirements for monorails and overhead cranes shall be as per IS: 800, IS: 875 or manufacturer's data, whichever is more stringent.

### 3.7 BLAST FORCES

Blast resistant Control Room or any other specified structure, subjected to blast forces generated due to accidental blast from hydrocarbon ignitions should be designed to withstand all such forces. Unless specifically mentioned by the process licensor, design blast loads and blast resistant construction shall be as specified below and shall conform to relevant IS codes and good engineering practices.

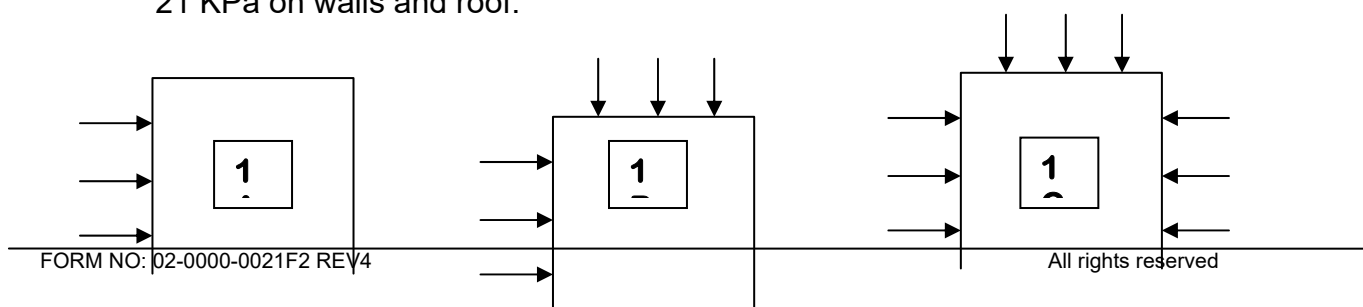
Buildings located within 30 m from a potential blast source, shall be designed to withstand the maximum combination of loads resulting from any one of the following:

- 1) Blast pressure equivalent to static pressure 21KPa acting on all exterior surfaces.
- 2) Suction blast pressure equivalent to static pressure 7 KPa acting on all extreme surfaces.

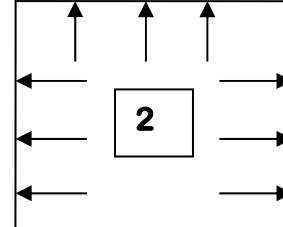
Design of blast resistant control building shall be according to the following minimum blast-loading conditions:

Condition 1:

Any of the following combinations:  
1A, 1B, 1C whichever is the most critical  
21 KPa on walls and roof.



Condition 2:  
7KPa on interior wall and roof surfaces.



Control buildings located more than 30 m from a blast source shall be designed to resist maximum combination of loads in accordance with the following table :

#### Distance versus Design Pressure



Distance from Process Equipment (meter)	Blast Pressure (KPa)	Suction Blast Pressure (KPa)	Wind Velocity Pressure (KPa)
30 to 45	21	7	4
45 to 60	10	3	2
60 to 75	7	2	1
75 to 150	3	1	*
Over 150	*	*	*

#### Structural Design Criteria

- Design the structure as a shear wall structure with the roof acting as a horizontal diaphragm that transfers the transverse loads to the side shear walls. External shear walls shall be continued up to 1.5 m below GL or up to founding level whichever is less.
- Design of walls and roof shall be based on the “Yield Line Theory”.
- Provide cast-in-situ reinforced concrete walls and roof of load-bearing type, designed to resist bending and transmit horizontal shear. Precast concrete panels may be used but shall be either mechanically bonded to cast-in-situ reinforced concrete columns or provided with built-in load transmitting steel plates or angles so that the panels can be welded in place.
- Anchor walls to foundations and concrete roof slabs with steel reinforcing bars to provide full moment connections.

Provide roof framing with adequate bearing and good anchorage to the supporting walls. Weld roof form decking if used to the top member of the roof frame.

- Distribute loads on roofs and walls in two directions where possible.

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		Document No.	Rev	
		Sheet 78 of 242		

- Consider stress reversals at each member and provide a minimum 20% stress reversal.
- Design reinforced concrete members with good ductile properties. Limit tension steel to 1% of the concrete area and 2% of the concrete area for tension plus compression steel. To allow for stress reversal provides reinforcing steel in both concrete faces and set shear bars perpendicular, not inclined.
- Provide local strengthening of concrete at opening by additional reinforcing without local thickening where possible.

#### **Load combinations with blast loads**

- For Flexure  
1.0(Dead load + Blast load)
- For shear  
1.2 (Dead load + Blast load)

Live load shall not be considered on the roof during blast.

#### **Soil Bearing Capacity**

Design bearing pressure shall be taken as equal to twice the allowable static bearing pressure for load combinations with blast load.



#### **Stability Ratio**

Factor of Safety in case of load combinations with blast load shall be as follows:

Overturning	-	1.2
Sliding	-	1.3

#### **Openings:**

- Minimize openings in the building enclosure and locate openings to avoid or be shielded from direct blast pressures.
- Windows, if unavoidable shall be limited in size and provided with special glazing.
- Select external doors, louvers and similar items, together with their frames, capable of withstanding the pressures. Do not use glass panels in these doors. Provide for personnel at least for two access doors, located remote from each other and where possible not in opposite walls. The size of equipment doors for maneuvering factory-fabricated control boards into or out of the control room.

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		Document No.	Rev	
		Sheet 79 of 242		

### 3.8 CONTINGENCY LOADS

#### 3.8.1 RCC Structures

All floor slabs and beams shall be designed for a concentrated load of 10 KN acting simultaneously with the uniform live load, but not with actual concentrated loads from equipment, piping etc. This load shall be placed to result in maximum moment and / or maximum shear.

This load shall not be considered for the design of columns, foundations and in overall frame analysis. For floor slabs, the load shall be considered to be distributed over an area of 0.75 m x 0.75 m.

#### 3.8.2 Structural Steel

For process plants, the following contingency additional loading shall be applied to individual beam elements, these shall be applied as point loads to produce worst shear and bending stresses:

Platform Walkways	3 KN
Secondary Floor Trimmers	5 KN
Primary / Grid beams	10 KN

### 3.9 MISCELLANEOUS LOADS

Apart from the specified live loads, possible overloading during construction / hydro-test maintenance / erection shall also be considered in the design Job specifications shall also be referred to, for any specific loading.

Hydrostatic pressure shall be adequately accounted for, in the design of structures, below ground water table.

All the handrails, parapets, parapet walls, balustrades shall be designed for horizontal load mentioned in Table 3 of IS-875 (Part-2).

### 3.10 LOAD COMBINATIONS

Structural analysis and design shall take into consideration, worst combination of the above loads under different phases, such as, Erection, Operation, Hydro-test, Shutdown, Maintenance, and Blast for control room, as applicable.

The design shall be governed by worst load combinations as per the procedures of relevant BIS codes.

## 4.0 DESIGN CRITERIA FOR FOUNDATIONS

### 4.1 GENERAL

Foundation sizing shall be based on working loads, not on loads which may have been increased by factors for the purpose of concrete design.

### 4.2 TYPE OF FOUNDATIONS

Type of foundations to be adopted and the pertinent details there of shall be as per provisions of scope and job specifications documents.

Following clauses describe the general guidelines to be followed while designing the foundations; these clauses do not per se stipulate the type of foundations to be followed.

### 4.3 SHALLOW FOUNDATIONS

4.3.1 For gravity loading, allowable net bearing capacity of soil shall be based on the following settlement criteria:

Foundation Type	Allowable Settlement(mm)
Foundations in unit areas, utility areas and Foundations for plant buildings including substation, Compressor house, control room, technological structures	25
Machine foundations and critical equipment with interconnected piping	25

Foundations supporting non-plant buildings	40
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- 4.3.2 For transient loadings, such as wind / seismic, allowable net bearing capacity based on shear criteria may be considered.
- 4.3.3 For load combinations including wind, the Safe Soil Bearing Pressure may be increased by 25%.
- 4.3.4 For load combinations including earthquake, the Safe Bearing Pressure of Soil may be increased as permitted in IS: 1893.
- 4.3.5 Under blast (due to hydrocarbon explosion) load combinations if any, the design bearing pressure of soil shall not exceed twice the allowable static bearing pressure of soil.
- 4.3.6 Allowable Loss of contact area between underside of foundation and soil (due to resultant Overturning Moment) under different loading conditions shall be as given below.

	Load Combination description	Allowable % Loss of Contact Area
A	Operating Load case ( Plant operating, with or without Live Loads, for worst cases)	0 % to 10%
	Operating Load Case with Wind or Earthquake (with or without Live Loads, for worst cases)	up to 25%
B	Operating Load case (Plant operating, with or without Live Loads, for worst cases)	0 % to 20%
	Operating Load Case with Wind or Earthquake (with or without Live Loads, for worst cases)	up to 30%

Where

A = Foundations on Soil

B = Foundations on Rock

#### 4.3.7 Soil and hydrostatic pressure on walls below grade.

In the design of walls below grade, provision shall be made for the lateral pressure of adjacent soil. Due allowance shall be made for possible surcharge from fixed or moving loads. When a portion or whole of the adjacent soil is below a free water surface, computations shall be based on the weight of the soil, diminished by buoyancy, plus full hydrostatic lateral pressure.

The lateral pressure from surcharge loads shall be taken in addition the lateral earth pressure loads.

#### 4.3.8 Stability of foundations



Foundations shall be checked for stability against overturning, sliding & uplift.

While checking against uplift, the following shall be considered.

#### FOUNDATION DESIGN – FACTORS OF SAFETY

Type of Structures	Minimum factor of safety against overturning		Minimum factor of safety against Sliding		% Weight of Overburden over projected plan area of footing
	With wind or seismic	Without wind or seismic	With wind or seismic	Without wind or seismic	
All Buildings/ Structures / Eqpt. In Units	1.5	2.0	1.5	1.5	100
Pipe Rack (Offsite)	1.5	2.0	1.5	1.5	50
Flood Light Mast	1.5	-	1.5	1.5	50**
Retaining Wall	1.5	2.0	1.5	1.75	100
Over Head water tank	1.5(empty) 2.0(full)	-	1.5	-	50**
Blast Resistant Structures	1.5	2.0	1.5	1.5	100



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		Document No.	Rev	
		Sheet 83 of 242		

Flare supporting Structures	1.5	-	1.5	-	50**
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\*\* In case area is paved, overburden shall be based on NGL (for area under filling) or 600 mm below HPP, whichever is lower. In case of unpaved area, it shall be w.r.t. FGL.

Minimum factor of safety against uplift shall be 1.2 for all structure. (Note: In case of sumps, lining weight shall not be included). Beneficial load of backfill can be included on in circumstances where it will never be removed.

Buoyancy from high ground water levels shall be taken into account in investigating stability against uplift.



#### 4.4 PILED FOUNDATIONS

Piles shall be designed as per IS: 2911. However, pile capacity shall be proven by a sufficient number of initial load tests before preparing piling plans.

The increase in Safe Working Load permitted as per codal provisions, under load combinations including wind / earthquake shall apply equally to uplift and sheer conditions, subject to confirmations by the piling Contractor with respect to the particular piling system. Pile capacity may be similarly increased in blast condition to 1.5 times the permissible capacity under compression, tension and shear modes.

When any major machinery is to be supported on piles, behavior of the piles under dynamic, loading conditions, as established by necessary field test, shall be considered.

The capacity of pile groups shall be obtained by applying appropriate group efficiency factors. Where piles pass through filed ground, the available pile safe working load shall be suitably reduced to account for negative skin friction caused by settlement of fill. Where suitable, consideration shall be given to reducing drawdown effects by slip coating the piles

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 84 of 242		

While computing horizontal capacity, piles shall be treated as fixed head or free head depending on the degree of fixity at the top.

#### 4.5 MACHINE/EQUIPMENT FOUNDATIONS:



Machine / Mechanical equipment foundations shall satisfy the requirements of IS: 2974 and any other parameters as per machine vendors.

Generally, foundations and structures supporting rotating machinery shall be so proportioned that their natural frequency shall not fall within the range of 0.8 to 1.2 of normal operating speed of the equipment. Further for major rotating machinery such as main compressor, the amplitude of foundation of structure during normal operation shall not exceed the allowable amplitude specified by the equipment manufacturer. The above consideration may be omitted for centrifugal pumps and fans and other minor rotating equipment weighing less than 1 ton or if the mass of the rotating parts are less than  $1/100^{\text{th}}$  of the mass of foundation installed directly on concrete provided that the weight of foundation is not less than 3 times of the equipment weight. In such cases, dynamic analysis is not necessary.

When dynamic analysis is called for, the combined centre of gravity of the machine and foundation system shall, as far as possible, pass through the centre of area of the foundation raft or centroid of the pile group. Wherever unavoidable, eccentricity shall be less than 5% for block foundations and 3% for frame foundations. However, in highly compressible soils, no eccentricity shall be permitted.

Foundations shall be so designed that natural frequency of the foundation system shall not resonate with the following:

- Operating speed of the motor / turbine
- Operating speed of the machine
- 2 x Operating speed of the machine
- Critical speed of the machine (for centrifugal machines)

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 85 of 242		

It shall be ensured that there is no transfer of vibrations from machine foundations to any part of the adjoining structures. In case such machines are sitting on building floors, approved damping pads shall be used with prior approval of the Owner / Consultant.

Where deviations (resulting from inaccuracies in soil parameter measurements, approximations in design method, etc.) from calculated natural frequencies, leading to amplitudes in excess of specified limits are foreseen, provision for increasing the foundation mass without removal of the machine and without affecting surrounding space availability or connected piping shall be made, if possible.

#### 4.6 CONCRETE GRADE



Grade of concrete to be used in foundation shall in general be as per the philosophy adopted for the entire structure. Minimum cement content, type of cement and any remedial actions, if required for foundations due to aggressiveness of subsoil water, shall be as stated elsewhere in this document. For underground structures, such as, foundations, manholes M30 grade reinforced concrete shall be used.

#### 4.5 FOUNDATION BOLTS

All holding down bolts or threaded rods for non-post tensioned applications shall be out of Mild Carbon steel conforming to IS: 2062 with  $F_y = 250$  MPa unless Noted Otherwise. For scrubbing section and acid storage section, holding down bolts should conform to SS 316.

##### 4.7.1 Minimum cover to Foundation Bolts

Minimum distance between a Standard Holding down Bolt or Anchor Sleeve and the face of Foundation/pedestal shall not be less than  $6 \times (\text{dia of bolt})$  mm.

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></p><p><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></p></div>	PC288/E/001/P-II/5.5	P	<div><p>भारत कोयला गैसिफिकेशन लिमिटेड <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 86 of 242		

4.7.2 All equipment foundation bolts / templates shall be designed and supplied by equipment vendor. Foundation bolts for steel structures shall be designed and supplied by contractor as per standard drawings or approved equivalent.

#### 4.7.3 Other Inserted And Embedded Items

Unless otherwise specified, all structural steel shall be weldable structural steel “Standard Quality” (Fe 410 WA), in accordance with code IS: 2062.

All embedded steel items (exposed to atmosphere) shall be hot-dip galvanized in accordance with IS: 2629, except if noted otherwise on the design drawings.

All inserted and embedded items shall be accurately placed or template in and be securely anchored prior to placing concrete.

At sliding ends of vessels and horizontal exchangers, sets of plain steel plates shall be provided. In order to reduce the horizontal force due to friction at sliding ends sets to PTFE bonded steel plates may be provided.

## 4.8 PEDESTAL HEIGHTS

Pedestals for structural columns : As per design requirement

Open paved area : 300 mm (min.) OR as indicated in Equipment  
Layout drawing

Open unpaved area : 300 mm

Covered area(building etc.) : 300 mm (min.) OR as indicated in drawing

Storage tank foundation : As per equipment layout



All equipment supporting foundations / pedestals

Open area : As required but not less than 300 mm

Covered area : As required but not less than 150 mm

Stair Pedestals : 300 mm (min.) OR as indicated in equipment  
Layout drawing.

Ladder pedestals : 300 mm

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 87 of 242		

## 4.9 GROUTING

The minimum thickness of grout shall be 25 mm.



All anchor bolts sleeves / pockets and spaces under column bases, shoe plates etc. shall be grouted with free flow, non shrink (premix type) grout, with 28 days minimum cube crushing strength of 40 N/mm<sup>2</sup>. Ordinary grout consisting of 1 part of OPC and 2 parts of clean, dry well graded sand mixed with water to obtain the required consistency shall only be used under the base plates of cross-overs, short pipe supports (not exceeding 1.5 m height) and small operating platforms (not exceeding 2 m height) not supporting any equipment.

For rotating equipment bases, (above 300 kw rating), grout shall be as per requirements of equipment vendor, as per the approved list / as per the decision of EIC.

## 5.0 DESIGN CRITERIA FOR REINFORCED CONCRETE STRUCTURES

### 5.1 GENERAL

- All buildings, structures, foundations, machine equipment foundations, liquid retaining storage structures, trenches, pits etc. shall be of RCC and designed based on the following IS codes (latest revision with all amendments, issued there to) in general, and other relevant IS codes applicable : IS:456, 875, 1893, 1904, 2911, 2950, 2974, 3370, 4326, 4991, 4998, 5249, 6403, 8009, 13920.
- Only limit state method as per IS: 456 shall be followed for the design unless otherwise specified elsewhere in this document for special structures.
- All skeletal structures shall be of frame type construction, and detailing shall be as per provision of IS: 13920.
- Where the specified design depth of groundwater table so warrants, all underground pits, tunnels, basements, etc. shall be leak-proof R.C.C. construction using water proofing compounds.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 बी एच ई लिमिटेड <b>BHEL</b>
		Document No.	Rev	
		Sheet 88 of 242		

## 5.2 LIQUID RETAINING R.C.C. STRUCTURES AND BASEMENTS

- 5.2.1 All liquid retaining / storage R.C.C. structures shall be leakproof and designed as uncracked section in working stress method as per IS:3370. However, the parts of such structures not coming in contact with the liquid, shall be designed according to IS:456 except ribs of beams of suspended floor slabs and counterforts of walls (located on the side remote from liquid) and roof of liquid retaining structures which shall be designed as uncracked section. Hot/cold water basin, and other primary framing members of Cooling Towers and similar liquid retaining structures, which remain constantly in contact with water (stored / sprayed) shall be designed as uncracked sections. No increase in permissible stresses in concrete and reinforcement shall be made under wind or seismic conditions for such structures.
- 5.2.2 All liquid retaining / storage structures shall be designed assuming liquid up to the full height of wall, irrespective of provision of any overflow arrangement. Pressure relief valves or similar pressure relieving devices shall not be considered in underground water retaining RCC structures. Hot water basin in cooling tower shall be designed for the weight of water up to top of parapet wall.
- 5.2.3 Following conditions shall be also considered for design of liquid retaining structures, basement, trenches and other underground structure:-
- Only water pressure from inside and no earth pressure, groundwater pressure or surcharge from outside wherever such a condition is likely to exist either in operation or during installation / testing.
  - Earth pressure, surcharge pressure or ground water pressure from outside and no water pressure from inside.
  - Base slab shall also be designed for the empty condition during construction and maintenance stages with maximum ground water table. Pressure Relief Valves shall not be used.
  - Intermediate dividing walls of pump sumps shall be designed considering water in one pump only and the other sump being empty for maintenance.

5.2.4 The walls and base slabs of liquid retaining storage structures shall be provided with reinforcement on both faces for thicknesses greater than 150 mm.

5.2.5 In all liquid retaining structures, PVC water bars (230 mm wide, 6 mm thick) shall be provided at each construction joint. PVC water bars shall be of minimum 150/230 mm width and 6 mm thickness, and generally shall be rified/serrated type with a central bulb Kicker type PVC water bars shall be used for the base slab and in other areas where it is required to facilitate concreting. Material quality of PVC water stops shall confirm to IS 12200.

### 5.3 CONCRETE GRADE



All cast-in-situ structural concrete shall be Reinforced Concrete conforming to IS: 456. Minimum grade M30 shall be used for all sub-structures (foundations/ Pile foundations etc) except for grade slabs / paving for which M20 may be used. M25 grade shall be used for all super-structures. For compressor, M30 grade concrete shall be used.

Pre-cast concrete shall be of minimum grade M35.

From durability consideration the minimum cement content and maximum water-cement ratio shall be as follows:-

Type of Cement	Plain concrete		Reinforced concrete		Remarks Exposure Condition
	Minimum cement content (kg/m <sup>3</sup> )	Maximum water- cement ratio	Minimum cement content (kg/m <sup>3</sup> )	Maximum water- cement ratio	
43 Grade-OPC	240	0.55	shall be as specified in IS 456	0.45	Moderate (or as per IS Code)
53 Grade-OPC	240	0.55		0.45	Moderate (or as per IS Code)
PPC	240	0.55		0.45	Moderate (or as per IS Code)

Maximum cement content shall not exceed 450 kg/m<sup>3</sup>.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 90 of 242		

If soil investigation report recommends high cement content and / or specified type of cement, the same shall have precedence.

75 mm thick PCC of grade M15 (nominal mix) shall be provided under all RCC foundations except under base slab of liquid retaining structures where 100 mm thick concrete of mix M15 (nominal mix) shall be used.

Concrete for encasing shall be M20 with 10 mm down aggregate.

Plain cement concrete (PCC) of grade M15 (nominal mix) of minimum 150 mm thickness shall be provided under all masonry wall foundations.

Plain cement concrete of grade M20 of minimum 40 mm thickness shall be provided as damp proof course, at plinth level of all masonry walls and to be coated with 3 mm thick bitumen emulsion.

Lean concrete of grade 1:5:10 shall be used as filler material wherever loose sub-grade exists by removing the loose soil/fill.

Any specific requirement regarding grade and thickness of PCC to be provided shall be incorporated in the drawing.

#### 5.4 REINFORCEMENT BARS



HYSD Fe500 corrosion resistant bars confirming to IS: 1786 shall be used in foundations, piles and pile caps and super structures. The Minimum dia. used shall be 8mm. All structural steel and reinforcements shall be procured from SAIL / TISCO /RINL or Owner's approved Vendor List.

Binding wire of 16 Gauge GI shall be used for tying the reinforcement conforming to IS: 280 unless specifically mentioned herein or in engineering drawings or other engineering design basis prepared for the individual units/structures.

#### 5.5 MINIMUM THICKNESS OF STRUCTURAL CONCRETE ELEMENTS

For structural concrete elements, the following minimum thickness shall be followed:-



<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></div> <div><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></div> <div><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></div>	PC288/E/001/P-II/5.5	P	<div><p>बी एच ई लि. <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 91 of 242		

Footings (All types with or without beams) Note: Tapered footings shall not have thickness less than 150 mm at the edges. Minimum average thickness shall not be less than 300 mm	300 mm
Pile Cap	500 mm
Basement walls	150 mm
Basement slab with beams / without beams	200/300 mm
Slab thickness in raft foundations with beam & slab construction	150 mm
Floor / roof slab, walkway, canopy slab	150 mm
Cable / Pipe Trench, Launder Walls & Base Slab	125 mm
Parapet	100 mm
Louvre/Fin (not in contact with liquid)	100 mm
Louvre (in contact with liquid)	100 mm
Precast Trench Cover / Precast Floor Slab	125 mm
Liquid retaining / Leak proof structures, Underground Pits	
Walls	150 mm
Base slab with beams	200 mm
Base slab without beams	300 mm

## 5.6 MINIMUM COVER TO REINFORCEMENT

The following minimum clear cover shall be provided to all steel reinforcement including links.

<b>Slab (roof &amp; floors, canopy, cantilever, waist slab)</b>	30 mm
<b>Beam (roof, floor tie, &amp; lintel)</b>	30 mm or dia. of bar whichever is greater
<b>Column, Pedestal</b>	40 mm above FGL, 50 mm below FGL
<b>Retaining wall, Basement and Pit Wall</b>	
a. Face in contact with earth	50 mm
b. Free face	30 mm or dia.of bar whichever is greater
<b>Liquid retaining structure</b>	
a. Face in contact with liquid	30 mm or dia.of bar whichever is greater

b. Face away from liquid but in contact with earth	50 mm
c. Free face	30 mm or dia.of bar whichever is greater
<b>Foundation slab, base slab, plinth beam</b>	50 mm
<b>Pile Cap</b>	
a. Bottom face	100 mm
b. Top face	50 mm

## 5.7 EXPANSION JOINTS

Expansion points in concrete structures shall be provided at 30-35 m centers. The expansion joint shall be provided preferably by way of twin columns on a common foundation. Sliding joints shall be avoided as far as possible.

## 5.8 DEFLECTIONS



5.8.1 Deflections in concrete structures shall in general be limited by adherence to the limits on span by depth ratio for beams and slabs and length to lateral dimension ratios for columns as prescribed in IS: 456. Where special functional / serviceability requirements or large spans demand actual deflections and / or crack widths shall be calculated and the following limits adhered to:

Total vertical deflection due to all loads including the	Span/250
Effects of temperature creep and shrinkage	
Crack width (for non-liquid retaining structure)	0.3 mm
Crack width (for liquid retaining structure)	As per design requirement
Total horizontal deflection between two floors	Storey height/200

## 5.9 MISCELLANEOUS APPLICATIONS

### 5.10.1 Admixtures

Admixtures shall conform to IS: 9103 and to be mixed with concrete (if required) strictly as per manufacturer's recommendations.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसीकरण और रासायनिक उद्योग <b>BHEL</b>
		Document No.	Rev	
		Sheet 93 of 242		

### 5.10.2 Water for Construction

Water used for mixing and curing shall be clean and free from injurious amounts of soils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. Portable water is generally considered satisfactory for mixing concrete. It should meet the requirement of IS: 456-2000.

### 5.10.3 Aggregates

These shall conform to IS: 383, specification for Coarse and Fine Aggregates from Natural resources.

### 5.10.4 Plinth protection

Each building shall be provided with 1.0 m wide concrete M10, 100 thick laid on 75 mm thick M7.5 concrete with 8 Tor @ 250 c/c both ways Reinforcement bars all round as plinth protection. A surface drain to be provided along-with plinth protection which shall be connected to the drainage system.

### 5.10.5 Ramps



Ramps for building entrance shall be cast in situ R.C.C. designed as a grade slab and the slope of ramps shall not be less than 1 in 10. Minimum thickness of the slab shall be 150 mm.

### 5.10.6 Hot Bitumen Paint

All underground structures including top surface of foundations shall be painted with two coats of hot bitumen paint of grade 20/30 with quantity of bitumen at least 1.2 kg/m<sup>2</sup> per coat.

### 5.10.7 Masonry Wall

- a. All masonry walls from ground floor shall be placed on R.C.C. grade beams. However, light internal partitions may be placed on ground floor slab.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 बी एच ई लि. <b>BHEL</b>
		Document No.	Rev	
		Sheet 94 of 242		

- b. All brick masonry (M 7.5 MPa) grade walls shall be considered as 230 mm thick, except for partition walls which will be 115 mm thick. However, for fire barrier walls minimum thickness shall be considered as 350 mm.

However, if there is scarcity of common burnt clay bricks availability, Bricks shall be of non modular fly ash bricks conforming to IS: 12894, class designation 10 average compressive strength.

- c. All in-filled brick panels shall be designed to transfer horizontal loads from wind and seismic to the structural frameworks without damage and the extent of brick panel dimensions shall be as per the recommendations in IS. All brickworks shall be provided with reinforcement consisting of 2 Nos. of 6 mm diameter bars at every fourth layer.



#### 5.10.8 Anti-termite treatment

Anti-termite treatment shall be provided under all buildings as per IS:6313. Materials shall be as per IS: 8944.

#### 5.10.9 Building Slabs on Grade

The specifications given in Table below are based on minimum requirements and shall be followed after proper design and requirement.

Sl. No.	DESCRIPTION		FLOORING TYPE		
			I	II	III
1.a	Sub Grade	Earth fill base compacted to 95% dry density	Yes	Yes	Yes
1.b		Rubble soling	230 Thick	230 Thick	150 Thick
2.a	Structural Grade Slab	Lean concrete 1:5:10 over 1.b layer	50 Thick	50 Thick	50 Thick
2.b		Stable in Grade M20 concrete (Reinforced with 8 mm dia bars @ 200 c/c	150 Thick	150 Thick	100 Thick
			R/F placed centrally	R/F placed in two layers	No reinforcement

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		Document No.	Rev	
		Sheet 95 of 242		

		both ways) over lean concrete		at top & bottom	nt required
3	Finish	Floor finish	As/Architectural detail	As/Architectural detail	As/Architectural detail

TYPE I: Plant buildings such as Sub-stations, Control Rooms, Process Operators' Room, Pump Houses, Utility Compressor Houses, D.M. Plant, E.T.P., Parking Areas, Stores, Porches.

TYPE-II: Warehouses, Workshops, Cement Godowns, Fire Stations, Process Compressor House.

TYPE III: Non Plant Buildings (viz. Administration, Laboratory, Canteen, Time Office, Gate House, Training Centre, Guest House, Residential Building)

Note: 1. Reinforcement steel shall be as per clause 5.5

#### 5.10.10 Insulation

For equipment with temperatures over 200° C, or sub zero temperatures, insulation shall be provided between equipment base / lugs and concrete / steel structure.

## 6.0 DESIGN CRITERIA FOR STEEL STRUCTURES



### 6.1 GENERAL / DESIGN METHODS

6.1.1 Design fabrication and erection of the above work shall be carried out in accordance with the following IS Codes as applicable to the specific structures, viz, IS: 800, 801, 802, 806, 814, 816, 875, 1893, 6533, 9595, etc.

Structure and its elements shall normally, be designed by the limit state method.

Where the limit states method cannot be conveniently adopted, the working stress design may be used.



Basic consideration of structural frame work shall primarily be stability, ease of fabrication/erection and overall economy, satisfying relevant Indian Standard Codes of Practice. Steel structures adequately braced in vertical and horizontal planes, consistent with functional requirements, shall be preferred over structure

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 बी एच ई लिमिटेड <b>BHEL</b>
		Document No.	Rev	
		Sheet 96 of 242		

having moment connections. Moment connections, if adopted, shall be fully rigid as per IS:800. Where fully rigid joints are adopted they shall generally be confined to the major axis of the column member. Flare stack supporting structure shall be adequately braced on all four faces.

Structural elements, continuously exposed to temperatures above 200° C, shall be designed for reduced stress as per Table-4 of IS: 6533 (Part-2). The expected temperature of steel components shall not be allowed to exceed 400 ° C. The structures connected to column, heater vessels working at high temperatures shall not be rigidly connected with staircase and adjoining structures, which are on ambient temperatures.

- 6.1.2 Crane gantry girders shall generally be of welded construction and of single span length. Chequered plate shall be used for gantry girder walkway flooring.
- 6.1.3 Monorails shall be provided for all pumps and motors located in buildings, sheds and in open areas having rating more than 55 KW. For pumps and motors of smaller ratings, monorails shall be provided if directed by Owner / PMC.
- 6.1.4 Steel staircases shall have channels provided as stringers with minimum clear width of 750 mm and maximum slope of 41 degree. The vertical height between successive landings shall not exceed 4.0 meters. Treads shall be minimum 230 mm wide made of grating (with curved chequered plate nosing) spaced equally so as to restrict the rise to maximum 200 mm. If relevant local by-laws or applicable Factory Act Rules stipulates more stringent requirements in this regard, the same shall be adhered to.
- 6.1.5 Hand rails, 1000 mm high, shall be provided to all walkways, platforms, staircases. Toe plate (100 mm x 5 mm) shall be provided for all hand railing (except for staircases). Spacing of uprights shall be 1500 mm (maximum). Two types of hand railing shall be provided.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 97 of 242		

- a. For walkways, platforms (except platform around/on circular & horizontal vessels), and staircases: Top rail, mid rail and upright shall be 32 mm dia. (NB) galvanized MS tubes.
- b. For platforms around circular vessels : Top rail shall be 32 mm dia. (NB) galvanized MS tubes, but mid rail and upright shall be of structural steel.

6.1.6 Electro-forged/Welded hot dip galvanized MS gratings shall be minimum 25 mm deep. The maximum size of voids in the grating shall be limited to 30 mm x 55 mm. The minimum thickness of galvanizing shall be 120 microns. Gratings shall be suitable for the operation and maintenance loads for the floors

6.1.7 Welded connections shall be adopted as far as practicable, except for cases where bolted connections are required viz. (Galvanized) electrical switchyard structures and transmission towers. Structural connections shall have minimum two bolts of 16 mm dia. unless otherwise limited by the size of members

6.1.8 Lock nuts shall be provided for anchor bolts of tall structures, tall process columns, vibrating equipment, etc.



6.1.9 Minimum two nuts shall used for all anchor bolts except for ladder, stair and hand rail.

## 6.2 EXPANSION JOINTS

Expansion joints shall be provided at 80 – 100 m centres, where possible, column bracing shall be provided at the center of a longitudinal frame, rather than at the ends so as to avoid constraints on free expansion.

## 6.3 STEEL GRADE

Structural steel shall be of yield stress of 250 Mpa conforming to grade A, Grade B0 & BR for Plates & Grade C for crane Girder as per IS: 2062.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 98 of 242		

Tubular steel shall conform to Yst 310 of IS: 1161 & IS: 4923. Structural pipes shall be either seamless or mild welded. Spiral welded pipe is not acceptable.

#### 6.4 **FIRE PROOFING OF STEEL STRUCTURES (if required)**



Fire proofing for steel structures and equipment supports that could collapse under fire condition and contribute to intensity of the fire shall be provided to meet the requirements of OISD 164 and other relevant standards.

Fire resistance of a material is defined by fire rating, evaluated through a fire test based on applied thickness and time taken to reach the defined critical steel temperature. Fire rating adopted is based on UL-1709 rapid rise fire tests of protection materials for structural steel, conducted by Underwriters Laboratory, USA. In this test, fire resistance of a material is evaluated on a W10x49 steel column as per UL-1709 fire curve and fire rating is published in a UL design number under XR category for thickness and time. In addition to the fire rating, under this test, material for exterior use is also evaluated for accelerated ageing, high humidity, salt spray, wet-freeze-dry cycling, acid spray, solvent spray etc.

Thickness of fireproof coating to be applied shall be based on the following:

- a) Type-I: In-situ cement concrete for application up to 1.8m from grade level for steel structures shall be applied with minimum 65mm thickness.
- b) Type-II: Structural steel members such as column, beam etc which shall be protected for 2 hours from reaching critical temperature 538°C, shall be applied with vermiculite based lightweight cementitious fireproof of thickness corresponding to 2 hours fire rating as per respective UL design number under UL-1709 (XR category) subject to a minimum of 30mm
- c) Type-III: For equipment skirts/ saddles/ supports (which shall be protected for 2 hours from reaching critical temperature 427°C), 2 hours fire rating as per UL design is not adequate as the UL-1709 test is based on 538°C critical



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 99 of 242		

temperature. Therefore for the required fire protection from reaching 427°C, higher thickness shall be necessary. For this, fireproof thickness corresponding to 3 hours fire rating as per respective UL design number under UL-1709 (XR category) shall be adopted subject to a minimum of 30mm.



## 6.5 LIMITING PERMISSIBLE STRESSES

- Permissible stresses in structural members shall be as specified in:
  - IS: 800 - Hot rolled sections (excluding transmission towers and Switchyard structures).
  - IS: 801 - Cold formed light gauge sections
  - IS: 802 - Transmission towers & switchyard structures
  - IS: 806 - Tubular Structures
- Permissible stresses in bolts shall be as specified in :-
  - IS: 800 - Hot rolled sections
  - IS: 801 - Cold formed light gauge sections
  - IS: 802 - Transmission towers & switchyard structures
  - IS: 806 - Tubular Structures
- Permissible stresses in welds shall be as specified in :-
  - IS:801 - Cold formed light gauge sections
  - IS: 806 - Metal Arc Welding

## 6.6 LIMITING DEFLECTION

- a. The limiting permissible vertical deflection for structural steel members shall be as specified below :- (Where “L” represents the span)

Gantry girder for electric overhead crane(Capacity up to 50T)	: L/750
Gantry girder for electric overhead crane((Capacity over 50T)	: L/1000
Gantry girder for manually operated crane	: L/500

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></p><p><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></p></div>	PC288/E/001/P-II/5.5	P	<div><p>बी एच ई एल <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 100 of 242		

Girder beam for supporting dynamic equipment/hoist	: L/450
Grating / Chequered plate	: L/200 or 6mm Whichever Is less
Purlins supporting any type of roofing material under (dead load + live load) or (dead load + wind Load ) conditions	: L/200
- Other structural components	: As specified in relevant IS Code

- b. The limiting permissible horizontal deflection for multistoried steel structure/ building including flare stack shall be Height/325.

## 6.7 MINIMUM THICKNESS

### 6.7.1 Structural Components

The minimum thickness of various structural components (Rolled Steel sections) shall be as given:-

#### a. General Construction

Trusses, Purlins, Side Girts, Bracings	6 mm
Columns, beams	7 mm
Gussets in trusses & girders	
i. Upto and including 12 m span	8 mm
ii. Above 12 m span	10 mm
Flare Trestles, Stiffeners	8 mm
Base plates	10 mm
Chequered plate	6 mm (on plain)
Grating	5 mm

#### b. Transmission tower and Switch yard structure



The minimum thickness of various structural components shall be as per IS: 802

The minimum thickness for rolled beams and channels shall be mean flange thickness regardless of the web thickness.

The minimum thickness of tubes shall be as specified in IS: 806.

For structural members exposed to marked corrosive action, corrosion allowance shall be added as specified elsewhere, or otherwise suitably protected against corrosion.

The minimum thickness of structural components (except gratings & chequered plates) which are directly exposed to weather and inaccessible for repainting shall be 8 mm.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 102 of 242		

## 6.8 ELECTRICAL SWITCHYARD STRUCTURES AND TRANSMISSION TOWERS

All electrical switchyard structures and transmission towers shall have bolted connections, and designed on the basis of IS: 802.

## 6.9 PAINTING

Painting including shop primer to structural steel shall be Epoxy as per the painting specification for this project, included elsewhere in Technical Specification.

## 6.10 GROUTING

For structural columns : As required but not less than 25 mm

For equipment : As required but not less than 25 mm

## 6.11 CLADDING AND RAINWATER GUTTERS



All roof and cladding sheets should be galvalume sheet of 0.5 mm total coated thickness with 550 MPA grade steel confirming to AS 1397 with AZ150 grade coating.

Translucent sheets shall be provided, in non-process areas only, intermittently where day lighting is required. Rainwater gutters of Galvanized / Zinc coated sheets and UPVC rainwater pipes shall be provided for proper roof drainage.

## 7.0 CRITERIA FOR MASONRY WORKS

### 7.1 GENERAL

All masonry works shall be designed in accordance with IS: 1905, IS: 1597, IS: 2185, IS: 4326 and other relevant IS Codes as applicable. All external brick, stone and hollow concrete block masonry walls shall be of minimum 230, 350 and 250 mm thickness respectively. Hollow concrete blocks shall conform to IS: 2185. Masonry shall be plastered with CM 1:6, 12 mm thick on inside surfaces and 20 mm thick on outside surfaces.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 103 of 242		

## 7.2 CEMENT MORTAR

All masonry work shall be constructed in 1:6 cement sand mortar except half brick partition walls which shall be constructed in 1:4 cement sand mortar with two numbers of 6 mm diameter MS bars provided a every fourth course properly anchored with cross walls or pillars.

## 7.3 FIRE WALLS

Thickness of all masonry firewalls shall be as per Electricity Rules but not less than 345 mm.



## 8.0 DESIGN REQUIREMENTS FOR SPECIFIC APPLICATIONS

### 8.1 PIPERACK

For designing the pipe rack superstructure and foundation the following loads shall be considered:

#### 8.1.1 Vertical Loading

Actual weights of pipes coming at each tier shall be calculated. In calculating the actual weight of pipe, the class of pipe, material content and insulation, if any, shall be taken into consideration. Insulation density shall be taken as 2600 N/m<sup>3</sup> minimum. In case of gas / steam carrying pipes, the material content shall be taken as one-third volume of pipe filled with water. The total actual weight thus calculated, shall then be divided by the actual extent of the span covered by the pipes to get the uniformly distributed load per unit length of the span. To obtain the design uniformly distributed load, over the entire span, the u.d.l. obtained as above, shall be assumed to be spread over the entire span. However, minimum loading for any piperack shall not be less than 1.25 kN/m<sup>2</sup>. In case, the calculated loading is higher than 1.25 kN/m<sup>2</sup>, this shall be rounded off to the nearest multiple of 0.25 (i.e., 1.50, 1.75 kN/m<sup>2</sup>)

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 104 of 242		

Vertical loads of flare pipe shall be taken as one third full of water for piping within units & one sixth full for outside unit battery line. All flare line independent support shall be of four legged braced open lower type construction.

In addition to piping load, gravity loads due to encasement, if any, shall be considered.

### 8.1.2 Friction Force (Longitudinal & Transverse)

Where the pipes are of similar diameter and service conditions, the friction force at each tier on every portal both in longitudinal and transverse directions, shall be 10% of the design vertical loading of the pipes for four or more pipes supported on a tier and 30% of the design vertical loading of the pipes, for single to three pipes supported on a tier. Longitudinal friction force shall be considered as uniformly distributed over the entire span of the beam at each tier and transverse friction force shall be considered as a concentrated load at each tier level. Friction forces on T-supports and trestles shall be taken as 30% of the vertical loading. Both longitudinal and transverse friction forces shall be considered to be acting simultaneously.



For two-phase fluid flow/transfer lines frictional force shall be minimum 50% of the weight of pipe including contents & insulation, acting simultaneously in transverse & longitudinal direction.

### 8.1.3 Anchor and Guide Force (Thermal Load)

Anchor and guide force (thermal load) in transverse and longitudinal direction shall be as per piping data.

### 8.1.4 Loading on intermediate Beam at Tier Level

Intermediate beam at tier level shall be designed for 25% of load on main portal beams in transverse direction. A reduction of 10% in vertical loading shall be considered for main portal beams, if intermediate beams are provided.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 105 of 242		

### 8.1.5 Loading on Longitudinal beams

Longitudinal beams connecting portal columns shall be sufficiently strong to sustain 25% of the load on the transverse beams. The total load shall be assumed as two equal concentrated loads acting at  $1/3^{\text{rd}}$  span. Other longitudinal axial forces coming on it from

the design of the supporting system shall also be simultaneously taken into account in the design of the longitudinal beam. Friction & anchor forces, if specifically given by the Piping Specialist, shall also be catered for in the design. Loads from monorails, when supported from these beams, shall also be considered to be acting simultaneously along with all other loads mentioned above.

### 8.1.6 Cable Tray and Walkway Loads



The estimated actual load from electrical, instrumentation trays shall be considered at the specified locations, together with walkways, platforms for valve operation, wherever provided.

### 8.1.7 Wind Force

Wind forces on pipe rack structures shall be calculated as per IS875 part3.

Transverse wind loading on structures due to piping shall be calculated depending on the width of the piperack as per the following table. This force shall be considered irrespective of the height between two tiers.

Width of Piperack	Wind Force at each Tier level(N)
Upto 4 m	$1.25 \times p \times s$
Above 4 m but upto 6 m	$1.50 \times p \times s$
Above 6 m but upto 10 m	$2.00 \times p \times s$
Above 10 m	projected height $\times p \times s$

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 106 of 242		

Where  $p$  = Horizontal wind pressure as per IS:875 ( $N/m^2$ )

$s$  = Spacing of portals (m)

For pipe racks of width greater than 10 m, the projected height shall be lesser of the following two:

- i)  $0.8 \times (\text{diameter of largest pipe including insulation (m)} + \tan 10^\circ \times (\text{width of rack (m)}).$
- ii) height between consecutive tiers

8.1.8 For flare header or any other line supported on extended leg of piperack, the wind force shall be considered separately.

### 8.1.9 Seismic Loads

8.1.10 Seismic loads shall be as per IS: 1893 (latest version). Pipe racks should be adequately braced in all possible directions, consistent with function requirements.

8.1.11 Limiting permissible horizontal deflection for piperack shall be height / 325.



### 8.1.12 PLATFORMS BELOW AIR COOLERS

If handling pumps or other equipment is located below air coolers located on piperack or technological structures, blind floors shall be provided below air coolers, else, 2 m wide center platform with 3m wide local extension below motors shall be provided.

## 8.2 RCC AND STEEL CHIMENY

RCC and steel chimneys shall be designed as per IS: 4998 and IS: 6533 respectively.





 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 107 of 242		

### 8.3 CULVERTS

Culverts shall be designed as per the following IRC codes of practices and manual. Where crane access is specified, the culverts shall be designed for the crane loads.



1. Standard specifications and code of practice for Road Bridges IRC 5  
(Section – I - General features of design)
2. Standard specifications and code of practice for Road Bridges IRC 6  
(Section-II – Load and Stresses)
3. Guidelines for Evaluation of Load Carrying Capacity of Bridges SP 37

Note: The above list is suggestive and not exhaustive. Apart from these basic codes any other related codes shall also be followed wherever required. This list is to be read in conjunction with the list of codes given in Civil Structural job specifications.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 108 of 242		

## ANNEXURE- IV

### GENERAL DESCRIPTION OF STRUCTURES / FACILITIES

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसिफिकेशन लिमिटेड <b>BHEL</b>
		Document No.	Rev	
		Sheet 109 of 242		

## **SCOPE**

The dimensions & elevations of various units shall be furnished by LSTK contractor. All dimensions shall be finalized by the contractor during detail engineering phase & shall be got approved by Owner / PMC.

It is the contractor's responsibility to design safe, sturdy and robust structures, foundations etc. to withstand all static and dynamic forces in accordance with design specifications and engineering specifications laid down in the document. The contractor should make suitable choice of foundations, e.g. isolated footings, raft foundation, pile foundation etc. depending on soil data, loads, settlement criteria.

The general description of structures / facilities shall be read in conjunction with the technical requirements & specifications given elsewhere in this document.



### **a) Compressor House**

Structural steel shed with RC foundation, steel roof with monitor, S type louvers, roof and cladding sheets should be galvalume sheet of 0.5 mm total coated thickness with 550 MPA grade steel confirming to AS 1397 with AZ150 grade coating, Translucent sheets shall be provided, in non-process areas only, intermittently where day lighting is required. Rainwater gutters of Galvanized / Zinc coated sheets and UPVC rainwater pipes shall be provided for proper roof drainage. Gantry girder for crane with walkway having handrail on one side with access ladders & open steel staircases for access at appropriate places.

RC deck mounted foundations for compressors with structural steel operating platform having HDG grating floor & handrail all-round, RC grade slab with flooring of type mentioned elsewhere, RC cable trench & RC floor drains at ground level.

### **b) Technological Structure**

Open steel structure with RC foundations, structural steel platforms & floors at different levels with HDG grating, handrails all-round, supporting arrangement for equipments. Approaches to various levels shall be through structural steel

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 बी एच ई लिमिटेड <b>BHEL</b>
		Document No.	Rev	
		Sheet 110 of 242		

staircases. Open steel staircase from ground to top level with handrails on both sides.

RC foundations for equipments, RC grade slab with RC cable trenches & RC floor drains at ground level.

The foundations of all equipments / structures shall be as per requirement.

### c) Control Room

Control Room building shall be designed as RCC framed structure.

Besides housing of control panel/ operator's consoles, rack area for marshalling cabinets, Engineering console room, process operator's room, HVAC/ Air handling room(s), UPS and UPS battery room, toilet, rest rooms etc. shall be accommodated in the control room building in general.

Also the instrumentation engineering specification for Control Room should be followed.



### d) Pipe-rack

Structural steel pipe-rack with RC foundations having multiple tiers for supporting pipes with suitable platforms for control valve operations and walkway, having HDG grating, MS handrails on both sides with local ladders.

In case, air cooler structures are required, it shall be suitably supporting over pipe-rack. Structural steel platforms be provided with HDG grating, handrails and ladders for the entire width of rack below air coolers. Operating platform at top of air coolers with ladder for approach to the same. Open steel staircase for operation & maintenance at required places to be provided from ground to top level with landing at appropriate locations.

Endeavour shall be made to utilize the unoccupied space of the existing pipe rack(if any), after checking the adequacy of the system. Modification/ strengthening, if required shall be carried by the contractor.

There should be RC paving below pipe-rack for entire width where crane movement/vehicular traffic is anticipated. There should be PCC paving below pipe-rack located in plants.

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></p><p><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></p></div>	PC288/E/001/P-II/5.5	P	<div><p>भारत कोयला गैसिफिकेशन लिमिटेड <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 111 of 242		

#### e) Pipe Sleepers

The suitable arrangement of concrete supports shall be used to support pipes. The top of concrete of pipe sleepers shall be minimum 300mm above the highest paving points. MS steel insert plates with 20mm bar shall be provided on the sleeper top for pipe fixing depending on requirements. Suitable road crossing arrangement shall be provided for pipe sleepers wherever required.

#### f) Substation

The Sub-Station building shall be a RCC framed building with Hollow/solid block work side covering and flat roof at top. The ground floor shall be utilized as cable cellar for installation of cable trays. The first floor will have LT/HT panels, UPS & battery room, operator's room & toilets. The access to first floor shall be provided through two nos. of R.C.C. staircases, each located on either side of building. Transformer bay will be on the rear side of the building, provided with Chain link fencing & gates. Separating walls shall be provided between transformers. The separating walls between sub-station and outdoor transformer bays shall have four hour fire rating.

Also the electrical engineering specification for Substation should be followed



#### g) Stack Structure and Foundation;

R.C.C. foundation having steel structure/RCC super structure with intermediate platform and accessible cat ladders with cage.

#### h) Miscellaneous

- i) Lifting beams / monorails of required capacity for maintenance and / or erection purpose at various locations as per requirements mentioned elsewhere in this document shall be provided. Statutory provisions shall be applicable for all electrically driven monorails.
- ii) Miscellaneous local platforms, pipe sleepers, local foundations, local supports etc. as per requirement.

**Note:** The above mentioned requirement are general in nature & may be suitably modified during detail engineering phase by contractor to meet design functional requirement of the facility. However, Same shall be reviewed & approved by PMC/client.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 112 of 242		

## ANNEXURE-V

ES-2516



### TECHNICAL SPECIFICATIONS

FOR

CIVIL, STRUCTURAL



AND

OTHER ALLIED WORKS

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></p><p><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></p></div>	PC288/E/001/P-II/5.5	P	<div><p>बी एच ई लि. <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 113 of 242		

## CONTENTS

SL. NO.	DESCRIPTION	Page No.
1.	GENERAL	121
2.	REFERENCE CODES AND STANDARDS	121
3.	EARTH WORK	123
4.	PLAIN AND REINFORCED CONCRETE WORK	129
5.	STEEL REINFORCEMENT	133
6.	FORM WORK	134
7.	HOLLOW BLOCK MASONRY	135
8.	STRUCTURAL STEEL WORK	137
9.	PAINTING ON STRUCTURAL STEEL	139
10.	STEEL/ALUMINIUM DOORS, WINDOWS AND VENTILATORS	149
11.	ROOFING & CLADDING	149
12.	FLOORING AND PAVING	149
13.	PLASTERING	150
14.	EXTERIOR PAINTING	151
15.	GLAZING	152
16.	PROTECTIVE COATING AND LINING SYSTEM	152
17.	CULVERT WORK	158

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 114 of 242		

## 1.0 General



- 1.1 Specifications of materials and workmanship shall be as described in the Central Public Works Department Specifications Vol. I & II (latest) include latest amendments, unless otherwise specified. These CPWD Specifications shall be deemed to form part of this contract. The **CONTRACTOR** shall procure and maintain copies of the latest CPWD Specifications at site for reference.
- 1.2 These technical Specifications shall be supplementary to the specifications contained in the CPWD specifications, wherever at variance, these Particular Specifications shall take precedence over the provisions in the CPWD Specifications.

## 2.0 Reference Codes & Standards



- 2.1 Wherever reference of IS Specifications/ or IS Codes of Practice are made in the Specifications/ Schedule of Rates or Preambles, reference shall be to the latest edition of IS (Bureau of Indian Standards).

IS - 383	Coarse & Fine aggregates from natural sources for concrete.
IS - 427	Distemper, dry, colour as required.
IS - 432	Mild Steel & Medium tensile steel bars.
IS - 456	Code of Practice for Plain and Reinforced Concrete.
IS - 515	Natural and Manufactured aggregates for use in mass concrete
IS - 730	Hook bolts for corrugated sheet roofing
IS - 800	Code of Practice for General Construction in Steel
IS - 1079	Hot rolled carbon steel sheets & strips
IS - 1081	Code of practice for fixing and glazing of metal (steel & aluminium) doors, windows and ventilators.



<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></p><p><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></p></div>	PC288/E/001/P-II/5.5	P	<div><p>भारत कोयला गैसीकरण और रासायनिक उद्योग <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 115 of 242		

- IS - 1161 Steel tubes for structural purposes.
- IS - 1285 Wrought aluminium & aluminium alloy extruded round tube and hollow sections
- IS - 1361 Steel windows for Industrial Buildings.
- IS - 1363 Hexagon head bolts, screws & nuts of product grade C : Part - I Hexagon head bolts ( size range M5 to M64)
- IS - 1367 Technical supply conditions for threaded steel fasteners
- IS - 1566 Hard - Drawn steel wire fabric for concrete reinforcement.
- IS - 1786 High strength deformed steel bars & wires for concrete reinforcement.
- IS - 2062 Steel for general structural purposes.
- IS - 2116 Sand for masonry mortars.
- IS - 2212 Code of practice for brickwork.
- IS - 2386 Methods of test for aggregates.
- IS - 2835 Flat transparent sheet glass
- IS - 4021 Timber door, window and ventilator frames
- IS - 4923 Hollow Steel sections for structural use.
- IS - 4925 Concrete batching and mixing plant.
- IS - 5410 Cement Paint
- IS - 6477 Dimensions for wrought aluminium & aluminium alloys, extruded hollow sections.
- IS - 7318 Fusion welding of steel.
- IS - 10262 Recommended guidelines for concrete mix design.
- IS - 14871 Products in Fibre Reinforced Cement – Long Corrugated or



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 116 of 242		

## Asymmetrical Section Sheets and Fittings for Roofing and Cladding - Specification



### 3.0 Earthwork

#### 3.1 Excavation

- 3.1.1 Excavation shall be carried out in soil of any nature and consistency, in the presence of water or in the dry, met on the site to the lines, levels and contours shown on the detailed drawings and **CONTRACTOR** shall remove all excavated materials to soil heaps on site or transport for use in filling on the site or stack them for reuse as directed by the Engineer-in-Charge.
- 3.1.2 Surface dressing shall be carried out on the entire area occupied by the buildings including plinth protection as directed without any extra cost. The depths of excavation shown on the drawings are the depths after surface dressing.
- 3.1.3 The site around all buildings and structures to a width of 3 metres beyond the edge of plinth protection, ramps, steps, etc. shall be dressed and sloped away from the buildings.
- 3.1.4 Black cotton soil, and other expansive or unsuitable soils excavated shall not be used for filling in foundations, and plinths of buildings or in other structures including manholes, septic tanks etc. and shall be disposed off within the contract area marked on the drawings, as directed, levelled and neatly dressed.
- 3.1.5 In case of trenches exceeding 2 metres depth or where soil is soft or slushy, the sides of trenches shall be protected by timbering and shoring. The **CONTRACTOR** shall be responsible to take all necessary steps to prevent the sides of trenches from caving in or collapsing. The extent and type of timbering and shoring shall be as directed by the **Engineer-in-Charge**.
- 3.1.6 Where the excavation is to be carried out below the foundation level of adjacent structure, the precautions to be taken such as under pinning, shoring and strutting etc. shall be determined by **Engineer-in-Charge**. No excavation shall be done unless such precautionary measures are carried out as per directions of **Engineer-in-Charge**.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसिफिकेशन और रासायनिक उद्योग <b>BHEL</b>
		Document No.	Rev	
		Sheet 117 of 242		

- 3.1.7 Specification for Earth work shall also apply to excavation in rock in general. The excavation in rock shall be done such that extra excavation beyond the required width and depth as shown in drawings is not made. If the excavation done in depth greater than required /ordered. The **CONTRACTOR** shall fill the extra excavation with concrete of mix 1:5:10 as the foundation concrete at his own cost.
- 3.1.8 **CONTRACTOR** shall make all necessary arrangements for dewatering / defiling as required to carry out proper excavation work by bailing or pumping out water, which may accumulate in the excavation pit from any cause/ source whatsoever.
- 3.1.9 **CONTRACTOR** shall provide suitable draining arrangements at his own cost to prevent surface water entering the foundation pits from any source.
- 3.1.10 The **CONTRACTOR** is forbidden to commence the construction of structures or to carry out concreting before **Engineer-in-Charge** has inspected, accepted and permitted the excavation bottom.
- 3.1.11 Excavation in disintegrated rock means rock or Boulders including brickbats which may be quarried or split with crow bars. This will also include laterite and hard conglomerate.
- 3.1.12 Excavations in hard rock - meant excavation made in hard rock to be done manually, or by blasting using only explosives and / or pneumatic hammers. In case of blasting, control blasting should be adopted depending on site conditions. For using explosives **CONTRACTOR** shall follow all provisions of Indian Explosives Act / Rules 1983, corrected / revised up to date.
- 3.1.13 In case of hard rock excavation to be carried out using explosives the, **CONTRACTOR** shall obtain the written approval in advance.
- 3.1.14 The measurements for excavations shall be restricted and limited to minimum excavation line as per drawing for payment purposes.
- 3.1.15 Adequate protective measures shall be taken to see that the excavation does not affect or damage adjoining structures. The **CONTRACTOR** shall take all measures required for ensuring stability of the excavation and safety of



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 118 of 242		

property and people in the vicinity. The **CONTRACTOR** shall erect and maintain during progress of work, temporary fences around dangerous excavations at no extra cost.

- 3.1.16 Excavation in ordinary soil means excavation in ordinary hard soil including stiff heavy clay, hard shale, or compact moorum, or any materials, which can be removed by the ordinary application of spades, shovels, picks and pick axes. This shall also include removal of isolated boulders each having a volume not more than 0.50m<sup>3</sup>.
- 3.1.17 Excavation in soft rock includes limestone, sandstone, laterite, hard conglomerates, etc. or other rock which can be quarried or split with crowbars or wedges. This shall also include excavation of tarred pavements, masonry work and rock boulders each having a volume of not more than 0.25m<sup>3</sup>.
- 3.1.18 Excavation in hard rock includes any rock bound in ledges or masses in its original form or cement concrete for which in the opinion of the Engineer-in-Charge, requires the use of compressed air, equipment, sledge hammer and blasting or non-explosive materials viz. Acconex manufactured by A.C.C. Ltd. Specifications and instructions for use shall be as per manufacturer.
- 3.1.19 In case of any difficulty concerning the interpretation of type of soil as mentioned above, the Engineer-in-Charge shall decide whether the excavation in a particular material is in ordinary soil, soft rock or hard rock and his decision in this matter shall be final and binding on the CONTRACTOR and without appeal.
- 3.2 **Filling**
- 3.2.1 Back filling of excavations in trenches, foundations and elsewhere shall consist of one of the following materials approved by **Engineer-in-Charge**.

Soil

Sand

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 119 of 242		



Moorum

Hard-core

Stone/gravel



All back filling material shall be approved by the **Engineer-in-Charge**.

- 3.2.2 Soil filling - Soil material shall be free from rubbish, roots, hard lumps and any other foreign organic material. Filling shall be done in regular horizontal layers each not exceeding 20 cm. depth.
- 3.2.3 Back filling around completed foundations, structures, trenches and in plinth shall be done to the lines and levels shown on the drawings.
- 3.2.4 Back filling around pipes in the trench shall be done after hydro testing is done.
- 3.2.5 Back filling around liquid retaining structures shall be done only after leakage testing is completed and approval of **Engineer-in-Charge** is obtained.
- 3.2.6 Sand used for filling under foundation concrete, around foundation and in plinth etc. shall be fine/ coarse, strong, clean, free from dust, organic and deleterious matter. The sand filling under foundation shall be rammed with Mech. compactor. Sand material shall be approved by **Engineer-in-Charge**.
- 3.2.7 Moorum for filling, where ordered, shall be obtained from approved pits and quarries which contain siliceous material and natural mixture of clay. Moorum shall not contain any admixture of ordinary earth. Size of moorum shall vary from dust to 10 mm.
- 3.2.8 Hard-core shall be of broken stone of 90 mm to 10 mm size suitable for providing a dense and compact sub grade. Stones shall be sound, free from flakes, dust and other impurities. Hard core filling shall be spread and levelled in layers, 15 cm thick, watered and well compacted with ramming or with mechanical / hand compacts including hand packing wherever required.
- 3.2.9 If any selected fill material is required to be borrowed, **CONTRACTOR** shall make arrangements and procure such material from outside borrow pits. The material of source shall be subject to prior approval of **Engineer-in-Charge**. **CONTRACTOR** shall make necessary access roads to borrow areas and

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 120 of 242		

maintain the same, if such access roads do not exist, at no extra cost.

- 3.2.10 Plinth filling shall be carried out with approved material as described earlier, in layers not exceeding 150mm, watered and compacted with mechanical compaction machines. **Engineer-in-Charge** may however permit manual compaction by hand tampers in case he is satisfied that mechanical compaction is not possible. When filling reaches the finished level, the surface shall be flooded with water, unless otherwise directed, for at least 24 hours, allowed to dry and then the surface again compacted as specified above to avoid settlements at later stage. The finished level of the filling shall be trimmed to the level specified. Compacted surface shall have at least 95% of laboratory maximum dry density. A minimum of one test per 250 sq. meters of compacted area shall be done.
- 3.2.11 Whenever the fill material (earth or soil) is purchased, **CONTRACTOR** shall get the approval of Engineer-in-Charge. The CONTRACTOR shall arrange to determine the following properties of the soil and shall get the approval of **Engineer-in-Charge**.
1. Clay content : 15% to 20%
  2. Laboratory dry : Not less than 1600 kg/m<sup>3</sup>  
density
  3. Plasticity Index : Not more than 20
- 3.2.12 The fill shall be compacted using a vibrating compactor of not less than 1.5 tonne. The fill shall be thoroughly compacted in layers as directed but not more than 200 mm thick. Adequate water shall be used for compaction and the density after compaction shall be not less than maximum dry density obtained in test of IS: 2720 Part-8. Compacted surface shall have at least 90% of laboratory maximum dry density. A minimum of one test per 250 sq. meters of compacted area shall be done.
- 3.2.13 The Gravel fill shall be non plastic granular material, well graded, strong, with maximum particle size of 50 mm, with not more than 15% passing a 4.75 mm

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 121 of 242		

IS sieve, free of all debris, vegetable matter and chemical impurities.

3.2.14 All clods, lumps etc. shall be broken before compaction.

3.2.15 In case of grading/banking successive layers of filling shall not be placed, until the layer below has been thoroughly compacted to satisfy the requirements laid down in this specification.

Prior to rolling, the moisture content of material shall be brought to within +/- 2% of the optimum moisture content as described in IS 2720 Part-7. The moisture content shall preferably be on the wet side for potentially expansive soil.

After adjusting the moisture content as described, the layers shall be thoroughly compacted by means approved by Engineer-in-Charge, till the specified maximum laboratory dry density is obtained.



General, fill shall be placed in layers not exceeding 300 mm thickness and shall be thoroughly compacted to achieve a compaction of at least 90% of laboratory maximum dry density up to a depth of 600 mm below finished grade. Final fill of 600 mm thickness shall consist of preferably natural material in, as dug condition except that stones larger than 100 mm shall be removed. It shall be placed in layers not exceeding 150 mm thickness and compacted to achieve of at least 95% of laboratory maximum dry density. Each layer shall be tested in field for density and accepted by Engineer-in-Charge, subject to achieving the required density before laying the next layer. A minimum of one test per 250 sq meters for each layer shall be conducted.

If the layer fails to meet the required density, it shall be reworked or the material shall be replaced and method of construction altered as directed by Engineer-in-Charge to obtain the required density.

The filling shall be finished in conformity with the alignment, levels, cross-section and dimensions as shown in the drawing.

Extra material shall be removed and disposed off as directed by the **Engineer-in-Charge**.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 122 of 242		

## 4.0 Plain and Reinforced Concrete Work

This specifications deals with cement concrete, plain or reinforced, for general use, and covers the requirements for concrete materials, their storage, grading, mix design, strength & quality requirements, pouring at all levels, reinforcements, protection, curing, form work, finishing, painting, admixtures, inserts and other miscellaneous works.

### 4.1 Materials

4.1.1 Cement: Any of the following cements may be used as required. If soil investigation report recommends any specified type of cement then same shall have precedence.

IS - 269	Ordinary Portland cement, 33 grade
IS - 8112	43/53 Grade ordinary Portland cement
IS - 12269	53 Grade ordinary port land cement

4.1.2 Water: Water used for mixing and curing concrete and mortar shall conform to the requirements as laid down in IS: 456. Sea water shall not be used for concrete work.



4.1.3 Aggregates: Coarse and fine aggregates for cement concrete plain and reinforced shall conform to the requirements of IS 383 and / or IS 515.

Before using, the aggregates shall be tested as per IS: 2386.

Coarse aggregate: Coarse aggregate for all cement concrete work shall be broken or crushed hard stone, black trap stone obtained from approved Quarries or gravel.

Sand: Fine aggregate shall consist of natural or crushed sand conforming to BIS 383 and conforming to test as per BIS 2386 parts I to IV.f. Grading of coarse sand shall be within grading zones I, II or III as laid down in IS: 383, table 4. If required the aggregates (both fine and coarse) shall have to be thoroughly washed and graded as per direction of **Engineer-in-Charge**.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 123 of 242		

## 4.2 Mixing

All cement concrete plain or reinforced shall be machine mixed. Mixing by hand may be employed where quantity of concrete involved is small, with the specific prior permission of the **Engineer-in-Charge**. 10% extra cement shall be added in case of hand mixing as stipulated in IS-456.

For large and medium project sites the concrete shall be sourced from ready-mixed concrete plants or from on site or off site batching and mixing plants (IS 4926)

## 4.3 Water Cement Ratio, Laying & Curing

Water Cement Ratio, Laying & Curing shall be done as per IS: 456.

## 4.4 Grades of Concrete

4.4.1 Grades lower than M 25 shall not be used in reinforced concrete super structures.

4.4.2 A sieve analysis test of aggregates shall be carried out as and when the source of supply is changed without extra charge notwithstanding the mandatory test required to be carried out as per CPWD specification.

4.4.5 All tests in support of mix design shall be maintained as a part of records of the contract. Test cubes for mix design shall be prepared by the CONTRACTOR under his own arrangements and at his costs, but under the supervision of the **Engineer-in-Charge**.

## 4.5 Design Mix Concrete

4.5.1 Design mix shall be allowed for major works where it is contemplated to be used by installing weigh batch mixing plant as per IS 4925. At the time of tendering, the CONTRACTOR, after taking into account the type of aggregates, plant and method of laying he intends to use, shall allow in his tender for the design mix i.e., aggregate/cement and water/cement ratios which he considers will achieve the strength requirements specified, and workability for concrete to be properly finished.

4.5.2 Before commencement of concreting, **CONTRACTOR** shall carry out preliminary tests for design mix on trial mixes proposed by him in design of mix to satisfy the **Engineer-in-Charge** that the characteristic strength is obtained. In this regard, CONTRACTOR may consult govt. approved/reputed institute to get design mix done as per IS 10262 at his own cost. The concrete mix to be actually used shall be approved by the **Engineer-in-Charge**.

4.5.3 Notwithstanding the above, the following shall be the maximum combined weight of coarse and fine aggregate per 50 kg of cement.

Grade of Concrete	Maximum weight of fine & coarse aggregates together per 50 kg of cement (for nominal mix only)
1. M - 10	480 kg
2. M - 15	350 kg
3. M - 20	250 kg



4.5.4 The workability of concrete produced shall be adequate, so that the concrete can be properly placed and compacted. The slump shall be as per IS 456.

4.5.5 The minimum consumption of the cement irrespective of design mix shall not be less than the following:

M 7.5 (1:4:8)	170 kg/cu m
M 10 (1:3:6)	240 kg/cu m
M 15	300 kg/cu m
M 20	330 kg/cu m
M 25	350 kg/cu m
M 30	400 kg/cu m

#### 4.6 Testing of Concrete

4.6.1 Testing of concrete, sampling and acceptance criteria shall be in accordance with IS 456.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 125 of 242		

#### 4.7 **Proportioning**

Mixes of cement concrete shall be as ordered. Where the concrete is specified by grade, it shall be prepared by mixing cement, sand and coarse aggregate by weight as per mix design. In case the concrete is specified as volumetric mix, then dry volume batching shall be done, making proper allowances for dampness in aggregates and bulking in sand. Equivalent volume batching for concrete specified by grade may however be allowed by the **Engineer-in-Charge** at his discretion.



#### 4.8 **Pre Cast Concrete**

The specifications for pre cast concrete will be similar as for the cast in situ concrete. All pre cast work shall be carried out in a yard made for the purpose. This yard shall be dry, properly levelled and having a hard and even surface. If the ground is to be used as a soft former of the units, shall be paved with concrete or masonry and provided with a layer of plaster (1:2 proportion) with smooth neat cement finish or a layer of MS sheeting. The casting shall be over suitable vibrating tables or by using form vibrators as per directions of **Engineer-in-Charge**.

The yard, lifting equipment, curing tank, finished material storage space etc. shall be designed such that the units are not lifted from the mould before 7 (seven) days of curing and can be removed for erection after 28 (Twenty Eight) days of curing. The moulds shall preferably be of steel or of timber lined with G.I .sheet metal. The yard shall preferably be fenced.

Lifting hooks, wherever necessary or as directed by **Engineer-in-Charge** shall be embedded in correct position of the units to facilitate erection, even though they may not be shown on the drgs. and shall be burnt off and finished after erection.

Pre cast concrete units, when ready shall be transported to site by suitable means approved by **Engineer-in-Charge**. Care shall be taken to ensure that no damage occurs during transportation. All adjustments, levelling and plumbing shall be done as per the instructions of the **Engineer-in-Charge**. The

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></p><p><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></p></div>	PC288/E/001/P-II/5.5	P	<div><p>बी एच ई लि. <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 126 of 242		

CONTRACTOR shall render all help with instruments, materials and staff to the **Engineer-in-Charge** for checking the proper erection of the pre cast units.

After erection and alignment the joints shall be filled with grout or concrete as directed by **Engineer-in-Charge**. If shuttering has to be used for supporting the pre cast unit they shall not be removed until the joints has attained sufficient strength and in no case before 14 (fourteen) days. The joint between pre cast roof planks shall be pointed with 1:2 (1 cement : 2 sand) mortar.

## 5.0 STEEL REINFORCEMENT

5.1 Steel reinforcement shall comprise:

1) CRS bars

5.2 All joints in reinforcement shall be lapped adequately to develop the full strength of the reinforcement as per provision of IS: 456 or as per instruction of **Engineer-in-Charge**.

## 6.0 Form Work

6.1 The shuttering or form work shall conform to the shape, lines and dimensions as shown on the drawings and be so constructed as to remain sufficiently rigid during placing and compacting of the concrete and shall be sufficiently tight to prevent loss of liquid from the concrete. The surface that becomes exposed on the removal of forms shall be examined by **Engineer-in-Charge** or his authorized representative before any defects are made good. Work that has sagged or bulged out, or contains honey combing, shall be rejected. All shuttering shall be plywood or steel shuttering.

6.2 The **CONTRACTOR** shall be responsible for sufficiency and adequacy of all form work. Centering and form work shall be designed & detailed in accordance with IS 14687 and approved by the **Engineer-in-Charge**, before placing of reinforcement and concreting.

## 6.3 Stripping Time

Forms shall not be struck until the concrete has reached strength at least twice the stress to which the concrete may be subjected at the time of removal of form

work. The strength referred to shall be that of concrete using the same cement and aggregates, with the same proportions and cured under conditions of temperature and moisture similar to those existing on the work. Where possible, the form work shall be left longer as it would assist the curing.

Note 1: In normal circumstances and where ordinary Portland Cement is used, forms may generally be removed after the expiry of the following periods:



1.	Walls, columns and vertical faces of all structural members	24 to 48 hours as may be decided by the <b>Engineer-in-Charge</b>
2.	Slabs (props left under)	3 days
3.	Beam soffits (Props left under)	7 days
4.	Removal of props under slabs 1. Spanning up to 4.5 m 2. Spanning over 4.5 m	7 days 14 days
5.	Removal of props under beams & arches: 1. Spanning up to 6 m 2. Spanning over 6m	14 days 21 days

For other types of cements, the stripping time recommended for ordinary Portland Cement may be suitably modified.

Note 2: The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slab, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

## 7.0 Cement Concrete Block

Cement concrete block shall be machined made in the proportion of such that mix shall not be leaner than one cement to twelve combined aggregates (by volume) but having minimum strength of 7.5 MPa. Combined aggregate shall be

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 128 of 242		

graded as near as possible to IS: 383. The fineness modules of combined aggregate shall be between 3.6 and 4. The concrete block shall be properly cured as per IS-456. The surface of conc. block shall have even face without any honeycomb and free from cracks.

#### 7.7.1 **Mortar**

Cement and water shall confirm to the requirements laid down for cement concrete work.

7.7.2 Sand for concrete block masonry mortars shall be coarse sand generally conforming to IS: 2116. Maximum quantities of clay, fine dust, shall not be more than 5% by weight. Organic impurities shall not exceed the limits laid down in IS: 2116.

7.7.3 Mix of mortar for building concrete block shall be as specified in the item of work.

7.7.4 Mixing of the mortar shall be done in a mechanical mixer. When quantity involved is small hand mixing may be permitted by **Engineer-in-Charge**. Any mortar remaining unused for more than 30 minutes after mixing shall be rejected.

#### 7.8 **Concrete Block Masonry**



The thickness of joints shall be 10 mm +/- 3mm. Thickness of joints shall be kept uniform. In case of foundation and manholes etc. joints up to 15 mm may be accepted.

#### 7.9 **Half Concrete Block**

All courses shall be laid with stretchers. Reinforcement comprising 2 nos. 6 mm dia MS bars shall be provided over the top of the first course and thereafter at every fourth course.

#### 7.10 **Fixtures**

All iron fixtures, pipes spouts, hold fasts of doors and windows which are required to be built into the wall shall be embedded in cement concrete blocks 1:2:4 mix (1 cement :2 coarse sand :4 graded stone aggregate. 20 mm nominal size) of size indicated in the item.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 129 of 242		

### 7.11 Curing

Concrete block masonry shall be protected from rain by suitable covering when mortar is green. Masonry work shall be kept constantly moist on all faces for a minimum period of seven days.

## 8.0 STRUCTURAL STEEL WORK

This specification covers the technical requirements for the preparation of shop drawings, supply, fabrication, protective coating, painting and erection of all structural steel rolled sections, built up sections, plates and miscellaneous steel required for the completion of the work.

### Steel

All structural steel used in construction within the purview of this contract shall, comply with one of the following Bureau of Indian Standard Specifications, whichever, is appropriate or as specified.

IS – 2062 Hot rolled sections and plates

IS – 1079 Cold formed light gauge sections

IS – 1161 Tubular sections



IS – 4923 Hollow sections (rectangular or square)

### Fabrication

Fabrication of steel structure shall be carried out in conformity with the best modern practices and with due regard to speed with economy in fabrication and erection and shall conform to IS-800. All members shall be so fabricated as to assemble the members accurately on site and erect them in correct positions. Before dispatch to site the components shall be assembled at shop and any defect found rectified. All members shall be free from kink, twist, buckle, bend, open joints etc. and shall be rectified before erecting in position. Failure in this respect will subject the defective members to rejection.

### Fabrication Drawings:

Connections, splices and other details shall be suitably designed based on good Engineering practice.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 130 of 242		

### Electrodes:

Electrodes used for welding shall comply with IS-814 or IS - 815.

### 8.1 MS Black/High Strength Bolts and Nuts

M.S.Black or high strength bolts, nuts and washers etc. shall be as per IS-800, IS-1363 and IS-1367. Manufacturer's test certificate shall be made available to the **Engineer-in-Charge**. For bolted joints, shanks and threaded bolts are to be used to ensure that threaded length do not encroach within the thickness of connected members of dimension beyond the following limit:-



1. 1.5 mm for connected members of thickness below 12 mm and
2. 2.5 mm for connected member of thickness 12 mm and above and that adequate shearing and bearing values required as per design are achieved.

Every portion work shall have its erection mark or numbers stencilled on the member for guidance in erection and bear all necessary marks of erections as directed by the Owner / Consultant.

7.13 No part of the work is to be oiled, painted (except contact surfaces ) packed, bundled, crated or dispatched until it has been finally inspected and approved by the Owner / Consultant or his authorized representative. The whole steel work before being dispatched from the Contractor's shop shall be dry and after being thoroughly cleaned from dust, mills scale, rust etc., and shall be given two coats of primer and one coat of final paint as per painting specification attached in this enquiry. Unless otherwise specified, all surfaces inaccessible after welding shall be given two coats of primer and two coats of paints as per painting specification attached in this enquiry.

7.14 The Owner / Consultant or his authorized representative shall have free access at all reasonable time to all places where the work is being carried out, and shall be provided by the Contractor at his own expenses all necessary facilities for inspection during fabrication and erection. The Owner / Consultant or his authorized representative shall be at liberty to reject the work in whole or in part if the workmanship or materials do not conform to the terms of the specifications



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 131 of 242		

mentioned herein. The Contractor shall remove, replace or alter any part of the work as ordered by the Owner / Consultant or his authorized representative.

## 9.0 PAINTING ON STRUCTURAL STEEL

Painting on structural steel shall be as per Painting specification given elsewhere with this Tender. However, the following specification may be considered and used for painting of structural steel work.

### 9.1 Scope

This specification covers the technical requirements for shop and site application of paint and protective coatings and includes; the surface preparation, priming, application, testing and quality assurance for protective coatings of structural steelwork, plate work, handrails and associated metal surfaces, which will be exposed to atmospheric for industrial plants.



### 9.2 Definitions

C.S	-	Carbon steel and low chrome (1-1/4 Cr through 9 Cr) alloys
S.S	-	Stainless steel, such as 304,316, 321, 347,
Non-ferrous	-	copper, aluminium and their alloys.
High Alloy	-	Monel, Inconel, Incoloy, Alloy 20, Hastelloy, etc.
DF	-	Dry Film thickness, the thickness of the dried or cured paint or coating film.

### 9.3 Safety Regulations

Protective coatings and their application shall comply with all national, state, and local codes and regulations on surface preparation, coating application, storage, handling, safety, and environmental recommendations.

Sand or other materials producing silica dust shall NOT be used for any open-air blasting operations.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 132 of 242		

## 9.4 Material Safety Data Sheets

The latest issue of the coating manufacturer's product datasheet, application instructions, and material safety data Sheets shall be available prior to starting the work and shall be complied with during all preparation and painting / coating operations.

## 9.5 Materials

All paints and paint materials shall be obtained from the company's approved manufacturer's list. All materials shall be supplied in the manufacturer's containers, durably and legibly marked as follows.

Specification number

Colour reference number

Method of application

Batch number

Date of Manufacture

Shelf life expiry date

Manufacturer's name or recognised trade mark.

## 9.6 CODE AND STANDARDS:

Without prejudice to the provision of Clause 1.1 above and the detailed specifications of the contract, the following codes & standards shall be followed. Wherever reference to any code is made, it shall correspond to the latest edition of the code.

## 9.7 Indian Standards:



IS-5: 1994 Colors for ready mixed paints and enamels.

IS-2379: 1990 Color codes for identification of pipe lines.

IS-2629: 1985 Recommended practice for hot-dip galvanizing on iron and steel.

IS-2633: 1986 Methods for testing uniformity of coating of zinc-coated articles.

IS-8629: 1977 Code of practice for protection of iron and steel structures from atmospheric corrosion.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 133 of 242		

IS: 110                      Specification for Ready Mixed Paint, Brushing, Grey Filler, for Enamels, for Over Primers

IS: 101                      Methods of test for ready mixed paints & enamels.

## 9.8 Other Standards:

9.8.1 Swedish Standard: SIS-05 5900-1967 / ISO-8501-1-1988

(Surface preparations standards for Painting Steel Surface).

This standard contains photographs of the various standards on four different degrees of rusted steel and as such is preferable for inspection purpose by the Engineer-in-charge.

9.8.2 DIN: 53151 Standards for Adhesion test.

**9.9** The paint manufacturer's, instructions shall be followed as far as practicable at all times. Particular attention shall be paid to the following:

- a. Instructions for storage to avoid exposure as well as extremes of temperature.
- b. Surface preparation prior to painting.
- c. Mixing and thinning.
- d. Application of paints and the recommended limit on time intervals between coats.



## 9.10 Surface Preparation

9.10.1 Safety

All work in adjacent areas, which may negatively affect the quality of blast cleaning, and/or impose safety hazards, must be completed or stopped before the blasting operation starts.

9.1.2 Pre-Cleaning

Prior to surface preparation all weld spatter shall be removed from the surface, all sharp edges ground down and all surfaces cleaned free of contaminants including chalked paint, dust, grease, oil, chemicals and salt. All shop primed

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 134 of 242		

surfaces shall be water washed by means of suitable solvent, by steam cleaning, with an alkaline cleaning agent if necessary or by high-pressure water, to remove contaminants prior to top-coating.

#### 9.1.3 Surface decontamination

Surface decontamination shall be performed prior to paint application when uncoated surface is exposed to a corrosive environment or existing paint work is to be repaired. Existing coatings shall be removed by abrasive blast cleaning, and then high pressure potable water shall be used to clean steel surfaces. Prior to application of coatings, the surface shall be chemically checked for the presence of contaminants. A surface contamination analysis test kit shall be used to measure the levels of chlorides, iron salts and pH in accordance with the kit manufacturer's recommendations.

Swabs taken from the steel surface, using cotton wool test swabs soaked in distilled water shall not be less than one swab for every 25m<sup>2</sup> of surface area to be painted.

Maximum allowable contaminant levels and pH range is as follows:

Sodium chloride, less than 50 microgram / cm<sup>2</sup>;

Soluble iron salts, less than 7 microgram / cm<sup>2</sup>; and

pH between 6 – 8



If the results of the contamination test fall outside the acceptable limits, then the wash

water process shall be repeated over the entire surface to be painted, until the

Contaminant test is within the specified levels.

#### 9.1.4 Abrasive blasting

All C.S materials shall be abrasive blast cleaned in accordance with relevant IS Codes. To reduce the possibility of contaminating S.S., blasting is not usually specified. However, for coatings which require a blast-cleaned surface for proper

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		Document No.	Rev	
		Sheet 135 of 242		

adhesion, S.S. may be blast cleaned using clean aluminium oxide or garnet abrasives (Free from any chloride or Iron / Steel contamination). When hand or power tool cleaning is required on S.S., only S.S. wire-brushes (including 410 S.S.) which have not been previously used on C.S. surfaces may be used.

The surface profile of steel surfaces after blasting shall be of preparation grade Sa 2-1/2 of Swedish Standards SIS-05-5900 (Latest Revision) or better according to ISO 8501-1 and shall be measured using the replica tape method or the comparator method.

The roughness (profile) of blast-cleaned surfaces shall be Medium (G) according to ISO 8503-2: 1988 (appendix 1) unless otherwise specified. Medium defines a surface profile with a maximum peak-to-valley height of 60-100 microns, and G indicates that the surface profile is obtained by grit blasting. For the evaluation of surface roughness Comparator G shall be used.



Abrasive blast cleaning shall NOT be performed when the ambient or the substrate temperatures are less than 3 Degree Celsius above the dew point temperature. The relative humidity should preferably be below 50% during cold weather and shall never be higher than 60% in any case.

Abrasive blast cleaning shall be performed with a clean, sharp grade of abrasive. Grain size shall be suitable for producing the specified roughness. Abrasives shall be free from oil, grease, moisture and salts, and shall contain no more than 50ppm chloride. The use of silica sand, copper slag and other potentially silica containing materials shall not be allowed.

The blasting compressor shall be capable of maintaining a minimum air pressure of 7 kPa at the nozzle to obtain the acceptable surface cleanliness and profile.

The blast cleaning air compressor shall be equipped with adequately sized and properly maintained oil and water separators. The air supply shall be checked to ensure no oil and water contamination at the beginning of each work shift.

Blast cleaning abrasive shall be stored in a clean, dry environment at all times. Recycling of used abrasive is prohibited. After blast cleaning, the surfaces shall be cleaned by washing with clean water (Pressure 7kg/cm<sup>2</sup> using suitable

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		Document No.	Rev	
		Sheet 136 of 242		

nozzles. During washing broom corn brushes shall be used to remove foreign matter.

Assessment of the blast cleaned surfaces shall be carried out in accordance with reference code.

Blast cleaned surfaces which show evidence of rust bloom or that have been left uncoated overnight shall be re-cleaned to the specified degree of cleanliness prior to coating.

All grit and dust shall be removed after blasting and before coating application. Removal shall be by a combination of blowing clean with compressed air, followed by a thorough vacuum cleaning with an industrial grade, heavy duty vacuum cleaner.

All cleaned surfaces shall have protection from atmospheric corrosion as per IS8629:1977

#### 9.1.2 **Painting system to be used is indicated below:**



##### **1. Epoxy Painting:**

- a) Primer P 1-2 coats + finish paint FP1 (2 coats) where P1 is epoxy polyamide cured zinc chromate primer having DFT of 35 micron per coat and FP1 is epoxy polyamide cured finish paint having DFT (Dry Film Thickness) of 35 micron per coat.

Equivalent product chart for approved paint manufactures for primer P1 finish paint FP1 indicated above is enclosed.

##### **2. For PU painting:**

- i) P1 – One coat of Ethyl silicate inorganic zinc primer having DFT of 70 microns per coat.
- ii) IP1 – One coat of Epoxy MIO having DFT of 70 microns per coat.
- iii) FP1 - One coat of finish epoxy paint using two pack Polyamide cured epoxy having DFT of 40 microns per coat.

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></p><p><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></p></div>	PC288/E/001/P-II/5.5	P	<div><p>भारत कोयला गैसीकरण और रासायनिक उद्योग लि. <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 137 of 242		

- iv) FP2 - One coat of Aliphatic Acrylic Polyurethane paint having DFT of 40 microns per coat.

Equivalent product chart for approved paint manufactures for P1, IP1, FP1 & FP2 indicated above is enclosed.

- 9.1.3 All the surfaces must be abrasive blasted and 2 coats of primer plus 1 coat of finish paint applied in the fabrication shop before the same are shifted to site for erection. All the members must be suitably match marked for facilitating proper assembly.

After erection is over all surfaces shall be washed up as follows:

Washing with clean water (pressure 7 kg/cm<sup>2</sup>) using suitable nozzles. During washing broom corn brushes shall be used to remove foreign matters.



Solvent washing if required to remove traces of oil grease etc.

After washing the surface as indicated above, the surfaces shall be suitably touched up to the extent required so that all the damages to the primed surfaces caused during erection are done up.

- b) The surfaces affected by welding and / or gas cutting during erection shall also be suitably touched up. Before touch up is taken up surfaces shall be prepared by mechanical means such as grinding, power brushing etc. to achieve surface finish to ST-3.
- c) After touch up work is over as indicated above, all the surfaces shall be given one coat of finish paint to the required specification.

- 9.1.4 The following points must be observed for painting work:

1. Primer and paint shall be compatible to each other and should be from the same manufacturer.
2. The recommendation of the paint manufacturer regarding mixing, matching and application must be followed meticulously.

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></p><p><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></p></div>	PC288/E/001/P-II/5.5	P	<div><p>भारत कोयला गैसिफिकेशन लिमिटेड <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 138 of 242		

3. Technical representative of paint manufacturer should be available at site as and when required by **Engineer-in-Charge** for their expert advice as well as to ensure that the painting work is executed as per the instruction of paint manufactures.
- d) Paints and primers shall be supplied at site in original container with factory seal otherwise such paints and primers shall not be allowed to be used. Mode of application i.e. by spray, brush or roller shall be strictly as per recommendation of paint manufacturer.
  - e) Painting materials must be used before the expiry date indicated on the containers.
  - f) Number of coats and DFT per coat must be strictly followed as indicated above. If the desired DFT is not achieved for primer and finish paints in two coats (each), **CONTRACTOR** shall be required to apply extra coat (s) to achieve the desired DFT without any extra cost to **Engineer-in-Charge**.
  - g) Color shade for each coat of primer and finish paint must be different to identify the coats without any ambiguity.
  - h) Shade for the final finish coat shall be decided by **Engineer-in-Charge** at site.
  - i) All painting materials must be accompanied by manufacturers test certificates. However, Engineer-in-Charge has any doubt regarding quality of materials, he shall have the right to direct CONTRACTOR to get the doubtful material tested or and provided (by CONTRACTOR) testing agencies for which no extra payment shall be made to the CONTRACTOR and the charges shall deemed to be covered in the unit rates quoted for fabrication and erection of structural work.
  - j) DFT for paint shall be measured at least 20 points and mean DFT shall not vary by more than 10% than specified in DFT.
  - k) Reliable and calibrated Instrument for measurement of DFT shall be arranged and provided by **CONTRACTOR** at his cost.
  - l) Thickness of each coat shall also be checked regularly to ensure uniformity in DFT.
- 9.1.5 Abrasive blasting and painting works, being a specialized job must be carried out through the approved agencies only.





### 9.1.6 Equivalent Chart for Various Paint Manufacturers for Epoxy paint

	ASIAN	G & N	SHALIMAR	J & N	BERGER	BOMBAY
P1	APCODUR - Epoxy Zinc Chrome Primer	AMERCO AT-71	EPIGARD-4 Zinc Chromate Primer	EPILAC Zinc Chromate Primer	EPILUX-4 Zinc Chromate Primer	PENTADUR PRIMER 1532
FP1	APCODUR CF 692	NEROLAC TWO COMP EPOXY	EPIGARD XL FINISH	EPILAC 974 ENAMEL	EPILUX-4 ENAMEL	PENTADUR ENAMEL 5534 GRAY

### 9.1.7 Equivalent Chart for Various Paint Manufacturers for PU paint

CODE	ITEM	DFT PER COAT (MICRO NS)	ASIAN	G & N	SHALIMAR	J & N	BERGER	BOMBAY
P1	ETHYL SLILICATE INORGA- NIC ZINC PRIMER	70	APCOSIL 601	DYMET - COTE - 9	TUFFKOTE ZILICATE	J&N INORGA- NIC ZINC SILICATE PRIMER	ZINC ANODE 304	HEAPELS GALVO- SIL 1570
IP1	EPOXY MIO	70	APCO- DUR MIO	AMER COAT 385	EPIGUARD HB MIO	EPILAC HB MIO	EPILUX- 4 HB MIO	PENTA- DUR HB MIO 4567
FP1	TWO PACK POLYA- MIDE CURED EPOXY	40	APCO- DUR CF-692	NERO- LAC TWO COMP EPOXY	EPIGUARD XL	EPILAC 974	EPILUX- 4 ENAMEL	PENTA- DUR ENAMEL 5534
	ALIPHA-	40	APCO-	AMER-	SHALI-	JN 992	BERGA-	PENTO-

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>					PC288/E/001/P-II/5.5	P	
						Document No.	Rev	
						Sheet 140 of 242		
FP2	TIC ACRYLIC POLYURE- THANE PAINT		THANE 674	COAT 450 GL	THANE	PU FINISH PAINT	THANE ENAMEL	THANE 4513

## 10.0 Steel / Aluminium Doors, Windows and Ventilators

- 10.1 The Steel doors, windows and ventilators shall be of the size and type as per IS-1361 and IS-1038. Fixing and glazing shall be done as per IS-1081 and as per manufacturer's instructions. The putty of approved make such as special gold size or equivalent conforming to IS-419 shall be used.
- 10.2 Aluminium doors, windows and ventilators shall be manufactured from wrought aluminium and aluminium alloy extruded round tube and / or hollow rectangular / square sections conforming to IS: 1285 & IS : 6477 or equivalent as approved by **Engineer-in-Charge**.

## 11.0 ROOFING & CLADDING



All roof and cladding sheets should be galvalume sheet of 0.5 mm total coated thickness with 550 MPA grade steel confirming to AS 1397 with AZ150 grade coating.

Translucent sheets shall be provided, in non-process areas only, intermittently where day lighting is required.

## 12.0 FLOORING AND PAVING

### 12.1 Sub Base of floor

- 12.1.1 The area to be paved shall be divided into suitable panels. Form work shall be provided. The boarding / battens shall be fixed in position with their toe at proper level, giving slope where required. Alternatively base concrete may be deposited in the whole area at a stretch.
- 12.1.2 Before placing the base concrete the sub-base shall be properly wetted and rammed. The concrete of the specified mix shall then be deposited between the forms where provided, thoroughly tamped and the surface finished level with the

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसिफिकेशन और केमिकल्स लिमिटेड <b>BHEL</b>
		Document No.	Rev	
		Sheet 141 of 242		

top edge of the forms. The surface of base concrete shall be spreader uniformly. The surface shall be finished rough to provide adequate bond for the topping. Two or three hours after concrete has been laid the surface shall be brushed with wire brush to remove any scum or Latinate and swept clean so that coarse aggregate is exposed.

## 12.2 Cement Concrete Floor Finishes

12.2.1 The surface of base concrete shall be thoroughly cleaned by scrubbing with coir or steel wire brush. Before laying the topping, the surface shall be soaked with water at least for 12 hours and surplus water mopped up immediately before the topping is laid.

12.2.2 The forms shall be fixed over the base concrete dividing into suitable panels. Where glass dividing strips are provided, thickness of glass dividing strips shall be 4 or as indicated. Before placing the concrete topping, neat cement slurry at the rate of 2 kg/sq.m shall be then thoroughly brushed into the base concrete just ahead of the finish. The topping shall then be laid, thoroughly compacted by using screed board/plate vibrator. The surface floated with a wooden float to a fair and even surface shall be left for some time till moisture disappears from it. Junctions with skirting / dado or wall surfaces shall be rounded off using cement mortar 1:2 curing shall be carried out for a minimum of 7 days.

## 13.0 PLASTERING



13.1 Sand for plastering shall be 50% fine sand and 50% coarse sand from approved sources.

13.2 Preparation of surface shall be done as per CPWD specifications.



13.3 Cement mortar shall be of the mix as indicated in the items and shall be mixed as specified in the CPWD specifications.

13.4 Joints in walls etc. shall be raked to a depth of 12 mm, brushed clean with wire brushes dusted and thoroughly washed before starting the plaster work.

13.5 The surface shall be thoroughly washed with water cleaned and kept wet to saturation point before plastering is commenced.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 142 of 242		

- 13.6 Cement mortar as indicated, shall be firmly applied to the masonry walls in a uniform layer to the thickness specified and will be pressed into the joints. On concrete surfaces rendering shall be dashed to the roughened surface to ensure adequate bond. The surface shall be finished even and smooth. Hectoring wherever required shall be done as per directions of **Engineer-in-Charge**. Nothing extra shall be paid on this account.
- 13.7 All plaster work shall be cured for at least 7 days.
- 13.8 Integral water proofing compound shall be mixed with cement in the proportion recommended by the manufacturer. Care shall be taken to ensure that the water proofing material gets well and integrally mixed with cement. All other operations are the same as for general plaster work.
- 13.9 For sand face plaster undercoat of cement plaster 1:4 (1 cement : 4 sand) of thickness not less than 12 mm shall be applied similar to one coat plaster work. Before the under coat hardens the surface shall be scared to provide for the top coat. The top coat also of cement mortar 1:4 shall be applied to a thickness not less than 8 mm and brought to an even surface with a wooden float. The surface shall then be tapped gently with a wooden float lined with cork to retain a coarse surface texture, care being taken that the tapping is even and uniform.
- 14.0 Exterior Painting or Apex**
- 14.1 Exterior painting shall be Apex.
- 14.2 Where shown on drawings for external surfaces of sand faced plaster, or any other surface, two coats of cement paint shall be applied of tint and shade as approved by the **Engineer-in-Charge**.
- 14.3 The surfaces shall be prepared as specified for white washing. Before applying cement paint the surface shall be thoroughly wetted to control surface suction. The surface shall be moist but not dripping wet, when the paint is applied. Not less than 24 hours shall be allowed between the two coats. In hot weather the first coat shall be slightly moistened before applying the second coat.
- 14.4 On external plastered surfaces (one coat primer + minimum 3 coat of paints), sand faced or plain plastered and concrete surfaces, apex weather proof paint

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 143 of 242		

shall be vigorously scrubbed on to work the paint into the voids and provide a continuous paint film free from pin holes and other openings.

## 15.0 GLAZING

15.1 Sheet glass glazing of doors, windows etc. shall be of selected quality glass conforming to IS: 2835. Toughened splinter proof industrial safety glass shall confirm to IS: 2553. No cracked chipped or disfigured glass shall be accepted. Glass shall be in one piece for each pan.

15.2 Glazing shall be fixed with timber or steel / aluminium beading as called for. Glass shall be back puttied and fixed with beading for a water tight and rattle free installation. Sizes of timber/ steel / aluminium beading shall be as directed.

## 16. PROTECTIVE COATING AND LINING SYSTEM

### 16.1 ACID PROOF TILES:

#### MATERIAL

#### 1) TILES



These tiles shall be made of clays, feldspar, quartz, talc and vitrified at high temperature in ceramic kilns and kept unglazed so as to prevent from slipperiness. Tiles shall not absorb more than 2% of their own dry weight when soaked in water. Compression strength: 700 Kg/cm<sup>2</sup> Min. & Flexural strength: 200 Kg/cm<sup>2</sup> Min. It shall not lose more than 1.5% of its weight when soaked in acid.

#### Chemical compositions of tiles:

- Al<sub>2</sub>O<sub>3</sub> : 22-24%
- SiO<sub>2</sub> : 60-65%
- Fe<sub>2</sub> O<sub>3</sub> : 1.0-2.0%
- Alkalise : 10-12%

#### 2) K-BASED SILICATE MORTAR

Acid Proof cement KSC is a potassium silicate based corrosion cement. Acid tile linings carried out with KSC cement are not subject to crystal formation in

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 144 of 242		

the pores of cement. Besides Bitumastic surface is joint-less, hence there is no danger of Acids percolating through the surface.

Characteristics of K-based Silicate mortar:

- Colour : White
- Density (lbs/Cub. ft.) : 130
- Water Absorption : 2-5 %
- Tensile Strength (Psi) : 400
- Compressive strength (Psi) : 2800
- Bond Strength (Psi) : 180
- Coefficient of thermal expansion :  $6.0 \times 10^{-6}$

### 3) BITUMASTIC MORTAR

It shall consist of an acid proof inorganic filler and blended bitumen. It shall be trowelled to concrete having total thickness of 10 mm.

#### Characteristics of Bituminous compounds:

- Density ( $\text{Kg/m}^3$ ) : 2200
- Water content by mass percent (max) : 0.5
- Flash point  $^{\circ}\text{C}$  ,min. : 35

#### Consistency

- a) Before setting (test after 1 hr) min. : 100
- b) After setting (test after 24 hr) min. : 80

Mastic shall be heated to  $150\text{-}300^{\circ}\text{C}$  and shall be applied in 5 mm layers after surface is cleaned and dried.

### 4) BITUMINOUS PAINT

This is generally of heavy grade bituminous corrosion resisting paint. 2 coats of the paint shall be given, and drying time between the 2 coats shall not be

less than 5 hours. Also, its drying time after second coat shall not be more than 8 hours. Its finish shall be smooth, glossy and elastic.

The primer shall confirm to the following requirements:

- Viscosity by standard tar viscometer, 4mm orifice at 25°C: 4 to 24
- Penetration at 25°C, 100g, 5sec in 1/100 cm : 20 to 50
- Water content percent (max) : 0.2

### APPLICATION

SL. NO.	DESCRIPTION	ITEM OR AREA
1.	Bituminous Paint (Primer)	Concrete surface
2.	10mm Bitumastic Laying in two layers each shall not be more than 5mm thick	Over Bituminous Paint
3.	One layer, 5mm Acid, K-based Silicate Type mortar	#
4.	10 mm thick Acid proof tiling	Over K-based Silicate

# - Tiles should be fixed on bitumastic surface with the help of 5mm K-based silicate mortar.

16.2



### EPOXY COATING

#### A. MATERIAL

##### 1) EPOXY COATING

Characteristics of coated surfaces (after application)

- Compressive strength : min. 90 N/mm<sup>2</sup>
- Tensile strength : min. 10 N/mm<sup>2</sup>
- Abrasion resistance : as per Amsler 1.5 mm after 3000 revol.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 146 of 242		

- Bonding (joining) factor : 1

#### APPLICATION:

SL. NO	DESCRIPTION	APPLICATION
1.	One coat of two pack interpenetration polymer (Epoxy Phenolic)  Thickness 60 micron per coat	Primer coat on Concrete surface
2.	One coat of two pack interpenetration polymer (Epoxy Phenolic)  Thickness 100 micron per coat	Intermediate Coat over Primer Coat
3.	One coat of two pack interpenetration polymer (Polyurethane)  Thickness 50 micron per coat	Final Coat over Intermediate Coat
4.	Sealing by polysulphide compound	This will be provided at all joints with foundation, pits & wall etc



### 16.3 ACID RESISTANT BRICK LINING

#### A. MATERIAL

These bricks are made of raw materials such as clay or shale of suitable composition with low lime and iron content, feldspar, flint or sand and vitrified at high temperature in ceramic kilns. Bricks shall not absorb more than 2% of their own wt. when soaked in water. Compression strength: > 700 Kg/cm<sup>2</sup>. Bricks shall not lose more than 1.5% at their own weight when tested for acid resistance.

Chemical compositions of bricks are



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 147 of 242		

- a)  $\text{Al}_2\text{O}_3$  22-24%
- b)  $\text{SiO}_2$  60-65%
- c)  $\text{Fe}_2\text{O}_3$  1.0-2.0%
- d) Alkalies 10-12%

#### 1) K-BASED SILICATE MORTAR

Acid Proof cement KSC is a potassium silicate based corrosion cement. Acid brick linings carried out with KSC cement are not subject to crystal formation in the pores of cement. Besides Bitumastic surface is joint-less, hence there is no danger of Acids percolating through the surface.

Characteristics of K-based Silicate mortar:



Colour	: White
Density (lbs/Cub. ft.)	: 130
Water Absorption	: 2-5 %
Tensile Strength (Psi)	: 400
Compressive strength (Psi)	: 2800
Bond Strength (Psi)	: 180
Coefficient of thermal expansion	: $6.0 \times 10^{-6}$

#### 2) BITUMASTIC MORTAR

It shall consist of an acid proof inorganic filler and blended bitumen. It shall be trowelled to concrete having total thickness of 10 mm.

Characteristics of Bituminous compounds:

Density ( $\text{Kg/m}^3$ )	: 2200
Water content by mass percent (max)	: 0.5
Flash point $^{\circ}\text{C}$ , min.	: 35
Consistency	
c) Before setting (test after 1 hr) min.	: 100

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></div>	PC288/E/001/P-II/5.5	P	<div></div>
		Document No.	Rev	
		Sheet 148 of 242		

d) After setting (test after 24 hr) min. : 80

Mastic shall be heated to 150-300°C and shall be applied in 5 mm layers after surface is cleaned & dried.

### 3) BITUMINOUS PAINT(PRIMER)

This is generally of heavy grade bituminous corrosion resisting paint. 2 coats of the paint shall be given, and drying time between the 2 coats shall not be less than 5 hours. Also, its drying time after second coat shall not be more than 8 hours. Its finish shall be smooth, glossy and elastic.

The primer shall confirm to the following requirements:

Viscosity by standard tar viscometer, 4mm orifice at 25°C : 4 to 24



Penetration at 25°C, 100g, 5sec in 1/100 cm : 20 to 50

Water content percent (max) : 0.2

### APPLICATION

SL. NO.	DESCRIPTION	ITEM OR AREA
1.	Bituminous Paint (Primer)	Concrete surface
2.	10mm Bitumastic Laying in two layers each shall not be more than 5 mm thick	Over Bituminous Paint
3.	One layer, 5mm Acid, K-based Silicate Type mortar	#
4.	One layer, 40mm Acid resistant Brick lining	Over K-based Silicate

#:- K-based Silicate mortar should be buttered on all sides of acid-resistant brick except the side facing the surface to be exposed to corrosives

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसीकरण और रासायनिक सीएल <b>BHEL</b>
		Document No.	Rev	
		Sheet 149 of 242		

## 17.0 CULVERT WORK



### 17.1 Pipe Culverts

17.1.1 Reinforced concrete pipes shall be provided between the drain pits of storm water drains to cross the roads. These pipes shall be non-pressure type conforming to IS: 458 and class as specified in the nomenclature of the item. The pipes shall be laid between the drain pits with a uniform slope and with proper bedding, if required, as per approved drawings. The reinforced concrete pipes shall be manufactured by centrifugal process. All pipes shall be true to shape, perfectly straight, sound and free from cracks. The pipes shall be free from defects resulting from imperfect grading of the aggregate mixing or moulding.



17.1.2 Reinforced concrete pipes shall be laid, jointed and tested as per IS: 783. Pipes shall be laid true to alignment and gradients over cement concrete bed of 1:2:4 mix and / or encased, if required, as per approved drawings or as directed by Engineer-in-Charge. No deviations from the lines, depths of cuttings or gradients shall be permitted without approval in writing by Engineer-in-Charge. The joint between concrete drain pit wall and concrete pipe shall be done properly to make it water-tight. The pipe joints shall be spigot and socket joint (rigid type) for pipes of 600 mm. diameter and below and collar joint (rigid type) for pipes over 600 mm. diameter. For both types of joints, the annular space shall be filled up with cement and sand mortar 1:2 mix which shall be rammed with caulking tools. After the day's work, any extraneous matter shall be removed from inside of the pipes. Joints shall be cured properly as per IS: 783. Reinforced concrete pipes shall be tested hydraulically as per IS: 783. Refilling of trenches shall not be commenced until the entire length of the pipe has been tested and approved. The excavation of earth in trenches for laying the concrete pipes and refilling shall be done as per IS: 783.

### 17.2 Box Culverts

17.2.1 The box-culverts are to be provided across the roads joining the storm water drains on both sides of the road. These box-culverts shall be of either complete reinforced cement concrete construction or brick masonry and reinforced cement

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 150 of 242		

concrete construction as specified in the schedule of items. The box-culvert construction shall be carried out as per the approved drawings.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 151 of 242		



## ANNEXURE-VI

**ES-2517**

### TECHNICAL SPECIFICATION



**FOR**

**WATER SUPPLY, DRAINAGE & SANITATION**

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 152 of 242		

## CONTENTS

SL.NO.	DESCRIPTION	Page No.
1.0	SCOPE	162
2.0	GENERAL REQUIREMENTS	162
3.0	CODES & STANDARDS	163
4.0	MATERIALS	166
5.0	MANHOLES	173

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 153 of 242		

## 1.0 Scope

### 1.1 This Specification Covers

The supply, laying and installation of pipes / open surface drains for draining off rain / surface water, fire water, sewage, plant effluent / blow down / floor washings etc., with all fittings and fixtures including jointing.

The supply, laying and installation of pipes for supply of water with all fittings and fixtures including jointing.

The supply and installation of sanitary fixtures like water closets, urinals, wash basins, sinks etc., with all fittings and fixtures.

The supply and installation of toilet accessories like mirrors, shelves, towel rails, liquid soap containers etc., with all fittings and fixtures.

The supply and installation of overhead water tanks with all fittings and fixtures.



The supply and construction of ancillary works like manholes, drop connections, gully chambers, oil traps, soak pits etc., with all fittings and fixtures.

## 2.0 GENERAL REQUIREMENTS

2.1 The Contractor shall furnish all skilled and unskilled labour, plant, equipments, scaffolding, men, materials, etc., required for complete execution of the work in accordance with the drawings and as described herein and / or as directed by the Engineer.

2.2 The Contractor shall make his own arrangements for locating the coordinates and positions of all works and reduced levels (RL) at these locations based on two reference grid lines and one bench mark which will be furnished by the owner. The Contractor has to provide at site all the required survey instruments etc., to the satisfaction of the Engineer so that the work can be carried out accurately according to the specification and drawing.

2.3 The Contractor shall make good to the satisfaction of the Engineer all cuttings / damages resulting from his operations during the installation.

<div> पी डी आई एल <b>PDIL</b></div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div> <div>OWNER: Bharat Coal Gasification and Chemicals Limited</div> <div>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</div>	PC288/E/001/P-II/5.5	P	<div> भारत कोयला गैसीकरण और रासायनिक उद्योग <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 154 of 242		

2.4 Only tentative Plant layout shall be furnished by the Owner. Detailed working drawings showing the layout, installation and other details will be prepared by the Contractor and got approved from the Engineer.

2.5 The Contractor shall dispose of all unserviceable materials at least 50 m away from the plant boundary, unless otherwise directed by the Engineer. All serviceable material shall be stacked within a lead of 500 m as directed by the Engineer.

2.5 In case of any contradiction between the provisions stipulated in this module of technical specification and those of other modules like Excavation and Filling, Cast-in-situ Concrete and Allied works etc., the former shall govern.

All works shall be carried out by qualified / licensed plumbers.

### 3.0 CODES AND STANDARDS

3.1 All standards, specifications, acts, and Codes of practice referred to herein shall be the latest edition including all applicable official amendments and revisions.

3.2 In case of conflict between this specification and those (IS Standards, codes etc.) Referred to herein (in para 3.3) the former shall prevail.

3.3 Some of the relevant Indian Standards, Acts and Codes referred to herein are given below:

IS : 458 : Precast concrete pipes.

IS : 554 : Dimensions for pipe threads, where pressure tight joints are made on threads.



IS : 651 : Salt glazed stoneware pipes and fittings.

IS : 771 : Glazed fire clay sanitary appliances.



(Part-1 to 7)

IS : 774 : Flushing cisterns for water closets and urinals.





 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 155 of 242		

IS	:	775	:	Cast iron brackets and supports for wash basins and sinks.
IS	:	778	:	Copper alloy gate, globe and check valves for water works purposes.
IS	:	781	:	Cast copper alloy screw down bib taps and stop valves for water services.
IS	:	782	:	Caulking lead.
IS	:	783	:	Code of practice for laying of concrete pipes.
IS	:	805	:	Code of practice for use of steel in gravity water tanks.
IS	:	1172	:	Code of basic requirements for water supply, drainage and sanitation.
IS	:	1239	:	Mild steel tubes, tubular and other wrought steel fittings.
IS	:	1536	:	Centrifugally cast (Spun) iron pressure pipes for water, gas and sewage.
IS	:	1703	:	Copper alloy float valves.
IS	:	1726	:	Cast iron manhole covers and frames.
IS	:	1729	:	Sand cast iron spigot and socket, soil waste and ventilating pipes, fittings and accessories.
IS	:	1742	:	Code of practice for building drainage.
IS	:	1795	:	Pillar taps for water supply purposes.
IS	:	2065	:	Code of practice for water supply in buildings.
IS	:	2326	:	Automatic flushing cisterns for urinals.
IS	:	2501	:	Solid drawn copper tubes for general engineering purposes.
IS	:	2548	:	Plastic seats and covers for water closets.
IS	:	2692	:	Ferrules for water services.
IS	:	2963	:	Copper alloy waste fittings for wash basins and sinks.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 156 of 242		

IS	:	3311	:	Waste plug and its accessories for sinks and wash basins.
IS	:	3438	:	Silvered glass mirrors for general purposes.
IS	:	3486	:	Cast iron spigot and socket drain pipes.
IS	:	3989	:	Centrifugally cast (spun) iron spigot and socket soil, waste and ventilating pipes, fittings and accessories.
IS	:	4111 (Part-1 to 5)	:	Code of practice for ancillary structure in sewerage system.
IS	:	4127	:	Code of practice for laying of glazed stone-ware pipes.
IS	:	4764	:	Tolerance limits for sewage effluent discharged into inland- surface waters.
IS	:	4827	:	Electro plated coatings of nickel and chromium on copper and copper alloys.
IS	:	5219	:	Cast copper alloys traps.
IS	:	5329	:	Code of practice for sanitary pipe work above ground for buildings.
IS	:	5382	:	Rubber sealing rings for gas mains, water mains and sewers.
IS	:	5822	:	Code of practice for laying of welded steel pipes for water supply.
IS	:	6163	:	Centrifugally cast (spun) iron low pressure pipes for water, gas and sewage.
IS	:	7231	:	Plastic flushing cisterns for water closets and urinals.
IS	:	7740	:	Code of practice for construction and maintenance of road gullies.
IS	:	8931	:	Copper alloy fancy single taps combination tap assembly and stop valves for water services.
IS	:	8934	:	Cast copper alloy fancy pillar taps for water services.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 157 of 242		

- IS : 9762 : Polyethylene floats for float valves.
- IS : 10446 : Glossary of terms for water supply and sanitation.
- IS : 10592 : Industrial emergency showers, eye and face fountains and combination units.
- IS : 12592 : Specification for precast concrete manhole covers and frames.
- SP : 35 : Hand book on water supply and drainage.



#### 4.0 MATERIAL

- 4.1 All pipes, fittings, fixtures, appliances and accessories shall conform to the relevant Indian Standards as listed under Clause No. 3.0. These shall be obtained from an approved reputed manufacturer, and shall be approved, the Engineer. Wherever indicated by the Engineer, the Contractor shall submit samples of materials. These may be retained by him for subsequent comparison when bulk supplies are received at site. Ultimate choice of type lies completely with the Engineer.
- 4.2 The material brought to the site shall be stored in a separate secured enclosure, away from the building materials. Pipe threads, sockets and similar items shall be specially protected till final installation. Brass and other expensive items shall be kept under lock and key. Fragile items shall be checked thoroughly when received at the site and item found damaged shall not be retained at site.
- 4.3 Chromium plating fittings and appliances shall be of grade-2. (10 micron thickness), conforming to IS: 4827.

#### 4.4 Pipes

Unless otherwise specified, following types of pipes shall be used:

For water supply to buildings, fittings CPVC pipes conforming to IS 15778 shall be used.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 बी एच ई लिमिटेड <b>BHEL</b>
		Document No.	Rev	
		Sheet 158 of 242		

For inlet connecting pipes to appliances / fittings, C.P. brass pipe of 15 mm N.B. with union of approved make shall be used. Standard length of 300 mm to 450 mm pipe shall be used to suit the site requirements.

For building sanitary work above ground, UPVC pipes, fittings and accessories conforming to IS: 13592/relevant IS Codes shall be used. Pipes shall be coated with coal-tar by hot dipping process for both inner and outer surfaces.

Glazed stoneware pipes used for sewer and drain shall conform to Grade A of IS: 651. RCC pipe used for sewer and drain shall conform to IS: 458. Class NP2 pipe shall generally be used. However, for road or railway crossing higher class of pipe or concrete encashment shall be provided to take care of higher load. For drain and sewer line work in bad or unstable ground condition and under building, centrifugally cast (Spun) iron pressure pipes conforming to IS: 1536 shall be used. Class LA pipe with spigot and socket ends shall be used. Pipes shall be coated with coal tar.



PVC rain water pipes shall be used for roof drainage.

#### 4.5 Above Ground Level

##### 1) Galvanised mild steel pipes for water supply

For work above ground level, the galvanised mild steel pipes and fittings shall run on the surface of the walls, ceiling or in chase as specified or shown on the drawing. The fixing shall be done by means of standard pattern holder bat clamps, provided at no more than 90 cm and keeping the pipes about 1.5 cm clear of the wall. To conceal the pipes, chasing may be adopted or pipes fixed in the ducts or recess etc. Provided there is sufficient space to work on the pipes with the common tools. The pipes shall not ordinarily be buried in walls or solid floors. Under unavoidable situations, pipes may be buried for short stretch after providing adequate protection against damage. Union joints shall be provided for all required locations to facilitate maintenance.

Where directed by the Engineer, a M.S. tube sleeve shall be fixed at a place the pipe is passing through. In case the pipe is embedded, it should be painted with anti-corrosive bitumastic paints conforming to IS: 158. The pipes

<div> पी डी आई एल <b>PDIL</b></div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT OWNER: Bharat Coal Gasification and Chemicals Limited DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</div>	PC288/E/001/P-II/5.5	P	<div> भारत कोयला गैसीकरण और रासायनिक उद्योग <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 159 of 242		

shall be oiled and rubbed over the white lead and a few turns of spun yarn wrapped round the screwed end of the pipe. The end shall then be screwed in the socket, tee etc., with the pipe wrench. All pipes and fittings shall be properly jointed and made complete water tight. Burr from the joint shall be removed after screwing.



The pipes and fittings shall be checked under working pressure. Any joint found leaking, shall be rectified and all leaking pipes removed and replaced. The pipes and fittings shall be tested to a hydraulic pressure of 6 kg/sq.cm. All pipes used for water supply should be thoroughly and efficiently disinfected before being taken into use. The method of disinfection shall be subject to the approval of the Engineer.

The storage tanks and downtake distribution pipes shall be disinfected together as specified under clause no. 13.2 of IS: 2065-1983, using disinfecting chemical.

## 2) UPVC pipe above ground for Buildings Sanitary work

For sanitary pipe work above ground for Buildings, 1S:5329 shall be followed for general guidance. Proper ventilation shall be provided in the piping system. The single stack system shall not generally be provided.

Plain pipes shall be secured to the walls at all joints with M.S. holder bat clamps. The clamp shall be made from 1.6 mm thick M.S. sheet of 30 mm width, bent to the required shape and size so as to fit tightly on the socket of the pipe, when tightened with screw bolts. It shall be formed out of two semicircular pieces, hinged with 6 mm dia M.S. pin on one side and provided with flanged ends on the other side with holes to fit in the screw holt and nut, 40 mm long. The clamp shall be provided with a hook made out of 27.5 cm long, 10mm diameter M.S. bar, riveted to the ring at the centre of one semicircular piece. C.I. brackets can also be used. The clamps shall be fixed to the wall by embedding their hooks in cement concrete block 10 x 10 x 10 cm (1:2:4 mix) for which necessary holes shall be made in the wall at proper places. The clamps shall be kept about 25 mm clear of finished face of wall.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 160 of 242		

All soil pipes shall be carried up above the roof and shall have sand PVC terminal guard. The pipes above parapet shall be secured to the wall by means of clamps.



The pipes shall be fixed perfectly vertical or to the lines as directed. The spigot of the upper pipes shall be properly fitted in the socket of the lower pipe such that there is a uniform annular space for filling with the jointing material. The interior of the socket and exterior of the spigots shall be thoroughly cleaned and dried. The spigot end shall be inserted into the socket right up to the back of the socket and carefully jointed using solvent as per recommendation of manufacturer.

Floor trap shall be 'Nahni' or ordinary type and shall conform to IS:1729. The floor shall be suitably lowered to accommodate the trap and the top of the floor shall be properly sloped towards the trap for effective drainage. A chromium plated/galvanised grating shall be provided on the trap. The sunken floor slab shall be filled with light weight materials like cinder mixed with cement. Sunken slab shall be made watertight by means of Sika water proofing compound as recommended by the manufacturer.

### **Rain Water Downcomers**

Rain water downcomers and fittings shall be standard PVC rainwater downcomers shall run along and be secured to walls, columns etc. Where desired by the Engineer, these may have to be installed in chases cut out in the structure. All pipes shall be well secured to the walls and supported by adequately strong brackets. The brackets may be wrought iron clevis type, lip-ring type or perforated strap iron type, as approved by the Engineer. Suitable spacer blocks shall be provided against the vertical surface on which the pipe is fixed.

All bends and junctions shall be supplied with water tight cleaning eyes. For improving the aesthetic appearance of the portion of building carrying rain water downcomers, the pipes may have to be concealed by encasing them with brick masonry, concrete, etc.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 161 of 242		

Galvanised M.S. pipes shall be joined by using standard sockets or by welding. For welding of pipes, IS:11906 shall be followed. After welding, the welded area shall be coated with zinc rich paint after proper cleaning and preparation of the surface. Joints between successive lengths of pipe can be by collars according to provision of IS:1742-1983. All rainwater downcomers shall be provided with roof drain head of the shape and type as shown on the drawing. Unless otherwise specified, dome type drain head shall be used.

### 3) Khurras

The khurras shall be constructed before the brick masonry work in parapet wall is taken up, and it shall be 45x45cm in size, unless otherwise specified and be formed of cement concrete 1 :2:4 (1 cement: 2 sand: 4 graded stone aggregate of 20 mm nominal size).



A PVC sheet 1 mx1 mx400 micron shall be laid under khurras and then cement concrete shall be laid over it to a minimum thickness of 3cm with its top surface lower than the level of adjoining roof surface by not less than 50mm.

The concrete shall be laid to a size greater than the stipulated size of khurra in such a way that the adjoining terracing of brick tile overlaps the concrete on its 3 edges by not less than 7.5 cm. The concrete shall slope uniformly from the edges to the rainwater outlet. The concrete shall be continued at the same slope through the width of the wall into outlet opening to ensure a water tight joint.

The khurras and the sides of outlet shall then be rendered with 12 mm coat of cement plaster 1:3 (1 cement: 3 sand). This shall be done when the concrete is still green and shall be finished with a floating coat of neat cement. The sides of khurras and the sides of openings shall be well rounded. The size of finished outlet opening shall be 10cm wide by 20cm high or as directed by the Engineer.

Iron grating shall be provided at the outlet to prevent chocking. The grating shall be 20x25cm with an outer frame of 15mm x 3mm MS flat, to which 4



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसिफिकेशन और केमिकल्स लिमिटेड <b>BHEL</b>
		Document No.	Rev	
		Sheet 162 of 242		

nos. - 10mm dia MS bars shall be welded in vertical direction, keeping an equal clear spacing of 2.5cm.

#### 4) Rainwater Spout

No spout shall be less than 80 mm in diameter. The spacing of spouts shall be arranged to suit the position of openings in the wall.

The spouts shall be of PVC, 60 cm long. These shall be perfectly sound, free from cracks, imperfections of glazing etc. These must be straight, cylindrical and of Standard nominal diameter, length and depth of socket. Full length of pipes shall be used on the work. These must be salt glazed and shall generally conform to IS: 651.



These shall be provided at the mouths of khurras and shall be fixed in cement mortar 1: 4 (1 cement: 4 sand) with the socket embedded in the masonry and the spigot end projecting outside. The masonry around the pipe and socket shall be thoroughly wetted and the hole shall be given a coat of cement mortar around. The pipe shall then be inserted and fixed with a surround of mortar. In case the hole is made much larger than the size of the pipe. Cement concrete 1: 2: 4 (1 cement: .2 sand: 4 graded. stone aggregate of 12.5 mm nominal size) shall be used to fill in the annular space. The spouts shall slope downward at a slope of 1 in 6. The projection outside the wall shall be uniform and not less than 40 cm. The entrance with the pipe shall be smoothly rounded to meet the internal bore of the pipe to facilitate easy flow. Care shall be taken to ensure that the vertical plane through the centre line of the spouts in a row shall be true to line.

### 4.6 Below Ground Level:

#### 1) Trenches and other Excavation:

Except as mentioned hereunder, all work for earthwork shall be done as specified in relevant chapter of Excavation and Filling. The trenches shall be so dug that the pipe may be laid to the required alignment and at required depth. The cover shall be measured from top soil or other surface of the ground. Turf, top soil or other surface material shall be set aside, turf being



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 163 of 242		

carefully removed and stacked for use in reinstatement. The bed of the trench, if in soft or made up earth, shall be well watered and rammed before laying the pipes and the depressions, if any, shall be properly filled with earth and consolidated in 20 cm layers.

If the trench is extremely hard or rocky or loose stony soil, the trench shall be excavated at least 150 mm below the trench grade. Rocks, stone or other hard substances from the bottom of the trench shall be removed and the trench brought back to the required grade by filling with selected earth and compacted so as to provide smooth bedding for the pipe.

The last 7.5 cm. of excavation shall be trimmed and removed as separate operation immediately prior to the laying of the pipe on their foundations. The width of the trench shall be such as to provide not less than 20 cm clearance on either side of the pipe. Excavation in road shall be so arranged as to cause minimum obstruction to traffic.

## 2) Laying of Pipes:

In no case, pipes shall be rolled and dropped into the trench. After lowering, the pipes shall be arranged so that the spigot of one pipe is carefully centered into the socket of the next pipe and pushed to the distance that it can go.



The pipe shall be laid with socket facing the direction of flow of water. The connection to an existing sewer shall as far as possible be done at the manhole.

## 3) Filling of Trench

Filling of the trench shall not be commenced until the length of pipes therein has been tested and passed. Special care shall be taken to pack under and sides of the pipes thoroughly with selected material. At least 300 mm over the pipe shall also be filled with selected earth.

## 5.0 MANHOLES

5.1 Wherever applicable manhole should be suitably designed & constructed.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 164 of 242		

## ANNEXURE-VII

**ES-2518**



### TECHNICAL SPECIFICATIONS

**FOR**

**BORED CAST-IN-SITU CONCRETE VERTICAL PILES**

## C O N T E N T S

SL. NO.	DESCRIPTION
1.0	SCOPE
2.0	GENERAL REQUIRMENTS
3.0	CODES AND STANDARDS
4.0	MATERIALS
5.0	CONCRETE
6.0	REINFORCEMENT
7.0	PILE INSTALLATION
8.0	SAMPLING, TESTING & QUALITY ASSURANCE
9.0	LOAD TEST ON PILES
10.0	RECORDING OF DATA & PRESENTATION
ANNEXURE - A	PILE DATA
TABLE - 1	FREQUENCY OF SAMPLING AND TESTING
ANNEXURE - B	PILE LOAD TEST DATA



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 166 of 242		

## 1.0 SCOPE

- 1.1 The specifications cover the installation of bored cast-in-situ reinforced concrete Vertical Piles.
- 1.2 This specification also covers the technical requirements for load test (Initial and Routine tests) on reinforced concrete single vertical piles of specified diameter to assess their vertical, horizontal and pull-out load carrying capacity.
  - 1.2.1 Load tests on piles shall conform to IS : 2911 ( Part – IV ).



## 2.0 GENERAL REQUIREMENTS

- 2.1 The work shall include mobilisation of all necessary equipment, kentledge, reaction piles, or combination of reaction piles, providing necessary engineering supervision through qualified and technical personnel, skilled and unskilled labour, etc. as required carrying out the complete piling work, load tests and submission of records/ reports as per schedule.
- 2.2 The Bidder shall guarantee the “safe load” capacity of piles for various modes i.e., vertical, lateral and pull-out tests for piles installed by him.
- 2.3 Consequent upon award of work and prior to installation of piles, the Bidder shall submit design of piles in terms of allowable capacity, length, diameter, termination criteria, reinforcement, etc. for OWNER’S/CONSULTANT’S approval. OWNER’S/CONSULTANT’S approval on pile design in no way absolves the Bidder for his responsibility to carry out all the initial (vertical, lateral and pull-out) load test of piles prior to installation of the job piles. The pile capacity to be used in design shall be arrived at from the initial load test of piles.
- 2.4 The Bidder shall make his own arrangement for locating the co-ordinates and position of piles shown in approved drawings and for determining the Reduced Levels (R.L) of these locations with respect to the single Bench



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		Document No.	Rev	
		Sheet 167 of 242		

Mark indicated by the Engineer-in-Charge. Two established reference lines in mutually perpendicular direction shall be indicated to the Bidder. The Bidder shall provide at site all the required survey instruments to the satisfaction of the Engineering-in-Charge so that the work can be carried out accurately according to specifications and drawings.

- 2.5 In case of working piles, if the pile is rejected due to any other reasons, the Bidder shall install extra piles at no extra cost to OWNER/CONSULTANT. Further, the extra cost due to the increase in the pile cap size, if any, on account of extra piles shall be borne by the Bidder.
- 2.6 It is essential that all equipment and instruments are properly calibrated both at commencement and immediately after the tests so that they represent true values. Certificates to this effect from an approved institution shall be furnished to the Engineer-in-Charge. If the Engineer-in-Charge so desires the Bidder shall arrange for having the instruments tested at an approved laboratory at his own cost and the test report shall be submitted to the Engineer-in-Charge. If the Engineer-in-charge desires to witness such tests Bidder shall arrange to conduct the test in his presence.
- 2.7 The complete jacking system including the hydraulic jack, hydraulic pump and pressure gauge shall be calibrated as unit. The complete unit shall be calibrated over its complete range of travel for increasing and decreasing load same as that of test loads. The calibration certificate shall be submitted to the Engineer-in-Charge.
- 2.8 The reaction load to be made available for the test shall be at least 25% greater than the maximum jacking force. The reaction system as relevant shall be designed for the total reaction load. All reaction loads shall be stable and balanced during all operations of testing. During testing, stability of reaction system shall be ensured.

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		Document No.	Rev	
		Sheet 168 of 242		

- 2.9 The load applied on the pile shall be measured by a calibrated pressure gauge mounted on the jack.
- 2.10 The displacement of the pile (in vertical, horizontal and uplift) shall be measured using dial gauges having a least count of 0.01 mm.
- 2.11 Load test shall be conducted at pile Cut of Level (COL). If the water table is above the COL the test pit shall be kept dry throughout the test period by suitable dewatering methods.
- 2.11.1 In case initial vertical load test where the water table is higher than the COL BIDDER may use reaction piles for testing purpose in each case. Engineer-in-charge may at his discretion to decide to raise the COL above water table.
- 2.12 Full details of the equipment proposed to be used and the test set-up with detail sketches shall be submitted to the engineer-in-charge, before making arrangement to carry out the tests, for his approval. Approval of Engineer-in-charge shall also be obtained after the test set up is complete prior to commencement of loading.
- 2.13 All operations in connection with pile load test shall be carried out in a safe manner so as to prevent the exposure of people to hazard.
- 2.14 If any test has to be discontinued, which in the opinion of the Engineer interferes with the load test results, and he decides to abandon the test, BIDDER shall install another pile for the purpose and repeat the test after correcting the fault and the cost of all such operations, including the cost of test pile, shall be at the BIDDER'S expenses..
- 2.15 After completion of piling work Bidder shall submit four copies of the following documents for OWNER's record and future reference:



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		Document No.	Rev	
		Sheet 169 of 242		

- a. Initial load test data for all tests done along with the pile data and the analysis of the Initial load test results.
- b. Pile data along with concrete mix design detail ( Note : pile data shall contain details as per requirement of Annexure – A )
- c. Routine load test data for all tests done.
- d. A full record giving all details of test in the performa shown in Annexure–B shall be submitted in triplicate to the Engineer-in-charge immediately on completion of each test. The record shall also include the plots of:
  - i. Load vs. Settlement
  - ii. Time vs. Settlement
  - iii. Characteristic of the piles and the interpretation of the pile load test curve as per the criteria for safe loads as mentioned in the specification.

2.16 Before commencement of the work, the bidder shall submit Quality Assurance Plan to OWNER / CONSULTANT for their approval.

### **3.0 CODES AND STANDARDS.**

- 3.1 All standards and code of practice referred to herein shall be the latest editions including all applicable revisions issued.
- 3.2 All works shall be carried out as per the relevant latest Indian Standard Codes. In case of conflict between the specification and the IS codes referred to herein, the former shall prevail. Some of the applicable Indian Standards and codes are referred to here below. :

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 170 of 242		

IS : 432(part-I&II) Specifications for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement.

IS : 456 Code of practice for plain and reinforced concrete.

IS : 1786 Code of practice for twisted steel high strength deformed bars for concrete reinforcement.

IS: 2911(part I &II)Code of practice for design and construction of pile foundation - Bored cast in situ concrete piles.

IS : 2911 (part-IV) Code of practice for design and construction of pile foundations – Load test on piles.

SP-34 Handbook on concrete reinforcement and detailing

IS : 5121 Safety code for piling and other deep foundations.

IS: 10262 Recommended guidelines for concrete mix design.



IS: 12330 Code of practice for Sulphate resistant Cement.

## 4.0 MATERIALS

### 4.1 GENERAL

All materials viz. cement, steel, aggregate, water etc., which are to be used for pile construction shall conform to relevant IS codes specifications for properties, storage and handling of common building materials. However, aggregate more than 20 mm shall not be used.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसिफिकेशन और रासायनिक उद्योग <b>BHEL</b>
		Document No.	Rev	
		Sheet 171 of 242		

## 5.0 CONCRETE

5.1 Enclosed Technical Specification for cast-in-situ concrete and allied works along with IS: 2911 (Part-I/Sec.2) – Code of Practice for Design and construction of pile foundations (Bored cast- in- situ piles) shall be applicable to concrete works for piles. Use of plasticizer to control the water- cement ratio shall be permitted on specific approval from Engineer-in-charge.



## 5.2 GRADE AND MINIMUM CEMENT CONCRETE

5.2.1 Cement concrete of M-30 as per IS 456 shall be used. Cement content shall be as per mix design conforming to IS: 10262. However, the minimum cement content shall be 400 kg per cubic metre of concrete. In case of piles subsequently exposed to free water or in case of piles where concreting is done under water or drilling mud using methods other than the tremie, 10% extra cement over that required for the design grade of concrete at the specified slump shall be used subject to minimum cement specified above.

5.2.2 For the concrete, water, aggregate, cement, reinforcement etc., specification laid down in 9338-PSCV-0000-946 & IS: 456 shall be followed in general. Natural rounded shingle of appropriate size may also be used as coarse aggregate. It helps to give high slump with less water cement ratio.

5.2.3 The concrete for piles in aggressive surroundings due to presence of Sulphates, etc, should have a concrete mix of appropriate type of cement in suitable proportion.

- a. If the concentration of sulphates (measured as  $\text{SO}_3$ ) exceeds one percent in soil or 2500 parts per million ( ppm. ) in water, a mix using 400 kg/Cu.m. of super sulphated cement conforming to IS: 6909 or Sulphate resisting Portland Cement conforming to IS : 12330 shall be used. For soils with 0.5 to 1 percent of sulphates or ground water with 1200 to 2500

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		Document No.	Rev	
		Sheet 172 of 242		

ppm, the mix should be minimum 400 kg/Cu.m. of super sulphated or sulphate resisting Portland cement . For concentrations less than above, concrete mix with 400 kg/cu. Pozzolona/ blast furnace slag cement shall be used.



- b. For bored compaction piles rapid hardening cement shall not be used. To facilitate construction, admixtures for retarding the setting of concrete may be used in consultation with the Engineer-in-charge.

### 5.3 **SLUMP OF CONCRETE**

The slump of concrete shall vary between 150 mm to 180 mm for concreting in water-free unlined boreholes. For concreting by tremie, a slump of 150 mm to 200 mm shall be used.

## 6.0 **REINFORCEMENTS**

- 6.1 Kindly refer clause 5.4 (page 96) for longitudinal and lateral reinforcement in piles. The provision of reinforcement will depend on nature and magnitude of loads, nature of strata and method of installation. It should be adequate for vertical load, lateral load and moments, acting individually or in combination.
- 6.2 The minimum area of longitudinal reinforcement shall be 0.4 percent of the sectional area calculated on the basis of outside area of casing or pile shaft where casing is not used, whichever is more. The minimum number of longitudinal reinforcement shall be 6 (Six) and its minimum diameter shall be 12 mm. The stipulated minimum reinforcement shall be provided for full length of pile. Adequate reinforcement shall be provided to take full uplift loads.
- 6.3 Longitudinal reinforcement shall project 50 times its diameter above cut off level unless otherwise indicated.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 बी एच ई एल <b>BHEL</b>
		Document No.	Rev	
		Sheet 173 of 242		



- 6.4 The minimum diameter of the links or spirals bar shall be 8.0 mm and the spacing of the links or spiral shall not be more than 150 mm The laterals shall be tied to the longitudinal reinforcement to maintain its shape and spacing.
- 6.5 Reinforcement cage shall be sufficiently rigid to withstand handling and installation without any deformation and damage. As far as possible number of joints (laps) in longitudinal reinforcement shall be minimum. In case the reinforcement cage is made up of more than one segment these shall preferably be assembled before lowering into casing tube / pile bore by providing necessary laps as per IS : 456
- 6.6 Laps shall be staggered as far as practicable and not more than 50% bars shall be lapped at a particular section. Lap joints shall be staggered by at least 1.3 times the lapped length ( centre to centre ).
- 6.7 Proper cover and central placement of the reinforcement cage in the pile bore shall be ensured by use of suitable concrete spacers or rollers cast specifically for the purpose.
- 6.8 Minimum clear cover to all main reinforcements in piles shall not less than 50 mm unless otherwise specified.

## 7.0 PILE INSTALLATION

Installation of piles shall be carried out as per pile layout drawings, installation criteria and the direction of the Engineer-in-charge.

## 7.1 EQUIPMENT AND ACCESSORIES

- 7.1.1 The equipment and accessories for installation of bored cast-in-situ piles shall be selected giving due consideration to the sub-soil conditions, ground water

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 174 of 242		

condition and the method of casting etc. These shall be of standard type and shall have the approval of the Engineer-in-charge.

7.1.2 List of details of equipment and accessories proposed to be used for the job shall be submitted along with the bid.

7.1.3 The capacity of the rig shall be adequate so as to reach the specified founding level.



## 7.2 CONTROL OF POSITION AND ALIGNMENT

7.2.1 Piles shall be installed as accurately vertical as possible at the correct location and truly vertical. Great care shall be exercised of a single pile or piles in two piles groups under a column. The permissible limits for deviation with respect to position and alignment (inclination) shall conform to IS : 2911 (Part-I/ sec-2 ), which is reproduced below for ready reference :

- a. The maximum deviation of vertical piles shall not exceed 1.5% in alignment.
- b. Piles shall not deviate more than 75 mm (their designed position at cut off level). In case of single pile, this tolerance should not exceed 50 mm. In case of piles deviating beyond these limits, the pile shall be replaced or supplemented by one or more additional piles without any extra cost to NER/CONSULTANT.



## 7.3 BORING

7.3.1 Boring operation shall be done by rotary or percussion type drilling rigs using direct, reverse mud circulation (DMC or RMC) method or grab method. In soft clays and loose sand, bailer method, if used, shall be used with caution to

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसीकरण औद्योगिक कंपनी लि. <b>BHEL</b>
		Document No.	Rev	
		Sheet 175 of 242		

avoid the effect of suction. Boring operations by any of the above method shall be done using drilling mud.

- 7.3.2 Bidder shall satisfy himself about the suitability of the method to be adopted for site. If DMC or RMC is used bentonite slurry shall be pumped through drill rods by means of high pressure pumps. The cutting tool shall have suitable ports for the bentonite slurry to flow out at high pressure. If on mobilisation, Bidder fails to make a proper bore for any reason, the bidder has to switch over to other boring methods as approved by the Engineer-In-charge at no extra cost to OWNER.
- 7.3.3 Working level shall be above the cut of level. After the initial boring of about 1.0 to 2.0 m temporary guide casing shall be lowered in the pile bore. The diameter of guide shall be of such diameter to give the necessary finished diameter of concrete pile. The centre line of guide casing shall be checked before continuing further boring. Guide casing shall be minimum 1.0 m length. Additional length of casing may be used depending on the condition of strata, ground water level etc.
- 7.3.4 Use of drilling mud (bentonite suspension/slurry) for stabilising the sides of the pile bore is necessary wherever is likely to collapse in the pile bore. Drilling mud to be used shall meet the following requirement:
- 7.3.4.1 Liquid limit of bentonite when tested in accordance with IS : 2720 ( Part-V ) shall more than 300 percent and less than 450 percent.
- 7.3.4.2 Sand content of the bentonite powder shall not be greater than 7 percent.
- 7.3.4.3 Bentonite solution should be made by mixing it with fresh water using pump for circulation. The density of the freshly prepared bentonite suspension shall be between 1.034 and 1.100 gm/ml depending on the pile dimensions and type of soil in which the pile is to be cast. However, the density of bentonite

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 बी एच ई लिमिटेड <b>BHEL</b>
		Document No.	Rev	
		Sheet 176 of 242		

suspension after mixing with deleterious materials in the pile bore may be upto 1.25 gm/ml.

7.3.4.4 The marsh viscosity when tested by a Marsh cone shall be between 30 to 60 seconds.

7.3.4.5 The differential free swell shall be more than 540 percent.

7.3.4.6 The pH value of the bentonite suspension shall be between 9 and 11.5.

7.3.5 The bentonite slurry and the cuttings, which are carried to the surface by rising flow of slurry shall pass through settling tanks of adequate size to remove the sand and soils from the slurry, before the slurry is recirculated to the boring. The bentonite slurry mixing and recirculation plant shall be suitably designed and installed.

7.3.6 The bentonite slurry shall be maintained at 1.5 m above the ground water level during the boring operations and till the pile is concreted. When DMC and RMC method is used the bentonite slurry shall be under constant circulation still start of concreting.

7.3.7 The size of cutting tools shall be not less than the diameter of the pile by more than 75 mm. However, the pile bore shall be of the specified size.



7.3.8 Socketing shall be done as per Geo-technical Report/ pile design requirement point of view wherever required.

## 7.4 CHISELLING

7.4.1 Chiselling may be restored with the permission of the Engineer-in-charge below the socketing horizon. The chiselling tool or bit shall be of adequate size and weight so as to reach the desired depth.

## 7.5 CLEANING OF PILE BORE

7.5.1 After completion of the pile bore upto the required depth, the bottom of the pile bore shall be thoroughly cleaned. Cleaning shall ensure that the pile bore is completely free from sludge / bored materials, debris of rock/ boulder etc. Necessary checks shall be made for pile bore as described in the subsequent clauses to confirm thorough cleaning of the pile bore.

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></div>	PC288/E/001/P-II/5.5	P	<div><div>बी एच ई लि. <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 177 of 242		

7.5.2 Pile shall be cleaned by fresh drilling mud through tremie pipe before start of concreting and after placing reinforcement.

7.5.3 Pile bore spoil along with the used drilling mud shall be disposed off from site as directed by the Engineer-in-charge.

## 7.6 ADJECENT STRUCTURES

7.6.1 When working near existing structures care shall be taken to avoid any damage to such structures.

## 7.7 CONCRETING

7.7.1 Concreting shall not be done until the Engineer-in-charge is satisfied that the pile termination level is reached and the pile bore is cleaned properly and thoroughly.



7.7.2 The time interval between the completion of boring and placing of concreting shall not exceed 6 hours. In case the time interval exceeds 6 hours the pile bore shall be abandoned. However, the Engineer-in-charge may allow concreting provided the Bidder extends the pile bore by 0.5 m beyond the proposed depth, and clean the pile-bore. The entire cost of all operation and materials for this extra length shall be borne by the Bidder.

7.7.3 Pile bore bottom shall be thoroughly cleaned to make it free from sludge or any foreign matter before and after placing the reinforcement cage.

7.7.4 Proper placement of the reinforcement cage to its full length shall be ensured before concreting.

7.7.5 Concreting shall be done by tremie method, the operation of tremie concreting shall be governed by IS : 2911 ( Part-I/Section-2 ). Drilling mud shall be maintained sufficiently above the ground water level.

7.7.6 Concreting operation shall not proceed if the contaminated drilling mud at the bottom of the pile bore posses density more than 1.25 Te/Cu.M. or sand content more than 7%. The drilling mud bore sample shall be collected from the bottom of the pile bores as mentioned in subsequent clause.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 178 of 242		

7.7.7 Consistency of the drilling mud suspension shall be controlled throughout concreting operations in order to keep the bore stabilised as well as to prevent concrete getting mixed with the thicker suspension of the mud.

7.7.8 It shall be ensured that volume of concrete poured is at least equal to the theoretically computed volume of pile shaft being cast.

7.7.9 The temporary guide casing shall be withdrawn cautiously after concreting is done upto the required level. While withdrawing the casing concrete shall not be disturbed.

## **7.8 CUT OFF LEVEL (COL)**

7.8.1 Cut off level of piles shall be as indicated in drawings released for construction or as directed by Engineer-in-charge.

7.8.2 The top of concrete in pile shall be brought above the COL to remove all laitance and weak concrete and to ensure good concrete at COL for proper embedment in to pile cap.

7.8.3 When the pile cut off level is less than 1.0 metre below the working level, concrete shall be cast to the piling platform level to permit overflow of concrete for visual inspection. In case of COL of pile is more than 1.0 metre below working level then concrete shall be cast to a minimum of one metre above COL.



7.8.4 In the circumstance where COL is below ground water table, the need to maintain a pressure on the unset concrete equal to or greater than water pressure shall be observed and accordingly length of extra concrete above COL shall be determined by the Bidder with prior approval of Engineer-in-charge.

## **7.9 SEQUENCE OF PILING**

7.9.1 Each pile shall be identified with a reference number.

7.9.2 The convenience of installation may be taken into account while scheduling the sequence of piling in a group. This scheduling shall avoid piles being bored close to other recently constructed piles.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 179 of 242		

## 7.10.0 BUILDING UP OF PILES

7.10.1 If any pile, already cast as per construction drawing, requires any extra casting due to any change in cut off level or cast pile top level is less than the specified level or any other reason, then the pile shall be building up by using M-20 grade concrete with minimum 400 kg/Cu.m. of cement ensuring proper continuity with the existing concrete and to the satisfaction of the Engineer-in-charge. Necessary reinforcement as per design requirement and suitable shuttering shall be provided before casting the concrete. Surrounding soil shall also be built up to the required level by proper compaction to ensure lateral capacity of the pile.

## 7.11 BREAKING OFF OF PILES

7.11.1 If any pile already cast requires breaking due to lowering in cut off or for any other reason, then the same shall be carried out, not before seven days of casting of, without affecting quality of existing pile such as loosening, cracking etc., to the satisfaction of the Engineer-in-charge.

## 7.12 PREPARATION OF PILE HEAD



7.12.1 The soil surrounding the piles shall be excavated upto the bottom of the lean concrete below the pile cap with provision for working space sufficient enough to place shuttering, reinforcement, concreting and any other related operations.

7.12.2 The exposed part of the concrete above COL shall be removed/ chipped off and made square at COL not before seven days of casting of piles.

7.12.3 The projected reinforcement above COL shall be cleaned and bent to the required shape and level to be anchored into the pile cap.

7.12.4 The pile top shall be embedded into the pile cap by 50 mm or clear cover to the reinforcement, whichever is high.

7.12.5 At loose material on the top of pile head after chipping to the desired level shall be removed and disposed off upto a lead of 2 Km. as directed by Engineer-in-charge.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 180 of 242		

## 7.13 REJECTION AND REPLACEMENT OF DEFECTIVE PILES

- 7.13.1 The Engineer-in-charge reserves the right to reject any pile which in his opinion is defective on account of load capacity, structural integrity, position, alignment, concrete quality etc. Piles that are defective shall be pulled out or left in places as judged convenient by Engineer-in-charge, without affecting the performance of adjacent piles. The Bidder shall install additional piles to substitute the defective piles as per the directions of Engineer-in-charge at no extra cost to OWNER/ CONSULTANT.

## 7.14 RECORDING OF PILING DATA



- 7.14.1 The Bidder shall record all the information during installation of piles. Typical data sheet for recording pile data shall be as indicated in Annexure - A. enclosed and the pile load test data shall also be recorded as per the detailed indicated in Annexure-B enclosed. On completion of each pile installation, pile record in triplicate shall be submitted to Engineer-in-charge within two days of completion of concreting of the pile.

## 8.0 SAMPLING, TESTING AND QUALITY ASSURANCE

- 8.1. Facilities required for sampling and testing materials, concrete, etc. in field and in laboratories shall be provided by the Bidder. The Bidder shall carry out all sampling and testing in accordance with the relevant Indian Standards and this specification. Where no specific testing procedure is mentioned the testing should be carried out as per the prevalent accepted engineering practice to the direction of Engineer-in-charge. Test shall be done in presence of Engineer of Engineer-in-charge or his authorised representative. In case the Engineer-in-charge requires additional tests, the Bidder shall arrange to get these tests done and submit to him the test results in triplicate within three days after completion of any test.

## 8.2 RECORDS

The Bidder shall maintain records of all inspection and testing which shall be made available to the Engineer-in-charge. The Engineer-in-charge at his

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 181 of 242		

discretion may waive some of the stipulations for small and unimportant concreting operations and other works.

### **UNSUITABLE MATERIALS**

Materials found unsuitable for acceptance shall be removed and replaced by the Bidder. The work shall be done as per specification requirements and to the satisfaction of the Engineer-in-charge at no extra cost to OWNER.



## **8.3 QUALITY ASSURANCE PROGRAMME**

**8.3.1** The Bidder shall submit and finalise a detailed Field Quality Assurance Programme within 30 days from the date of award of contract according to the requirements of this specification. This shall include setting up a testing laboratory, arrangement of testing apparatus/ equipment, deployment of qualified / experienced manpower, preparation of field quality plan, etc. On finalised field quality plan, OWNER/ CONSULTANT shall identify, customer hold points, beyond which the work shall not proceed without written approval from the Engineer-in-charge. The testing apparatus / equipment installed in the field laboratory shall be calibrated/ corrected by the qualified persons as frequently as possible to give accurate testing results.

**8.3.2** Frequency of sampling and testing, etc. and acceptance criteria are given in Table–1. The testing shall be done at field laboratory or any other laboratory approved by the Engineer-in-charge. However, the testing frequencies set forth are the desirable minimum and Engineer-in-charge shall have the full authority to call for tests as he may deem necessary to satisfy himself that the materials and works comply with the appropriate specifications. The materials shall be tested to all the specified requirements as per relevant IS codes before acceptance at manufacturers premises or at independent Government laboratory. Tests indicated in the Table–1 are for cross checking at site the conformity of the materials to some of the specifications.

## **8.4 TESTING OF CONCRETE**

**8.4.1** a. Concrete and other materials shall be tested for quality and strength and other properties as per relevant IS codes.

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		Document No.	Rev	
		Sheet 182 of 242		

b. One sample consisting of six test cubes shall be made from the concrete used in each test pile, 3 to be tested after 7 days and 3 after 28 days.

8.4.2 For working piles testing should be done as per IS specifications.

8.4.3 In preparation o test cubes/ specimens vibrators shall not be used.

8.4.4 Concrete shall be tested for slump at every one hour interval.

8.4.5 Other materials like aggregate, reinforcement, etc. shall be tested as per relevant IS codes.

## 8.5 TESTING FOR POSITION AND ALIGNMENT

8.5.1 Each pile shall be checked for its position with respect to specified location. Each pile bore shall be checked for its alignment.

**8.5.2** Permissible limits for deviations shall be as specified elsewhere in this section of specification.

## 8.7 PROPERTIES OF DRILLING MUD



8.7.1 Properties of drilling mud shall be checked as per requirements specified in clause No. 7.03.4 of this specification. Prior to use in piling work and thereafter minimum once in a week or as found necessary by Engineer-in-charge one sample consists of 3 specimens shall be tested.

8.7.2 Density and sand content of the drilling mud shall be checked at least in each pile for the first 10 piles before concreting. In case of satisfactory results the frequency of sampling shall not less than one in 25 piles.

## 8.8 CHECK FOR PILE BORE

8.8.1 On completion of boring and cleaning the bottom of each pile bore shall be checked by the methods as approved by Engineer-in-charge to ensure that it is free from pile bore spoil/ debris and any other loose material before concreting. Concreting shall be done only after the approval of the Engineer-in-charge.

8.8.2 For sampling of drilling mud from the pile bore the following method or any suitable method shall be adopted.

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		Document No.	Rev	
		Sheet 183 of 242		

- 8.8.2.1 A solid cone shall be lowered by a string to bottom of pile-bore. A sampler tube closed at top with a central hole (hollow cylinder) is lowered over the cone, then a top cover shall be lowered over the cylinder. Care shall be taken for proper fittings of assembly to minimise the leakage while lifting the cone assembly to the ground surface. The slurry collected in the sampler tube shall be tested for density and sand content.

## **9.0 LOAD TEST ON PILES**

### **9.1 TYPE OF TESTS**

- 9.1.1 BIDDER shall carry out two categories of load tests i.e. Initial Load and Routine Load Tests in accordance with IS: 2911 (Part-IV).

- 9.1.2 Initial load test shall be conducted to assess the safe load carrying capacity of pile before start of installation of working piles. This shall include the following type of tests.

- Cyclic compression load test to assess safe vertical load capacity.
- Lateral load test to assess safe horizontal load capacity.
- Tension load test to assess safe pull out load capacity.

The above tests shall be performed in accordance with IS: 2911 ( Part-IV )



- 9.1.3 The minimum number of Initial Load Test for each diameter of pile proposed shall be as under.

- Vertical compression : 2 Nos.
- Lateral : 2 Nos.

- 9.1.4 Routine load tests of piles as per IS: 2911 (Part-IV) shall be conducted to verify the load capacity of working piles. This shall include the following types:

- Direct compression load tests for vertical load capacity.
- Lateral load test for horizontal load capacity.

- 9.1.5 The minimum number of routine load test for each diameter and type shall be 1.5 percent of the total number of working piles or minimum 2 no.'s of

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		Document No.	Rev	
		Sheet 184 of 242		

piles whichever is higher. The number of tests may be increased up to 2 percent as decided by the Engineer-in-charge in a particular case depending upon the nature, type of structure and strata condition.

## 9.2 TEST OF PILE

9.2.1 The test piles for routine load test shall be identified by the Engineer-in-charge

9.2.2 A minimum time period of four weeks shall be allowed between the time of pile casting and testing. Test pile head shall be prepared for testing purposes only one week after casting the pile.

9.2.3 The test pile shall be cut off at the proper level and provided with a proper cap so as provide a plane bearing surface for the test plate and for proper arrangements for seating of the jack and dial gauges.

## 9.3 VERTICAL LOAD TEST



### 9.3.1 EQUIPMENT AND TEST SET-UP

- I. A steel plate of sufficient thickness not less than 50 mm shall be centred on the pile head to prevent it from crushing under applied load. The size of plate shall not be less than the pile size nor less than the area covered the base of the hydraulic jack(s).
- II. The datum bars shall be supported on the immovable supports preferably of concrete pillars or steel sections placed sufficiently far away from the test pile. The distance shall not be less than 3 times the diameter of test pile and in no case less than 2 meter from the edge of test pile. These supports shall be placed at a sufficient depth below ground to be unaffected by ground movements.

### 9.3.2 LOADING SYSTEM

The test load on the pile shall be applied in one of the following way as approved by Engineer-in-charge.

- a. By means of hydraulic jack(s) which obtain reaction from kentledge heavier than the required test load. While using this method care shall

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		Document No.	Rev	
		Sheet 185 of 242		

be taken to ensure that the centre of gravity of kentledge is on the axis of the pile. The load applied by the jack shall also be coaxial with the pile. The nearest edge of the crib supporting the kentledge stack shall not be closer than 1.5 m to the edge of the test pile

- b. By means of hydraulic jack(s) which obtained reaction from anchor piles and /or suitable loading frame. While using this method all anchor piles shall be at a centre to centre distance of at least three times the test pile shaft diameter from the test pile and in no case less than 2 meter. Care shall be exercised to ensure that the datum bar supports are not affected by heaving up the soil.
- c. By means of hydraulic jack(s) which obtain reaction from suitable rock anchors. When this method is adopted the anchor transferring the load to the ground shall not be closer than two times the test pile shaft diameter to the test pile and in no case less than 1.5 m.
- d. By means of combination of kentledge anchor pile and rock anchors.

### 9.3.3 MEASURING SYSTEM

Settlement of the pile shall be recorded by four dial gauges placed at diametrically opposite locations and suspended from the datum bar around the pile.



### 9.3.4 TEST PROCEDURES

The test shall be carried out by Direct Loading Method in successive increments for routine load test and by the Cyclic Loading Method for initial load test as detailed below and as directed by Engineering-in-charge.

#### 9.3.4.1 DIRECT LOADING METHOD

The test shall be carried out as per the procedure outlined below:

- a. The load shall be applied to the pile top in increments (step) of about 20% of the rated capacity of the pile or as directed by Engineer-in-charge. Each increment of load shall be applied as smoothly and expeditiously as possible. Settlement regarding shall be taken before and

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		Document No.	Rev	
		Sheet 186 of 242		

immediately after the application of next increment and at 15, 30, minutes and thereafter at every half an hour until application of the next load increment.

- b. Each stage of loading shall be maintained till the rate of movement of the pile top is not more than 0.2 mm/hour. Or until two hours have elapsed whichever is earlier.
- c. The rate of movement of pile shall not be permitted to be extrapolated from period of test less than one hour.
- d. Loading on pile shall be continued till one of the following takes place :

In case of Initial load test applied load reaches three times the assumed safe load or settlement of pile exceeds a value of 10% of bulb diameter in case of under-reamed piles.

In case of Routine load test, applied load reaches one and half time the safe load or maximum settlement of test loading in position attains 12 mm.



- e. Where yielding of soil does not occur, the full test load shall be maintained on the pile head for a minimum period of 24 hours. After the last increment of load and settlement shall be recorded of 6 hours interval during this period.
- f. Unloading shall be carried out in the same steps as loading. A minimum period of 30 minutes shall be allowed to elapse between two successive stages of load decrement. The final rebound shall be recorded 6 hours after the entire test load has been released.

#### 9.3.4.2 CYLIC LOAD TEST

The test shall be carried out to find out separately skin friction and point bearing capacity of single pile. However, this test is not applicable for under-reamed piles. The test procedure shall be given below ;

- a. In general this test shall be conducted on similar lines as mentioned in Direct Loading Method. In addition, alternate loading and unloading up



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 187 of 242		

to zero load shall be done in steps at each stage of loading. The load increment/decrement for each steps shall be 20% of the rated capacity. The reading of all the dial gauges shall be recorded at the end of each step and the total and net settlement for each stage shall be calculated.

- b. For each stage, the loading of each step shall be maintained for 15 minutes before reaching the maximum load. The maximum load for each stage shall be maintained on the pile head for 24 hours.
- c. Each step of unloading shall be maintained for 15 minutes and the subsequent rebound in the pile shall be measured accurately.
- d. A period of 15 minutes shall be allowed to pass the successive unloading and loading operations.
- e. To find out separately skin friction and point bearing capacity of pile the procedure as given in Appendix-A of IS: 2911 (part-IV) shall be followed.

### 9.3.5 ASSESSMENT OF SAFE LOAD



9.3.5.1 The safe vertical load on single pile from the load test shall be the least of the following:

- a.  $\frac{2}{3}$  of the load at which the total settlement attains a value of 12 mm unless otherwise specified in tender documents.
- b. 50% of the final load at which the total settlement equal 10% of the pile diameter in case of uniform diameter.

## 9.4 HORIZONTAL LOAD TEST

### 9.4.4 EQUIPMENT AND TEST SET -UP

- a. The test plate shall be set in high strength grout to provide full bearing against the projected areas of the pile. The size of the test plate shall be adequate to accommodate the spherical bearing and transfer the load to the pile.
- b. Sufficient clearance shall be allowed between the test pile and the datum bar for the anticipated lateral movement of the pile when

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		Document No.	Rev	
		Sheet 188 of 242		

datum bar (for fixing the dial gauge) is located on the opposite side to the point load of application.

#### 9.4.5 **LOADING SYSTEM**



- a. Loading shall be applied by a hydraulic jack of adequate capacity equipped with spherical bearing at the top of ram and bearing plate at the bottom side abutting the pile horizontally and reacting against a suitable system.
- b. The reaction may be provided by the wall of the excavated pit when the test is being conducted below ground level or by a neighbouring pile in which case thrust pieces shall be inserted on their end of the jack to make up the gap as approved by Engineering-in-charge.
- c. Load shall be applied on the pile at or approximately at cut of level (COL).

#### 9.4.6 **MEASURING SYSTEM**

- 9.4.6.1 The deflection shall be measured at a point diametrically opposite to the point of load application. In case such a measurement is not possible the deflection shall be recorded using at least 2 dial gauges kept at a spacing of 30 cm at a suitable height and the displacement interpolated at load point from similar triangles.
- 9.4.6.2 Deflection of the pile at the level of load application shall be measured by dial gauge fixed to datum bar. The datum bar shall rest on immovable supports as described elsewhere in this specification.

#### 9.4.4 **TEST PROCEDURE**

- 9.4.4.1 The test shall be similar to that of vertical load test.
- 9.4.4.2 Loading on the pile shall be continued till one of the following takes place :

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		Document No.	Rev	
		Sheet 189 of 242		

- a. In case of initial load test applied load reaches thrice the assumed safe lateral load capacity of deflection pile at the loading point exceeds.
- b. In case of routine Load test, applied load reaches one and half times the assumed safe load capacity or a deflection of the loading point exceed 5 mm.

#### **9.4.5 ASSESSMENT OF SAFE LOAD**

9.4.5.1 The safe lateral load of single pile shall be the least of the following :

- a. 50% of the load for which the total deflection is 12 mm.
- b. Load corresponding to 5 mm total deflection.

However, for routine test(s) above is not applicable.

Note: The deflection of the pile is at the cut of level of pile.



#### **9.5 PULL OUT TEST**

##### **9.5.1 EQUIPMENT AND TEST SET-UP**

Uplift force may be applied by means of hydraulic jack(s) using suitable pullout set up as approved by Engineering-in-charge.

##### **9.5.2 LOADING SYSTEM**

- a. Load shall be applied along the longitudinal axis of the pile using an approved reaction system. Uplift forces on the pile may be applied directly to the test pile or through a lever system.
- b. The reaction may be provided by neighbouring piles or blocks constructed for this purpose.
- c. The reaction supports/blocks/piles shall be at least 2.5 times the test pile diameter.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 बी एच ई लिमिटेड <b>BHEL</b>
		Document No.	Rev	
		Sheet 190 of 242		

### 9.5.3 MEASURING SYSTEM

Displacement of the pile shall be recorded using two dial gauges placed at diametrically opposite locations and suspended from the datum bar around the pile. Datum bar shall be provided with immovable supports as described elsewhere in this specification.

### 9.5.4 TEST PROCEDURE



- 9.5.4.1 The test procedure shall be similar to that for vertical load test.
- 9.5.4.2 The loading on the pile shall be continued till one of the following takes place.
- The loading on the pile top equal three times the estimated safe load.
  - The load displacement curve shows a clear break (downward trend).

### 9.5.5 ASSESSMENT OF SAFE LOAD

- 9.5.5.1 The safe load of the pile shall be the least of the following :
- Two third of the load at which the total displacement is 12 mm.
  - 50% of the load at which the load displacement curves shows a clear break (downward trend).

## 10 RECORDING OF DATA AND PRESENTATION



- 10.1** The pile test data essentially concerns three variables, namely load, displacement and time. These are to be recorded sequentially for the tests under consideration and shall be recorded in a suitable tabular form along with the information about the pile as per Annexure–A, Annexure–B and Table-1
- 10.2** The data may be suitably presented by curves drawn between the variables and safe loads shown on the graphs. Load displacement curve should be an essential part of presentation.

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></div>	PC288/E/001/P-II/5.5	P	<div><div>बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 191 of 242		

## ANNEXURE – A

### PILE DATA

1. Reference No:                      Location (Co-ordinates):                      Area:
2. Sequence of piling:
3. Pile diameter and type:
4. Working Level (Platform level):
5. Cut Off level (COL):
6. Actual length below COL:
7. Pile termination level:
8. Top of finished concrete level:
9. Date & time of start and completion of boring:
10. Depth of Ground Water table in the vicinity:
11. Type of soil at pile tip:
12. Method of boring operation:
13. Detail of drilling mud as used :
  - a. Freshly supplied mud:
    - Liquid Limit:
    - sand content:
    - density:
    - Marsh viscosity:

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		Document No.	Rev	
		Sheet 192 of 242		

Swelling Index:

pH value:

b. Contaminated Mud:

Density:

Sand content:

14. SPT ( N ) Values in soil ( from the nearest bore hole )  
UDS value in rock (from the nearest bore hole)

15. Chiselling, if any From .....M to .....M

16. Date and time of start and completion of concreting

17. Method of placing concrete

18. Concrete quality:

Actual:

Theoretical:

19. Ref. Number of test cubes

20. Grade and Slump of concrete

21. Results of Test Cubes

22. Reinforcement Details

Main reinforcement

No. : .....

Dia.....

Depth .....

Stirrups: Type

No. :.....

Dia. ....



Spacing .....

23. Any other information regarding obstructions,  
delay and other interruption to the sequence of  
work.

**TABLE -1**

**FREQUENCY OF SAMPLING AND TESTING**

Sl. No.	Type of Material/ work	Nature of test/ characteristics	Method of test	No. of samples & frequency of test	Acceptance criteria
1	Pile-bore size		Physical measurement	Each pile	
a.	Diameter				Dia. As per drg.
b.	Length				Length as established by initial test
2.	Bentonite (mud ) properties				
a.	Basic properties of Bentonite before use	Liquid limit, Marsh viscosity, Specific gravity, Sand content, Swelling Index, pH value.	In laboratory	Minimum one sample consisting of 3 specimens once in a week.	As per clause No. 7.03.4
b.	Contaminated mud from pile- bore bottom before concreting	Density & sand content	In laboratory	In each pile for first 10 piles before concreting in case of satisfactory results, the frequency may be reduced to one in 25 piles	i Density shall not be more than 1.25 Te/ Cu.m ii Sand content shall not be more than 7%
3.	Position and alignment	---	Physical or any approved method.	Each pile	As per specification
4.	Cleaning of pile – bore	As per clause No. 8.08.0	Each	Pile-bore should be free from bored materials/ cutting / debris	.Dispensary

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		Document No.	Rev	
		Sheet 194 of 242		

## ANNEXURE – B

PROJECT \_\_\_\_\_

PILE LOAD TEST: VERTICAL / HORIZONTAL / UPLIFT



PILE No.	Date of cast	Type of equipment and method of boring
Type of pile	Commencement of test	Plan pf test arrangement showing position and distance of kentledge, supports, tension or compression piles and reference frame to test pile etc.
Diameter	Completion of test	
Capacity	Capacity of jack	
Type of test initial / routine	Jack constant weight of kentledge	
Loading Method Direct / cyclic	Reaction of pile details.	

Date	Time	Pressure Gauge	Load (M.Te)	Dial Gauge Reading	Average settlement	Net ( mm )	Rebound

Submission of Test Results

- i ) Time Vs. settlement
- ii) Load Vs. Settlement including the Safe Load.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 195 of 242		



## ANNEXURE-VIII

**ES-2519**

### TECHNICAL SPECIFICATIONS



**FOR**

**ROAD, CULVERT & STORM WATER DRAINS**

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></div> <div><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></div> <div><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></div>	PC288/E/001/P-II/5.5	P	<div></div>
		Document No.	Rev	
		Sheet 196 of 242		

## CONTENTS

Sl. No.	Description	Sheet Number
1.	SCOPE	3
2.	GENERAL	3
3.	ROAD WORK	4
4.	MATERIALS	5
5.	SUPPLYING & STACKING OF MATERIALS	11
6.	EARTHWORK IN ROAD CONSTRUCTION	11
7.	SUB-GRADE	12
8.	GRANULAR SUB-GRADE	14
9.	WET MIX MACADAM BASE	16
10.	DENSE BITUMINOUS MACADAM	22
11.	BITUMINOUS CONCRETE	30
12.	GENERAL REQUIREMENTS FOR BITUMEN MACADAM & SEAL COAT	34
13.	IS / IRC CODES	35
14.	PAVER BLOCK & KERB STONE	36
15.	SCARIFYING METALLED (WATER BOUND) SURFACE	41
16.	REINFORCED CEMENT CONCRETE PAVEMENTS	42
17.	CULVERT WORK	43
18.	STORM WATER DRAINS	44
19.	STONE PITCHING	45



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसीकरण और रासायनिक उद्योग <b>BHEL</b>
		Document No.	Rev	
		Sheet 197 of 242		

## 1.00.00 SCOPE

This specification covers the preparation of sub-grade, sub-base, base and bituminous surfacing in accordance with Section-16 of latest CPWD Specifications and relevant codes of Indian Road Congress (IRC) for road specifications. This shall also include shoulder works, culvert and storm water drain works.

## 2.00.00 GENERAL

- 2.01.00 All road shall be designed in accordance with IRC 37 (Latest). For crossing of drains, pipes, cable trenches, etc., suitable culverts shall be provided. The culverts shall be designed for class 'AA' loading and also checked for class 'A' loading in accordance with IRC.
- 2.02.00 The Owner shall furnish the Contractor with only reference points of the job at site and a level bench mark, and the Contractor shall at his own cost and initiative, set out the works to the satisfaction of the Engineer-in-Charge but shall solely be responsible for the accuracy of such setting up notwithstanding satisfaction as aforesaid of the Engineer-in-Charge or any other assistance rendered by the Engineer-in-Charge for the purpose.
- 2.03.00 The Contractor shall provide, fix and be responsible for the maintenance of all stakes, templates, level marks, profiles and the like and shall take all precautions necessary to prevent their removal or disturbance, and shall be responsible for the consequence of such removal or disturbance and for their efficient and timely re-instatement. The contractor shall also be responsible for the maintenance of all survey marks, boundary marks, distance marks and centre line marks, whether existing or supplied / fixed by the Contractor.
- 2.04.00 Before commencing the work, the Contractor shall at his own cost and initiative provide all necessary reference and level posts, pegs, bamboos, flags, ranging rods, strings and other materials for proper layout of the work in accordance with the scheme for bench marks acceptable to the Engineer-in-Charge. The centre of longitudinal or face line and cross line shall be marked by means of small masonry pillars. Each pillar shall have a distinct mark at the centre to enable a theodolite to be set over it. No work shall be started until all these points are approved by the Engineer-in-Charge in writing, but such approval shall not relieve the Contractor of any of his responsibilities in respect of the adequacy or accuracy thereof. The Contractor shall also provide all labour, material and other facilities necessary for the proper checking or layout and inspection of the points during construction.
- 2.05.00 Pillars bearing geodetic marks located at the site / unit of works under construction should be protected and fenced by the Contractor.
- 2.06.00 On completion of works, the Contractor must submit to the Engineer-in-Charge the geodetic documents according to which the work was carried out.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 198 of 242		



- 2.07.00 The contractor shall be exclusively responsible for the provision and maintenance of horizontal and vertical alignments and levels and for the correctness of every part of the work in accordance therewith and shall at his own cost rectify any errors or imperfections therein.
- 2.08.00 The Contractor shall at all times during the progress and continuance of the works be responsible for and effectually maintain and uphold in good, substantial, sound and perfect condition of all and every part of works and shall make good from time to time and at all times as often as the Engineer-in-Charge shall require any damage or defect that may during the above period arise in or be any way connected with works.
- 2.09.00 The portion which is under "HOLD" shown in the approved drawing or the portion which would be brought under "HOLD" during execution on account of coordinating different activities of other working agencies shall be taken up by the Contractor for execution only after the said "HOLD" is withdrawn. The Contractor on this account shall not be entitled to claim for any compensation.
- 2.10.00 Providing and operating necessary measurements and testing devices, materials and consumables are included in the scope of work and the rates quoted shall be deemed to include the cost of such tests which are required to ensure achievement of specified quality of work.
- 2.11.00 The Owner/ Consultant shall determine the suitability of materials to be used on the job and the Contractor shall get all materials approved by the Engineer-in-Charge. Any material procured and brought to site by the Contractor, found not to conform to the specifications and does not meet the approval of the Engineer-in-Charge, for use, will be rejected, and the Contractor shall remove and dispose off the same at his own cost and he shall not have any claim for compensation in this regard.
- 2.12.00 The contractor shall maintain adequate drainage facilities at the work site at all times during the execution of the work.
- 2.13.00 Adequate dewatering facilities like dewatering pumps, piping etc., will also be provided by the Contractor for this work and also for dewatering during excavation etc., at his own cost.
- 2.14.00 Methods of measurements are indicated in the specifications. Where not indicated, provisions of latest edition of IS: 1200 shall apply.

### **3.00.00 ROAD WORK**

- 3.01.00 Road Work shall be carried out generally in accordance with the provisions laid down in Section-16 of latest CPWD Specifications and relevant publications of Indian Road Congress for road specifications.

### **4.00.00 MATERIALS**

- 4.01.00 **COARSE AGGREGATES:** Coarse aggregates as specified in the items shall be either crushed or broken stone, crushed slag, over burnt brick aggregate or one

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 199 of 242		

of the naturally occurring aggregates such as kankar or laterite of suitable quality as stated hereinafter and approved by the Engineer-in-charge. The stone aggregate shall conform to the physical requirements set forth in Table No.- 1 below:

TABLE - 1 : PHYSICAL REQUIREMENTS OF COARSE AGGREGATES FOR WATER BOUND MACADAM				
Sl.No.	Type of Constr.	Test****	Test Method	Requirement
1	Sub-base	Los Angeles Abrasion Value*	IS : 2386(Part IV)	60% Max.
		or Aggregate Impact Value*	IS : 2386(Part IV) or IS : 5640 ***	50% Max.
2	Base Course	a) Los Angeles Abrasion Value* or Aggregate Impact Value*	IS : 2386(Part IV)	50% Max.
		b)Flakiness Index**	IS : 2386(Part IV) or IS : 5640***	40% Max.
			IS : 2386 (Part I)	15% Max.
3	Surface Course	a) Los Angeles Abrasion Value* or Aggregate Impact Value*	IS : 2386 (Part IV)	40% Max.
		b)Flakiness Index**	IS : 2386 (Part IV) or IS : 5640***	30% Max.
			IS : 2386 (Part I)	15% Max.
* Aggregates may satisfy the requirements of either the Los Angeles test or the Aggregate Impact Value Test.				
** The requirements of Flakiness Index shall be enforced only in case of crushed/broken stone and crushed slag.				
*** Aggregates like brick metal, kankar and laterite which get softened in presence of water, shall invariably be tested for Impact Value under wet conditions in accordance with IS : 5640				
**** Samples for tests shall be representative of the materials to be used and collected in accordance with the procedure set forth in IS: 2430				

The coarse aggregate shall conform to one of the gradings given in Table No.- 2 as specified. For crushable type of aggregates such as brick metal, kankar and

laterite, grading shall not be regarded as very important, but the material should generally be within the specified range indicated below:-

TABLE 2 : SIZE AND GRADING REQUIREMENTS OF COARSEAGGREGATES FOR WATER BOUND MACADAM			
Grading Nos.	Size Range	Sieve Designation	Percent By Weight Passing the Sieve
1.	90 mm. to 45 mm. (Suitable for Sub base courses of compacted layer of not less than 90 mm thickness).	125 mm	100
		90 mm	90 – 100
		63 mm	25 - 60
		45 mm	0 - 15
		22.4 mm	0 - 5
2.	63 mm to 45 mm	90 mm	100
		63 mm	90 – 100
		53 mm	25 - 75
		45 mm	0 - 15
		22.4 mm	0 - 5
3	53 mm to 22.4 mm	63 mm	100
		53 mm	95 – 100
		45 mm	65 - 90
		22.4 mm	0 - 10
		11.2 mm	0 - 5

- BRICK AGGREGATE:** Brick aggregate shall be broken from over-burnt and dense brick bats. It shall be homogeneous in texture, roughly cubical in shape, clean and free from dirt and other foreign matter.
- CRUSHED OR BROKEN STONE:** When crushed or broken stone is specified as the coarse aggregate, it shall be hard, durable and free from excess of flat elongated soft and disintegrated particles, dirt and other objectionable matter. However, the total quantity of such deleterious material including clay lumps, soft fragment, foreign material etc., shall not exceed 5 % of the weight of the aggregate.
- CRUSHED SLAG:** Crushed slag shall be made from air-cooled blast furnace slag. It shall be of angular shape, reasonably uniform in quality and density and generally free from thin, elongated and soft pieces, dirt or other objectionable matter. Crushed slag shall not weigh less than 1120 kg per cubic metre and the percentage of glossy material in it shall not be in excess of 20. Water absorption of slag shall not exceed 10% (IS: 2386 PT - III).
- KANKAR:** Kankar shall be tough, having a blue almost opalescent fracture. It shall not contain any clay in the cavities between nodule
- LATERITE:** Laterite shall be hard, compact, heavy and of dark colour. The light coloured sandy laterite as well as those containing much ochreous clay shall be rejected.

**4.02.00 FINE AGGREGATES:** The fine aggregates shall be the fraction passing through 2.8 mm sieve and retained on 90 micron sieve. It shall consist of crusher run

screenings, natural sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry and free from injurious, soft or flaky pieces and organic or deleterious substances. The contents of organic and deleterious materials shall not exceed the limits specified in Table No - 3 below:

TABLE - 3		
	Uncrushed	Crushed
Coal and lignite	1%	1%
Clay lumps	1%	1%
Materials passing through 75 microns (I.S.S.) Sieve	3%	3%
Shale	1%	1%

The sum of the percentages of all deleterious material shall not exceed 5 %. Tests for estimation of deleterious materials and organic impurities shall be done as per IS: 2386 (Part-II).

**4.03.00 BINDING MATERIALS:** Binding materials to prevent ravelling of water bound macadam construction shall consist of a fine grained material possessing plasticity index value of 4 to 9 when the water bound macadam is to be used as a wearing course, and 4 to 6 when W.B.M. is being adopted as a sub-base/ base course with bituminous surfacing on top of it. The plasticity index shall be determined in accordance with IS: 2720 (Part-V). The quantity of binding material used in each layer will be as per direction of the Engineer-in-Charge. Application of binding material may be dispensed with the approval of Engineer-in-Charge, where screenings consist of crushable type material like moorum or gravel.

**4.04.00 BITUMEN EMULSION:** A liquid product in which a substantial amount of bitumen is suspended in a finely divided condition in an aqueous medium and stabilised by means of one or more suitable materials. For all types of bitumen and tar, approved grades shall be specified in the description of the item.

**4.05.00 BITUMEN STRAIGHT RUN:** A range of grades, from a very soft to a very hard consistency, can be produced by varying the temperature and the rate of flow during distilling process. It shall conform to IS: 73. Grades of bitumen for different uses are given in Table- 4:

TABLE - 4 : BITUMEN GRADES		
Grade	Different Uses	Temp. to which it shall be





		heated
i.	<b>FOR PAINTING (Surface Dressing)</b>  1. Paving bitumen from Assam Petroleum A 90  2. Paving bitumen from other sources 80/100 - S 90  3. Bitumen Emulsion min. 50% bitumen content RS Grade IS : 8837  4. Cut backs RC-3 (Rapid curing) IS : 217	177° C to 190 ° C  177° C to 190° C  (cold application)  - do -
ii.	<b>FOR PREMIX CARPETING</b>  1. Paving asphalt 30/40 S-35 or 80/100 S-90  2. Bitumen Emulsion Min. 60% bitumen contents RS Grade IS : 8837  3. Cut back MC (Medium curing) IS : 4545	149° C to 177° C  (cold application)  (cold application)
iii.	<b>FOR ASPHALTIC CONCRETE STRAIGHT RUN BITUMEN 60/70(S-65) CONFORMING TO IS: 73</b>	150° C to 177 ° C

4.06.00 **BRICKS:** Bricks shall be of class designation 50 unless otherwise stated. The specifications of bricks shall be as detailed in Section 6 of C.P.W.D. Specifications.

4.07.00 **FILLER:** The filler, where specified, shall be an inert material, the whole of which passes through a 710 micron sieve, at least 90 % passing through a 180 micron sieve and not less than 70 % passing through a 90 micron sieve. The filler shall be cement, stone dust, hydrated lime, lime stone dust, fly ash or any other non-plastic mineral matter approved by the Engineer-in-Charge. Mineral aggregates, including mineral filler shall be so graded or combined as to conform to the grading set-forth in Table- 5 below:

TABLE - 5 : AGGREGATE GRADATION INCLUDING FILLER		
Sieve Designation	Percent By Weight Passing the Sieve	
	For 25 mm Thickness	For 20 mm Thickness
20.0 mm	100	...
12.5 mm	75 - 100	100
10.0 mm	60 - 85	75 - 100
4.75 mm	35 - 55	35 - 55
2.36 mm	20 - 35	20 - 35
600 micron	10 - 22	10 - 22



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 203 of 242		

300 micron	6 - 16	6 - 16
150 micron	4 - 12	4 - 12
75 micron	2 - 8	2 - 8

4.08.00 FLYASH: Flyash shall conform to IS: 3812 (Part III).

4.09.00 LIME: The Lime shall of specifications as directed by Engineer-in-Charge.

4.10.00 MOORUM: It shall be obtained from pits of weathered disintegrated rocks. It should preferably contain silicious material and natural mixture of clay of calcarious origin. The size of moorum shall not be more than 20 mm.

4.11.00 RED BAJRI: This shall be dark red in colour consisting of coarse grains, free from mica, dust and other foreign matter.

4.12.00 SCREENINGS: Screening to fill voids in the coarse aggregate shall generally consists of the same material as the coarse aggregate. However, where permitted, predominantly non-plastic material such as moorum or gravel (other than river borne rounded material) may be used for this purpose provided liquid limit and plasticity index of such material is below 20 and 6 respectively and fraction passing 75 micron sieve does not exceed 10 percent. As far as possible screenings shall conform to the grading set forth in Table- 6. Screenings of Type-A shall be used with coarse aggregate of Grade- 1 of Table- 2. Screenings of Type-A or B as specified, shall be used with coarse aggregates of Grade- 2. Type-B screenings shall be used with coarse aggregates of Grade- 3. The use of screenings may be omitted in the case of soft aggregates such as brick metal, kankar and laterite.

TABLE - 6 : GRADING FOR SCREENINGS			
Grading Classification.	Size of Screenings	Sieve Designation	Percent By Weight Passing Sieve
Type - A	13.20 mm	13.20 mm 11.20 mm 5.60 mm 180micron	100 95 - 100 15 - 35 0 - 10
Type - B	11.20 mm	11.20 mm 5.60 mm 180 micron	100 90 - 100 15 - 35

4.13.00 SOIL: Soil having a plasticity index (PI) between 5 and 20 shall be suitable. At least one test for 200 cubic metre of soil for determining P.I. shall be conducted.

- 4.14.00 **STONE CHIPPINGS:** For surface dressing / painting the stone chipping shall consist of fairly cubical fragment of clean, hard, tough and durable rock of uniform quality throughout. These shall be obtained by crushing stone, river gravel or other approved materials. Rounded gravel shall be used only if specifically permitted by the Engineer-in-Charge. The chipping shall be free of elongated or flaky pieces, soft or disintegrated stone, salt, alkali, vegetable matter, dust and adherent coatings. They shall conform to the quality requirements of Table- 7 below:



TABLE - 7 : PHYSICAL REQUIREMENTS OF AGGREGATES FOR SURFACE DRESSING / ASPHALTIC CONCRETE			
Sl. No.	Tests	Test Method	Requirements
1.	Los Angeles Abrasion Value	IS : 2386 (Part IV)	40% Max.
2.	Aggregate Impact Value *	IS : 2386 (Part IV)	30% Max.
3.	Flakiness Index	IS : 2386 (Part I)	25% Max.
4.	Stripping Value		25% Max.
5.	Water Absorption	IS : 2386 (Part III)	1% Max.
* Aggregates may satisfy requirements of either of the two tests.			

## 5.00.00 SUPPLYING AND STACKING OF MATERIALS

- 5.01.00 Supplying, Stacking And Measurements of all the materials shall be carried out in accordance with the provisions laid down in section 16 of latest CPWD Specifications and in relevant clauses of IS Codes.

## 6.00.00 EARTHWORK IN ROAD CONSTRUCTION

- 6.01.00 Earthwork connected with road construction fall broadly into three categories:
- Earthwork in cutting including borrow pits.
  - Earthwork in filling in embankments without optimum moisture condition and
  - Earthwork in filling in embankments under optimum moisture condition.
- 6.02.00 Detailed specifications relating to Earthwork described in latest CPWD Specifications so far as the various options in the earthwork for road construction as indicated below shall be applicable:
- 2.4 Site clearance.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 205 of 242		

- b. 2.5 Setting out and making profile.
- c. 2.6 Blasting operations.
- d. 2.7 Excavation in all kinds of soils.
- e. 2.8 Excavation in ordinary/ hard rock.
- f. 2.9 Earthwork in filling.
- g. 2.10 Measurements.
- h. 2.11 Rates.
- i. 2.12 Surface excavation.
- j. 2.13 Rough excavation and filling.

6.03.00 In addition to the above, there are certain special requirements of earthwork for road constructions, especially in embankments and excavations from borrow pits. These shall broadly conform to:

- a. IRC: 36 Recommended practice for construction of earth embankments for road works.
- b. IRC: 10 Recommended practice for borrow pits for road embankments by manual operation.

Excavation from borrow pits shall conform to provisions in para 3 of IRC: 10 and the road embankment shall generally conform to section, slopes and location of borrow pits as per fig. 5.



6.04.00 Embankment construction without optimum moisture content conditions and with optimum moisture content conditions shall conform to the provisions in Section 16 of latest CPWD Specifications.

6.05.00 **CUTTING:** Where the formation level of the road is lower than the ground level, cutting shall be done up to the formation level. Side slopes except in rock cutting shall be evenly and truly dressed.

6.06.00 **Disposal of Surplus Earth:** Earth from cutting, if suitable, shall be utilized for filling in embankment as directed by the Engineer-in-Charge. Earth not required for filling shall be disposed off as directed by the Engineer-in-Charge. The area where the surplus earth is disposed off shall be leveled and neatly dressed.

6.07.00 **MEASUREMENTS**

- a. The quantity of earth work shall be calculated by measuring the volume of earth excavated from the borrow pits and shall be done as specified in section 16 of CPWD Specifications. Where it is not possible or convenient to

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 बी एच ई लिमिटेड <b>BHEL</b>
		Document No.	Rev	
		Sheet 206 of 242		

take measurements from cutting, the filling shall be measured and the quantity of earth work computed from cross-sections of the filling. The quantity of earth work so computed shall be reduced by 5% to arrive at the quantity for payment.

- b. For the purpose of taking measurement of earth work in cutting or embankment, ground levels of the area shall be recorded as specified in section 16 of CPWD Specifications.

6.08.00 **RATE:** It includes the cost of all the operations described above and in Sections 16 of latest CPWD specifications. The lead and lift for depositing the earth or disposal of unsuitable material shall be as described in the description of item. It also includes the work mentioned in relevant sub-para of section for earth work of latest CPWD specifications.

## **7.00.00 SUB – GRADE**

7.01.00 In sub-grade composed of clay, fine sand or other soils that may be forced up into the course aggregate during rolling operations, an insulation layer of granular materials oversize brick aggregate not less than 10 cm thick of suitable thickness shall be provided for blanketing the sub-grade.

7.02.00 In slushy soils or in areas that are logged, special arrangements shall be made to improve the sub-grade and total pavement thickness shall be designed after testing the properties of the sub-grade soil.

## **7.03.00 PREPARATION OF SUB-GRADE**

The surface of the formation for a width of sub-base, which shall be 15 cm more on either side of base course, shall first be cut to a depth equal to the combine depth sub-base and surface courses below the proposed finished level (due allowance shall be made for consolidation). It shall then be cleaned of all foreign substances. Any ruts or soft yielding patches that appear due to improper drainage conditions, traffic hauling or from any other cause, shall be corrected and the sub-grade dressed off parallel to the finished profile.

## **7.04.00 CONSOLIDATION**

The sub-grade shall be consolidated with a power road roller of 8 to 12 tonnes. The roller shall run over the sub-grade till the soil is evenly and densely consolidated and behaves as an elastic mass (the roller shall pass a minimum of 5 runs on the sub-grade). All undulations in the surface that develop due to rolling shall be made good with material or quarry spoils as the cases may be and the sub-grade is rerolled.

#### 7.05.00 SURFACE REGULARITY

The finished surface shall be uniform conform to the lines, grades and typical cross-sections shown in the drawings. When tested with the template and straight edge, the variation shall be within the tolerances specified below:-

PERMISSIBLE TOLERANCES OF SURFACE EVENNESS OF SUB-GRADE	
Longitudinal Profile	Cross Profile
Maximum permissible undulation when measured with a 3 metre edge	Maximum permissible variation from specified profile when measured with a camber template
24 mm	15mm

Where the surface irregularity of the sub-grade falls outside tolerances, the contractor shall be liable to rectify these with fresh material or quarry spoils as the case may be, and the sub-grade rerolled to the satisfaction of Engineer-in-Charge.

**7.06.00 MEASUREMENTS:** The length and width shall be measured correct to a cm. The area shall be worked out in square metre, correct to two places decimal.

**7.07.00 RATE:** The rate for preparation and consolidation of sub-grade shall include the cost of materials and labour required for all the operations indicated in above unless otherwise specified.



#### 8.00.00 GRANULAR SUB-BASE

**8.01.00** This work shall consist of laying and compacting well-graded material on prepared sub grade in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as sub-base as necessary according to lines, grades and cross-sections shown on the drawings or as directed by the Engineer in charge.

**8.02.00 Materials:**  
The material to be used for the work shall be crushed aggregate and it shall be free from organic or other deleterious constituents and conform to Grading I as given in the below Table for coarse-graded granular sub-base materials.

**TABLE: GRADING FOR COARSE GRADED GRANULAR SUB-BASE MATERIALS**

IS Sieve Designation	Per cent by weight passing the IS Sieve		
	Grading I	Grading II	Grading III
75.0 mm	100	-	-
53.0 mm	-	100	-
26.5 mm	55-75	50-80	100
9.50 mm	-	-	-
4.75 mm	10-30	15-35	25-45

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 208 of 242		

2.36 mm	-	-	-
0.425 mm	-	-	-
0.075 mm	<10	<10	<10

CBR Value (Minimum) 30 25 20

- 8.02.01 **Physical requirements:** The material shall have a 10 per cent fines value of 50 kN or more (for sample in soaked condition) when tested in compliance with BS: 812 (Part III) . The water absorption value of the coarse aggregate shall be determined as per IS: 2386 (Part 3); if this value is greater than 2 per cent, the soundness test shall be carried out on the material delivered to site as per IS: 383. For Grading II and III materials, the CBR shall be determined at the density and moisture content likely to be developed in equilibrium conditions which be taken as being the density relating to a uniform air voids content of 5 percent.

Note: The material passing 425 micron (0.425 mm) sieve for all the three gradings when tested according to IS: 2720 (Part 5) shall have liquid limit and plasticity index not more than 25 and 6 percent respectively.

#### 8.03.00 **Construction Operations**

**Preparation of subgrade:** Immediately prior to the laying of sub-base, the subgrade already finished shall be prepared by removing all vegetation and other extraneous matter, lightly sprinkled with water if necessary and rolled with two passes of 80-100 kN smooth wheeled roller.



**Spreading and compacting:** The sub-base material shall be spread on the prepared subgrade with the help of a motor grader of adequate capacity, its blade having hydraulic controls suitable for initial adjustment and for maintaining the required slope and grade during the operation or other means as approved by the Engineer.

The sub-base material shall be mixed mechanically by the mix-in-place method.

The equipment used for mix-in-place construction shall be a rotavator or similar approved equipment capable of mixing the material to the desired degree. If so desired by the Engineer, trial runs with the equipment shall be carried out to establish its suitability for the work.

Moisture content of the loose material shall be checked in accordance with IS: 2720 (Part 2) and suitably by sprinkling additional water from a truck mounted or trailer mounted water tank and suitable for applying water uniformly and at controlled quantities to variable widths of surface or other means approved by the Engineer so that, at the time of compaction, it is from 1 percent above to 2 percent below the optimum moisture content corresponding to IS: 2720 (Part 8). While adding water, due allowance shall be made for evaporation losses. After water has been added, the material shall be processed by mechanical or other approved means like disc harrows, rotavators until the layer is uniformly wet.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 209 of 242		

Immediately thereafter, rolling shall start. If the thickness of the compacted layer does not exceed 100 mm, a smooth wheeled roller of 80 to 100 kN weight may be used. For a compacted single layer upto 225 mm the compaction shall be done with the help of a vibratory roller of minimum 80 to 100 kN static weight with plain drum or pad foot-drum or heavy pneumatic tyred roller of minimum 200 to 300 kN weight having a minimum tyre pressure of 0.7 MN/m<sup>2</sup> or equivalent capacity roller capable of achieving the required compaction. Rolling shall commence at the lower edge and proceed towards the upper edge longitudinally for portions having unidirectional crossfall and super elevation and shall commence at the edges and progress towards the centre for portions having crossfall on both sides.

Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. During rolling, the grade and crossfall (camber) shall be checked and any high spots or depressions, which become apparent, corrected by removing or adding fresh material. The speed of the roller shall not exceed 5 km per hour. Rolling shall be continued till the density achieved is at least 98 percent of the maximum dry density for the material determined as per IS: 2720 (Part 8). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

- 8.04.0 Surface Finish and Quality Control of Work  
Control on the quality of materials and surface finishing shall be as per direction of Engineer.



#### **9.00.00 WET MIX MACADAM BASE**

- 9.01.00 This work shall consist of laying and compacting clean, crushed, graded aggregate and granular material, premixed with water, to a dense mass on a prepared sub-base as the case may be in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as necessary to lines, grades and cross-sections shown on the approved drawings or as direction by the Engineer. The thickness of a single compacted Wet Mix Macadam layer shall not be less than 75 mm.

#### **9.02.00 Materials**

##### **9.02.01 Aggregates**

**Physical requirements:** Coarse aggregates shall be crushed stone. If crushed gravel is used, not less than 90 percent by weight of the gravel pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements as given below table.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 210 of 242		

**TABLE: PHYSICAL REQUIREMENTS OF COARSE AGGREGATES FOR WET MIX MACADAM FOR BASE COURSES**

	Test	Test Method	Requirements
1.	* Los Angeles abrasion value Or	IS : 2386 (Part-4)	40 per cent (Max.)
2.	* Aggregate Impact value	IS : 2386 (Part-4) Or IS : 5640	30 per cent (Max.)
3.	Combined Flakiness and Elongation indices (Total)	IS : 2386 (Part-1)	30 per cent(Max.)**

\* Aggregate may satisfy requirements of either of the two tests.

\*\* To determine this combined proportion, the flaky stone from a representative sample should first be separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particles be separated out from the remaining (non-flaky) stone metal. Elongation index is weight of elongated particles divided by total non-flaky particles. The value of flakiness index and elongation index so found are added up.

If the water absorption value of the coarse aggregate is greater than 2 per cent, the soundness test shall be carried out on the material delivered to site as per IS:2386 (Part- 5).

**Grading requirements:** The aggregates shall conform to the grading given in Table below.

**TABLE: GRADING REQUIREMENTS OF AGGREGATES FOR WET MIX MACADAM**



IS Sieve Designation	Per cent by weight passing the IS sieve
53.00 mm	100
45.00 mm	95-100
26.50 mm	-
22.40 mm	60-80
11.20 mm	40-60
4.75 mm	25-40
2.36 mm	15-30
600.00 micron	8-22
75.00 micron	0-8

Materials finer than 425 micron shall have Plasticity Index (PI) not exceeding 6. The final gradation approved within these limits shall be well graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa.

#### 9.03.00 **Construction Operations**

9.03.01 **Preparation of base:** The surface of the sub-base to receive the wet mix macadam course shall be prepared to the specified lines and crossfall (camber) and made free of dust and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm surface is



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसीकरण औद्योगिक कंपनी लि. <b>BHEL</b>
		Document No.	Rev	
		Sheet 211 of 242		

obtained if necessary by sprinkling water. Any sub-base surface irregularities, where predominant, shall be made good by providing appropriate type of profile corrective course (levelling course).



- 9.03.02 **Provision of lateral confinement of aggregates:** While constructing wet mix macadam, arrangement shall be made for the lateral confinement of wet mix. This shall be done by laying materials in adjoining shoulders along with that of wet mix macadam layer.
- 9.03.03 **Preparation of mix:** Wet Mix Macadam shall be prepared in an approved mixing plant of suitable capacity having provision for controlled addition of water and forced/positive mixing arrangement like pugmill or pan type mixer of concrete batching plant.
- Optimum moisture for mixing shall be determined in accordance with IS: 2720 (Part-8) after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22.4 mm size. While adding water, due allowance should be made for evaporation losses. However, at the time of compaction, water in the wet mix should not vary from the optimum value by more than agreed limits. The mixed material should be uniformly wet and no segregation should be permitted.
- 9.03.04 **Spreading of mix:** Immediately after mixing, the aggregates shall be spread uniformly and evenly upon the prepared subgrade/sub-base/base in required quantities. In no case should these be dumped in heaps directly on the area where these are to be laid nor shall their hauling over a partly completed stretch be permitted.

The mix may be spread either by a paver finisher or motor grader. For portions where mechanical means cannot be used, manual means as approved by the Engineer shall be used. The motor grader shall be capable of spreading the material uniformly all over the surface. Its blade shall have hydraulic control suitable for initial adjustments and maintaining the same so as to achieve the specified slope and grade.

The paver finisher shall be self-propelled, having the following features:

- (i) Loading hoppers and suitable distribution mechanism
- (ii) The screed shall have tamping and vibrating arrangement for initial compaction to the layer as it is spread without rutting or otherwise marring the surface profile.
- (iii) The paver shall be equipped with necessary control mechanism so as to ensure that the finished surface is free from surface blemishes.

The surface of the aggregate shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate as may be required. The layer may be tested by depth blocks during construction. No

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 212 of 242		

segregation of larger and fine particles should be allowed. The aggregates as spread should be of uniform gradation with no pockets of fine materials.

- 9.03.05 **Compaction:** After the mix has been laid to the required thickness, grade and cross fall/camber the same shall be uniformly compacted, to the full depth with suitable roller. If the thickness of single compacted layer does not exceed 100 mm, smooth wheel roller of 80 to 100 kN weight may be used. For a compacted single layer upto 200 mm, the compaction shall be done with the help of vibratory roller of minimum static weight of 80 to 100 kN or equivalent capacity roller. The speed of the roller shall not exceed 5 km/h.

In portions having unidirectional cross fall/super elevation, rolling shall commence from the lower edge and progress gradually towards the upper edge. Thereafter, roller should progress parallel to the centre line of the road, uniformly over-lapping each preceding track by at least one third width until the entire surface has been rolled. Alternate trips of the roller shall be terminated in stops at least 1 m away from any preceding stop.

In portions in camber, rolling should begin at the edge with the roller running forward and backward until the edges have been firmly compacted. The roller shall then progress gradually towards the centre parallel to the centre line of the road uniformly overlapping each of the preceding track by at least one third width until the entire surface has been rolled.



Any displacement occurring as a result of reversing of the direction of a roller or from any other cause shall be corrected at once as specified and/or removed and made good.

Along forms, kerbs, walls or other places not accessible to the roller, the mixture shall be thoroughly compacted with mechanical tampers or a plate compactor. Skin patching of an area without scarifying the surface to permit proper bonding of the added material shall not be permitted.

Rolling should not be done when the sub grade is soft or yielding or when it causes a wave-like motion in the sub-base/base course or sub grade. If irregularities develop during rolling which exceed 12 mm when tested with a 3 metre straight edge, the surface should be loosened and premixed material added or removed as required before rolling again so as to achieve a uniform surface conforming to the desired grade and crossfall. In no case should the use of unmixed material be permitted to make up the depressions.

Rolling shall be continued till the density achieved is at least 98 per cent of the maximum dry density for the material as determined by the method outlined in IS: 2720 (Part-8).

After completion, the surface of any finished layer shall be well-closed, free from movement under compaction equipment or any compaction planes, ridges,

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 213 of 242		

cracks and loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of the layer and recompacted.

9.03.06 **Setting and drying:** After final compaction of wet mix macadam course, the road shall be allowed to dry for 24 hours.

9.04.00 **Opening to Traffic**

Preferably no vehicular traffic of any kind should be allowed on the finished wet mix macadam surface till it has dried and the wearing course laid.

9.05.00 **Surface Finish and Quality Control of Work**

Control on the quality of materials and surface finishing shall be as per direction of the Engineer.

9.06.00 **Prime Coat Over Granular Base**

9.06.01 This work shall consist of application of single coat of low viscosity liquid bituminous material to an absorbent granular surface preparatory to any superimposed bituminous treatment or construction.

9.06.02 **Materials**

The choice of a bituminous primer shall depend upon the porosity characteristics of the surface to be primed as classified in IRC: 16. These are:



- (i) Surfaces of low porosity; such as wet mix macadam and water bound macadam,
- (ii) Surfaces of medium porosity; such as cement stabilized soil base,
- (iii) Surfaces of high porosity; such as a gravel base.

The different ranges of viscosity requirements for the primers to be used for the different types of surfaces to be primed as classified are given in Table.

**VISCOSITY REQUIREMENT AND QUANTITY OF BITUMINOUS PRIMER**

Type of surface	Kinematic Viscosity of Primer at 60° C (Centistokes)	Quantity per 10 sq. m (Kg)
Low porosity	30-60	6 to 9
Medium porosity	70-140	9 to 12
High porosity	250-500	12 to 15

The bituminous primer shall be Medium Curing Cutback (MC) produced by fluxing, in an approved manner, bitumen of 80/100 penetration grade with kerosene. The cutback shall be free from water and shall not show any signs of separation prior to use. Slow setting Cationic emulsion as per IS: 8887 may also be used, but the particular grade to be used for the work shall be got approved by the Engineer.

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></p><p><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></p></div>	PC288/E/001/P-II/5.5	P	<div><p>भारत कोयला गैसिफिकेशन लिमिटेड <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 214 of 242		

Sampling and testing of bituminous primer shall be as per IS: 217; IS: 454 and IS: 8887.

#### 9.06.03 **Weather and Seasonal Limitations**

The bituminous primer shall not be applied on a wet surface or during dust storm or when the weather is foggy, rainy or windy. The prime coat for surface treatment should not be applied when the temperature in the shade is less than 10°C.

#### 9.06.04 **Construction**

**Equipment:** The primer distributor shall be pneumatic tyred self-propelled pressure distributor equipped for spraying the material uniformly at the specified rates and temperatures. spraying by manual methods may be allowed for small areas at the discretion of the Engineer. Power broom and/or blowers may be supplemented by hand brooms as directed by the Engineer-in-charge.



**Preparation of road surface:** The surface to be primed shall be swept clean, free from dust and shall be dry. It shall be shaped to the specified grades and section. It shall also be free from ruts, any other irregularities and segregated materials. Minor depressions and potholes may be ignored until the surface is primed, after which they shall be patched with a suitable premix material prior to the surface treatment.

**Application of bituminous primer:** The bituminous primer shall be sprayed/distributed uniformly over the prepared dry surface using selfpropelled sprayer equipped with self-heating arrangement, suitable pump, adequate capacity compressor and spraying bar with nozzles having constant volume or pressure system capable of supplying primer at specified rates and temperatures so as to provide a uniformly unbroken spread of primer. If the surface to be primed is so dry or dusty as to cause freckling of bituminous material, it shall be lightly and uniformly sprinkled with water immediately prior to priming; however, the bituminous material shall not be applied till such time as no surface water is visible. The primer shall be applied at the rate as specified in above Table.

Temperature of application of a primer need only be high enough to permit the primer to be effectively sprayed through the jets of the spray bar and to cover the granular base surface uniformly in the desired quantity.

The desirable range of temperatures at the time application of MC-30, MC-70 and MC-250 grades shall be 30 to 55°C; 50 to 80°C and 75 to 100°C respectively. For a bituminous emulsion primer, the range of spraying temperature may be 20 to 60°C.

Following the application of bituminous material, the surface shall be allowed to cure for at least 24 hours or for any other period so as to allow penetration into the base course and aeration of volatiles from the primer material. If it is not absorbed within 24 hours after application, sand shall be spread over the

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></div>	PC288/E/001/P-II/5.5	P	<div> बी एच ई लि <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 215 of 242		

surface to blot the excess primer. Care shall be taken to prevent over-priming; any pools of excess primer left on any part of the surface shall be swept out over the adjacent surface before spreading sand.

The primer coat shall be applied only on the topmost water bound macadam or any granular layer, over which the bituminous base course/wearing course, is to be laid.

**Curing of primer and opening to traffic:** It shall always be ensured that while opening to any kind of traffic, the primed surface is fully cured and is not sticky to avoid being picked up by traffic. Normally, the primed surface shall be allowed to cure for not less than 24 hours and during this period no traffic of any kind shall be permitted.

**Laying of bituminous course over primed surface:** Bituminous base course or wearing course shall be laid over the primed water bound macadam, wet mix macadam or any other granular base course, in the usual manner as per relevant Specification for the same including the requirement of tack coat as per Clause 10.04.03.

#### 9.06.05 **Quality control of work**

Control on the quality of materials and work shall be as per the direction of engineer-in-charge

### 10.00.00 **DENSE BITUMINOUS MACADAM**

10.01.00 This work shall consist of construction in a single course of 50 to 100 mm thick base/binder course to the following Specifications on a previously prepared base.



#### 10.02.00 **Materials**

10.02.01 **Bitumen:** The bitumen shall be paving bitumen of Grade VG-10, VG-20, VG-30, VG-40 as per Indian Standard Specifications for “Paving Bitumen” IS: 73-2006.

10.02.02 **Coarse aggregates:** The coarse aggregates shall consist of crushed stone, crushed gravel/shingle or other stones. They shall be clean, strong, durable, of fairly cubical shape and free from disintegrated pieces, organic or other deleterious matter and adherent coating. The aggregates shall preferably be hydrophobic and of low porosity. If hydrophilic aggregates are to be used, the bitumen shall be treated with antistripping agents of approved quality in suitable doses. The aggregates shall satisfy the physical requirements as given below table.

**TABLE: PHYSICAL REQUIREMENTS OF AGGREGATES FOR DENSE BITUMINOUS MACADAM**

Sr.No	Test	Test Method	Requirement
1.	Los Angeles Abrasion Value *	IS: 2386 (Part-4)	40 percent Maximum
2.	Aggregate Impact value *	IS: 2386 (Part-4)	30 percent Maximum
3.	Flakiness and Elongation**	IS: 2386 (Part-1)	30 per cent Maximum

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 216 of 242		

	Indices (Total)		
4.	Coating and Stripping of Bitumen Aggregate Mixtures	AASHTO T 182	Minimum retained coating 95 per cent
5.	Soundness (i) Loss with Sodium Sulphate (ii) Loss of Magnesium Sulphate	IS: 2386 (Part-5) 5 cycles 5 cycles	12 percent Maximum 18 percent Maximum
6.	Water absorption	IS: 2386 (Part-3)	2 percent Maximum

\* Aggregates may satisfy requirements of either of the two tests.

\*\* To determine this combined proportion, the flaky stone from a representative sample should first be separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particles be separated out from the remaining (non flaky) stone metal. Elongation index is weight of elongated particles divided by total non-flaky particles. The value of flakiness index and elongation index so found are added up.

If crushed gravel/shingle is used, not less than 90 percent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The portion of the total aggregate passing 4.75mm sieve shall have a sand equivalent value of not less than 50 when tested in accordance with the requirement of IS: 2720 (Part-37).

4. The plasticity index of the fraction passing the 425 micron sieve shall not exceed

10.02.03 **Fine aggregates:** Fine aggregates shall be the fraction passing 2.36 mm sieve and retained on 75 micron sieve, consisting of crusher-run screening, gravel, sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry and free from any injurious, soft or flaky pieces and organic or other deleterious substances.



10.02.04 **Filler:** Filler shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement as approved by the Engineer.

The filler shall be graded within the following limits:

IS Sieve	Percent passing by weight
600 Micron	100
300 Micron	95 - 100
75 Micron	85 – 100

The filler shall be free from organic impurities and have a Plasticity Index not greater than 4. The Plasticity Index requirement shall not apply if filler is cement or lime. When the coarse aggregate is gravel, 2 per cent by mass of total aggregate of portland cement or hydrated lime shall be added and the



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 217 of 242		

percentage of fine aggregate reduced accordingly. Cement or hydrated lime is not required when the gravel is limestone.

- 10.02.05 **Aggregate gradation:** The combined coarse and fine aggregates and filler (when used) shall produce a mixture to conform to the grading set forth in Table below.

**Table: AGGREGATE GRADATION FOR DENSE BITUMINOUS MACADAM**

Sieve Designation	Percentage passing the sieve by weight
37.5 mm	100
26.5 mm	90-100
13.2 mm	56-80
4.75 mm	29-59
2.36 mm	19-45
300 micron	5-17
75 micron	1-7

The aggregate mix, as used in work, shall not vary from the low limit on one sieve to the high limit on the adjacent sieve but shall be well graded.



10.03.00 **Mix Design**

- 10.03.01 **Requirement of mix:** Apart from conformity with grading and quality requirements of individual ingredients, the mix shall meet the requirements set out in Table below.

**Table: REQUIREMENTS OF DENSE BITUMINOUS MACADAM MIX**

Sr. No.	Description	Requirements
1.	Marshall stability (ASTM Designation-D-1559) determined on Marshall specimens compacted by 75 compaction blows on each end	820 kg (1800 lb) minimum
2.	Marshall flow (mm)	2-4
3.	Per cent Air voids	3-5
4.	Minimum voids in mineral aggregates (VMA)	10 percent-12percent
5.	Per cent voids in mineral aggregates filled by bitumen (VFB)	65-75
6.	Binder content percent by weight of total mix	Not less than 4.0%

- 10.03.02 **Binder content:** The binder content shall be so fixed as to achieve the requirements of the mix set out in the above Table. Marshall method for arriving at the binder content shall be adopted, replacing the aggregates retained on 26.5 mm sieve by the aggregates passing 26.5 mm sieve and retained on 22.4 mm sieve.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 218 of 242		

10.03.03 **Job mix formula:** The Contractor shall intimate to the Engineer in writing, at least 20 days before the start of the work, the job mix formula proposed to be used by him for the work and shall give the following details:

- i) Source and location of all materials;
- ii) Proportions of all materials expressed as follows where each is applicable;
  - (a) Binder, as percentage by weight of total mix;
  - (b) Coarse aggregate/Fine aggregate/Mineral filler as percentage by weight of total aggregate including mineral filler.
- iii) A single definite percentage passing each sieve for the mixed aggregate;
- iv) The results of tests enumerated in above Table as obtained by the Contractor;
- v) Test results of physical characteristics of aggregates to be used;
- vi) Mixing temperature and compacting temperature.

While working out the job mix formula, the Contractor shall ensure that it is based on a correct and truly representative sample of the materials that will actually be used in the work and that the mix and its different ingredients satisfy the physical and strength requirements of these Specifications.

Approval of the job mix formula shall be based on independent testing by the Engineer-in-charge for which samples of all ingredients of the mix shall be furnished by the Contractor as required by the former.



The approved job mix formula shall remain effective unless and until modified by the Engineer-in-charge. Should a change in the source of materials be proposed, a new job mix formula shall be established and got approved from the Engineer-in-charge before actually using the materials.

10.03.04 **Permissible variation from job mix formula:** It shall be the responsibility of the Contractor to produce a uniform mix conforming to the approved job mix formula subject to the permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used within the limits as specified in below Table.

**TABLE: PERMISSIBLE VARIATIONS FROM THE JOB MIX FORMULA**

Sr. No.	Description of Ingredients	Permissible variation by weight of total mix-in per cent
1.	Aggregate passing 13.2 mm sieve and larger sieves	± 8
2.	Aggregate passing 11.2 mm sieve and 5.6 mm sieve	± 7



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसीकरण और रासायनिक उद्योग <b>BHEL</b>
		Document No.	Rev	
		Sheet 219 of 242		

3.	Aggregate passing 2.80 mm sieve and 1.40 mm sieve	± 6
4.	Aggregate passing 710 micron sieve and 355 micron sieve	± 5
5.	Aggregate passing 180 micron sieve	± 4
6.	Aggregate passing 90 micron sieve	± 2
7.	Binder	± 0.3
8.	Mixing temperature	± 10°C

#### 10.04.00 **Construction Operations**

10.04.01 **Weather and seasonal limitations:** The work of laying shall not be taken up during rainy or foggy weather or when the base course is damp or wet, or during dust storm or when the atmospheric temperature in shade is 10°C or less.

10.04.02 **Preparation of base:** The base on which Dense Bituminous Macadam is to be laid shall be prepared, shaped and conditioned to the specified lines, grades and cross sections as indicated in the drawings or as directed by the Engineer-in charge. The surface shall be thoroughly swept clean free from dust and foreign matter using mechanical broom and dust removed or blown off by compressed air. In portions where mechanical means cannot reach, other approved method shall be used. A priming coat where needed, shall be applied as per direction of the Engineer-in charge.

#### 10.04.03 **Tack coat**

The surface on which the tack coat is to be applied shall be cleaned of dust and any extraneous material before the application of the binder, by using a mechanical broom or any other approved equipment/method as specified by the Engineer-in-charge.

Binder may be heated to the temperature appropriate to the grade of cutback used and approved by the Engineer-in-charge and sprayed on the base at the rate specified in below Table. The normal range of spraying temperature for a bituminous emulsion shall be 20° C - 60° C and for a cutback 50° C – 80° C if RC70/MC-70 grade is used. It shall be the responsibility of the Contractor to carefully handle the inflammable bituminous cutback material so as to safeguard against any fire mishap. The binder shall be applied uniformly with the aid of either self-propelled or towed bitumen pressure sprayer with self– heating arrangement and spraying bar with nozzles having constant volume or pressure system, capable of spraying bitumen at specified rates and temperature so as to provide a uniformly unbroken spread of bitumen. Work should be planned so that no more than the necessary tack coat for the day's operation is placed on the surface. After application and prior to succeeding construction allow the tack coat to cure, without being disturbed, until the water/cutter has completely evaporated, as determined by the Engineer-in charge.

#### **TABLE: RATE OF APPLICATION OF TACK COAT**

Sr. No.	Type Surface	Quantity of liquid Bituminous material in kg per 10 sq. m. area
i)	Normal bituminous surfaces	2.0 to 2.5
ii)	Dry and hungry bituminous surfaces	2.5 to 3.0
iii)	Granular surfaces treated with primer	2.5 to 3.0
iv)	Non bituminous surfaces	
	a) Granular base (not primed)	3.5 to 4.0
	b) Cement concrete pavement	3.0 to 3.5

**Note:**



There is no need to apply a tack coat on a freshly laid bituminous course if the subsequent bituminous course is overlaid the same day without opening it to traffic.

**10.04.04 Preparation of mix:** Dense Bituminous macadam mix shall be prepared in a hot mix plant of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates.

Hot mix plant shall be of suitable capacity preferably of batch mix type. Total system for crushing of stone aggregates and feeding of aggregate fractions in required proportions to achieve the desired mix, deployed by the Contractor must be capable of meeting the overall Specification requirements under stringent quality control. The plant shall have the following essential features:

**General**

- The plant shall have coordinated set of essential units capable of producing uniform mix as per the job mix formula.
- Cold aggregate feed system with minimum 4 bins having belt conveyor arrangement for initial proportioning of aggregates from each bin in the required quantities. In order to have free flow of fines from the bin, it is advisable to have vibrator fitted on bin to intermittently shake it.
- Belt conveyers below each bin should have variable speed drive motors. There should be electronic load sensor on the main conveyor for measuring the flow of aggregates.
- Dryer unit with burner capable of heating the aggregate to the required temperature without any visible unburnt fuel or carbon residue on the aggregate and reducing the moisture content of the aggregate to the specified minimum.
- The plant shall be fitted with suitable type of thermometric instruments at appropriate places so as to indicate or record/register the temperature of heated aggregate, bitumen and mix.
- Bitumen supply unit capable of heating, measuring/metering and spraying of bitumen at specified temperature with automatic synchronisation of bitumen and aggregate feed in the required proportion.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 221 of 242		

- (g) A filler system suitable to receive bagged or bulk supply of filler material and its incorporation to the mix in the correct quantity wherever required.
- (h) A suitable built-in dust control system for the dryer to contain/recycle permissible fines into the mix. It should be capable of preventing the exhaust of fine dust into atmosphere for environmental control wherever so specified by the Engineer-in charge.
- (i) The plant should have centralised control panel/cabin capable of presetting, controlling/synchronising all operations starting from feeding of cold aggregates to the discharge of the hot mix to ensure proper quality of mix. It should have indicators for any malfunctioning in the operation.
- (j) Every hot mix plant should be equipped with siren or horn so that the operator may use the same before starting the plant every time in the interest of safety of staff.

The temperature of binder at the time of mixing shall be in the range of 150°C to 163°C and that of the aggregate in the range of 155°C-163°C provided that the difference in temperature between the binder and aggregate at no time exceeds 14°C.



Mixing shall be thorough to ensure that a homogeneous mixture is obtained in which all particles of the aggregates are coated uniformly, and the discharge temperature of mix shall be between 130°C to 160°C.

The mixture shall be transported from the mixing plant to the point of use in suitable tipper vehicles. The vehicles employed for transport shall be clean and be covered in transit if so directed by the Engineer-in charge. Any tipper causing excessive segregation of materials by its spring suspension or other contributing factors or that which shows undue delay shall be removed from the work unit such conditions are corrected.

**10.04.05 Spreading:** The mix transported from the hot mix plant to the site shall be spread by means of a self-propelled paver with suitable screeds capable of spreading, tamping and finishing the mix to specified grade, lines and cross section. However, in restricted locations and in narrow widths where the available equipment cannot be operated in the opinion of the Engineer-in-charge, he may permit manual laying of the mix. Similarly for smaller jobs, mechanical paver may be used with the approval of the Engineer-in charge.

The temperature of mix at the time of laying shall be in the range of 120°-160° C.

Mixes with a temperature of less than 120° C shall not be put into paver spreader. Longitudinal joints and edges shall be constructed true to the delineating lines parallel to the centre line of the road. Longitudinal and transverse joints shall be offset by at least 250 mm from those in the lower courses and the joint on the top most layer shall not be allowed to fall within the

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 222 of 242		

wheel path. All transverse joints shall be cut vertically to the full thickness of the previously laid mix with asphalt cutter and the surface painted with hot bitumen before placing fresh material. Longitudinal joints shall be preferably hot joints. Cold longitudinal joints shall be properly heated with joint heater to attain a suitable temperature of about 80°C laying of adjacent material.



**10.04.06 Rolling:** After spreading the mix by paver, it shall be thoroughly compacted by rolling with a set of rollers moving at a speed not more than 5 km/h, immediately following close to the paver. Generally the initial or breakdown rolling shall be done with 80-100 kN static weight smooth-wheeled roller. The intermediate rolling shall be done with 80-100 kN static weight vibratory roller or with a pneumatic tyred roller of 150-250 kN weight having a tyre pressure of at least 0.7 MPa. The finish rolling shall be done with 60-80 kN weight smooth wheeled tandem roller. All the compaction operations, i.e., breakdown rolling and intermediate rolling can be accomplished by using vibratory tandem roller of 80-100 kN static weight. During initial breakdown rolling and finish rolling, no vibratory compaction shall be resorted to. The exact pattern of rolling shall be established after trial compaction as approved by the Engineer-in-charge. Any displacement occurring as a result of reversing of the direction of a roller or from any other cause shall be corrected at once as specified and/or removed and made good. The rollers shall not be permitted to stand on pavement which has not been fully compacted and where temperature is still more than 70°C. Necessary precautions shall be taken to prevent dropping of oil, grease, petrol or other foreign matter on the pavement either when the rollers are operating or standing.

The wheels of roller shall be kept moist to prevent the mix from adhering to them. But in no case shall fuel/lubricating oil be used for this purpose nor excessive water poured on the wheels. Rolling shall commence longitudinally from edges and proceed towards the centre, except that on superelevated and unidirectional cambered portions, it shall progress from the lower to upper edge parallel to the centre line of the pavement. The roller shall proceed on the fresh material with rear or fixed wheel leading so as to minimise the pushing of the mix and each pass of the roller shall overlap the preceding one by half the width of the rear wheel.

Rolling shall be continued till the density achieved is at least 98 per cent of that of laboratory Marshall specimen (compacted as defined in Table requirements of Dense Bituminous Macadam mix) and all roller marks are eliminated. Skin patching of an area that has been rolled will not be permitted. Rolling operations shall be completed in all respects before the temperature of the mix falls below 100°C.

#### **10.05.00 Opening to Traffic**

Traffic may be allowed after completion of the final rolling when the mix has cooled down to the surrounding temperature. The Dense Bituminous Macadam shall be provided with an appropriate wearing course as early as possible prior to regular opening to normal traffic and/or impending rain.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 223 of 242		

#### 10.06.00 **Surface Finish and Quality Control of Work**

Control on the quality of materials & surface finishing shall be as per direction of the Engineer.

### 11.00.00 **BITUMINOUS CONCRETE**

11.01.01 This work shall consist of constructing in a single layer, bituminous concrete (asphaltic concrete) of thickness 25-100 mm on previously prepared bituminous course to the requirements of these Specifications.

#### 11.02.00 **Materials**

11.02.01 **Bitumen:** The bitumen shall be paving bitumen of Grade VG-10, VG-20, VG-30, VG-40 as per Indian Standard Specifications for "Paving Bitumen" IS: 73-2006.

11.02.02 **Coarse aggregates:** The coarse aggregates shall consist of crushed stone, crushed gravel/shingle or other stones. They shall be clean, strong, durable, of fairly cubical shape and free from disintegrated pieces, organic or other deleterious matter and adherent coating. The aggregates shall preferably be hydrophobic and of low porosity. If hydrophilic aggregates are to be used, the bitumen shall be treated with antistripping agents of approved quality in suitable doses. The aggregates shall satisfy the physical requirements as indicated in clause 10.02.02. If crushed gravel/shingle is used, not less than 90 per cent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The portion of the total aggregate passing 4.75mm sieve shall have a sand equivalent value of not less than 50 when tested in accordance with the requirement of IS: 2720 (Part-37).



The plasticity index of the fraction passing the 425 micron sieve shall not exceed 4.

11.02.03 **Fine aggregates:** Fine aggregates shall be the fraction passing 2.36 mm sieve and retained on 75 micron sieve, consisting of crusher-run screening, gravel, sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry and free from any injurious, soft or flaky pieces and organic or other deleterious substances.

11.02.04 **Filler:** Filler shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement as approved by the Engineer-in-charge.

The filler shall be graded within the following limits:

IS Sieve	Per cent passing by weight
600 Micron	100
300 Micron	95 - 100
75 Micron	85 - 100

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसीकरण और रासायनिक उद्योग <b>BHEL</b>
		Document No.	Rev	
		Sheet 224 of 242		

The filler shall be free from organic impurities and have a Plasticity Index not greater than 4. The Plasticity Index requirement shall not apply if filler is cement or lime. When the coarse aggregate is gravel, 2 per cent by mass of total aggregate of portland cement or hydrated lime shall be added and the percentage of fine aggregate reduced accordingly. Cement or hydrated lime is not required when the gravel is limestone.

- 11.02.05 Aggregate gradation: The combined coarse and fine aggregates and filler (when used) shall produce a mixture to conform to the grading set forth in Table below.

**Table: AGGREGATE GRADATION FOR BITUMINOUS CONCRETE**

Sieve Designation	Percentage passing the sieve by weight
26.5 mm	100
19 mm	90 - 100
9.5 mm	56 - 80
4.75 mm	35 - 65
2.36 mm	23 - 49
300 micron	5 - 19
75 micron	2 - 8

The aggregate mix, as used in work, shall not vary from the low limit on one sieve to the high limit on the adjacent sieve but shall be well graded.



### 11.03.00 Mix Design

- 11.03.01 **Requirement of mix:** Apart from conformity with the grading and quality requirements of individual ingredients, the mix shall meet the requirements set forth in Table below.

**TABLE: REQUIREMENTS OF BITUMINOUS CONCRETE MIX**

Sr. No.	Description	Requirements
1.	Marshall stability (ASTM Designation: D-1559) determined on Marshall specimens compacted by 75 compaction blows on each end	820 kg (1800 lb) Minimum
2.	Marshall flow (mm)	2-4
3.	Per cent voids in mix	3-5
4.	Per cent voids in mineral aggregates (VMA) Minimum	Minimum 11-13 per cent
5.	Per cent voids in mineral aggregates filled by bitumen (VFB)	65-75
6.	Binder content, per cent by weight of total mix	Minimum 4.5
7.	Water Sensitivity (ASTM D1075) Loss of stability on immersion in water at 60° C	Min 75 per cent retained strength
8.	Swell Test (Asphalt Instt. MS-2, No. 2)	1.5 per cent Max



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 225 of 242		

11.03.02 **Binder content:** The binder content shall be so fixed as to achieve the requirements of the mix set forth in above Table. Marshall method for arriving at the binder content shall be adopted.

11.03.03 **Job mix formula:** Clause 10.03.03 shall apply except that the requirement of Bituminous Concrete mix shall be as per above table.

11.03.04 **Permissible variations from the job mix formula:** The Contractor shall have the responsibility of ensuring proper proportioning of materials in accordance with the approved job mix formula and producing a uniform mix. The permissible variations of individual percentages of various ingredients in the actual mix from the job mix formula may be within the limits as specified in clause 10.03.04.

#### 11.04.00 **Construction Operations**

11.04.01 **Weather and seasonal limitations:** The work of laying shall not be taken up during rainy or foggy weather or when the base course is damp or wet, or during dust storm or when the atmospheric temperature in shade is 10°C or less.

11.04.02 **Preparation of base:** The base on which bituminous concrete is to be laid shall be prepared, shaped and conditioned to the specified levels, grade and crossfall (camber) as per drawing.

The surface shall be thoroughly swept clean free from dust and foreign matter using mechanical broom and dust removed by mechanical means or blown off by compressed air. In portions where mechanical means cannot reach, other approved method shall be used.

11.04.03 **Tack coat:** A tack coat complying with Clause 10.04.03 shall be applied over the base.

11.04.04 **Preparation of mix:** Clause 10.04.04 shall apply.

11.04.05 **Spreading:** Clause 10.04.05 shall apply.

11.04.06 **Rolling:** Clause 10.04.06 shall apply.



#### 11.05.00 **Opening to Traffic**

Traffic may be allowed immediately after completion of the final rolling when the mix has cooled down to the surrounding temperature.

#### 11.06.00 **Surface Finish and Quality Control of Work**

Control on the quality of materials and surface finishing shall be as per direction of the Engineer.

### 12.00.00 **GENERAL REQUIREMENTS FOR BITUMEN MACADAM & SEAL COAT**

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></div> <div><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></div> <div><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></div>	PC288/E/001/P-II/5.5	P	<div><p>बी एच ई लि <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 226 of 242		

**12.01.00 Testing:** The contractor shall have a well equipped testing laboratory with a competent laboratory staff. Daily test (not less than two specimen per day) shall be made by them on the bituminous mixture produced to ensure compliance with these specification and copy of the test results duly signed by the competent authority shall be submitted to Consultant / Owner for record. Tests shall include water absorption, stability, filler content etc. The contractor shall give all facilities at all items to the Consultant or his representative to inspect the work or testing done by him. Generally the frequency of site test shall be carried out as follows:-

**A) Borrow material**

- a) Sand content (IS: 2720-part IV) -- 1 to 2 tests per 8000 cum of soil
- b) Plasticity test (IS: 2720-part V) -- 1 to 2 tests per 8000 cum of soil
- c) Density test (IS: 2720-part VII) -- 1 to 2 tests per 8000 cum of soil
- d) Moisture content test (IS: 2720-part II)—1 test per 250 cum of soil
- e) CBR test (IS: 2720-part XVI) -- 1test per 3000 cum of soil
- f) Compaction control (IS: 2720-part XXVIII) -- 1test per 1000 SqM area

**B) Water Bound Maccadam**

- a) Aggregate impact value -- 1 test per 200 cbm of aggregate
- b) Grading -- 1 test per 100 cbm of aggregate
- c) Flakiness index -- 1 test per 200 cbm of aggregate
- d) Atterbergs limits -- 1 test per 25 cbm of binding material

**C) Prime coat/Seal coat**

- a) binder temperature -- at close intervals
- b) Rate of spread -- Two tests per day

**D) Seal coat/Surface dressing**



- a) Aggregate impact value -- 1 test/ 50 cbm of aggregate
- b) Flakiness index -- 1 test /50 cbm of aggregate
- c) Grading of aggregate -- 1 test /25 cbm of aggregate

**E) Bituminous concrete**

- a) Aggregate impact value, Flakiness index -- 1 test / 50-100 cbm of aggregate
- b) Density of compacted layer -- 1 test / 500 Sq.m area.

**12.02.00 Weighing:** Each lorry leaving the plant must be weighed on a weigh bridge in the presence of the representative of the Owner and a challan must be issued along with the lorry in duplicate showing the weight of the material loaded in the lorry. As and when required, the said lorries shall also be weighed at the Owners



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 227 of 242		

weigh bridge or any other weigh bridge approved by the Consultant / Owner to check the tonnage of the material stated on the challans. In case of short fall, the same shall be made good by the contractor without extra cost.

**12.03.00 Testing Surface:** The completed surface when ready for acceptance shall be thoroughly compacted, smooth, true to line, grade, camber and free from irregularities when tested by means of a straight edge of 3m long, laid on the finished surface parallel with the centre line of the road, the surface shall in no place vary more than 6mm from the working edge.

**12.04.00 Maintenance:** It will be binding on the contractor to maintain the road free of cost for a period of 5 (five) years from the date of completion of the work. Security deposit will be released as per relevant clause of general conditions of contract against a guarantee bond for the maintenance period of five years against the following defects.

**12.05.00** The defects in the bituminous paving which the contractor may be called upon to rectify are of the following type

- Deformation of bituminous pavement resulting in waves or ruts
- Cracking of bituminous pavement resulting in admission of water to the sub-grade and the deterioration of the bituminous pavement adjoining the cracks.
- Disintegration/Revealing of bitumen pavement resulting in the formation of pot holes.
- Polishing of the bitumen pavement under traffic resulting in a surface on which the vehicles are liable to skid.

**12.06.00** Defects in areas in bitumen pavement under guarantee shall, when they exceed the limits specified below, be remedied immediately by the contractor. The limiting values of the defects shall be the following



- Deformation : 25mm in 3 m
- Cracks : 1500 mm in lengths and 3mm in width
- Disintegrated revealed patches: 2.00 sqm and/ or 12mm in depth.

### **13.00.00 IS / IRC CODES**



- |          |   |
|----------|---|
| IRC: 37  | Guidelines for design of flexible pavements     |
| IRC: 73  | Geometric design of roads                       |
| IS : 73  | Paving Bitumen                                  |
| IS : 702 | Industrial Bitumen                              |
| IS :1201 | Methods of testing tar and Bituminous materials |

### **14.00.00 PAVER BLOCK & KERB STONE:**

**14.01.00 General:** The following points must be noted and taken into consideration for supply & laying of paver block, kerb stone and channel etc.

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></p><p><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></p></div>	PC288/E/001/P-II/5.5	P	<div><p>भारत कोयला गैसिफिकेशन लिमिटेड <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 228 of 242		

- a) Contractor shall be responsible for supply, installation, test and guarantee of all items including taking all measures that may be required to complete the work as per drawings and specification details.
- b) Clearing the site by removing all obstacles such as stones, debris etc. for laying of pavers blocks.
- c) Testing of colored Rubber mould type interlocking paver's blocks shall have to be done through reputed Govt./Non Govt. Test house and submission of test results as per requirements in Technical Specifications. Cost for such tests to be borne by party including carting of materials.
- d) The contractor shall guarantee that all material and components designed, fabricated, supplied and laid by him shall be free from any type of defect due to faulty material and/or workmanship/erection for a period of 1 year from the date of completion of work during the warranty/Guarantee period. The contractor shall render free maintenance.
- e) All measurements and computations, unless otherwise specified, shall be carried out nearest to the following limits.
  - i) Length, width and depth (height) 0.01 Meter.
  - ii) Areas 0.01 SqM.
  - iii) Cubic Contents 0.01 CuM.
- f) Definite particulars covered in the items of work, through not mentioned or elucidated in it, specifications shall be deemed to be included there in.
- g) Approval to the samples of various materials given by the Engineer-in-charge shall not absolve the contractor from the responsibility of replacing defective material brought on site or materials used in the work found defective at a later date.
- h) The contract rate of the item of work shall be for the work completed in all respects.
- i) Materials, when rejected by the Engineer-in-charge, shall be immediately removed from the site of work within 24 hours.
- j) The contractors shall be fully responsible for the correct setting out and execution of the work. All tools, tackles, construction equipments etc., required for the successful execution / construction of the complete work shall be responsibility of the Contractors.
- k) The quoted rates shall be applicable for all heights, depths etc. except otherwise clearly stated in the description of items and nothing extra shall be paid to the contractor on this account.
- l) Any materials / accessories / fittings etc. which may not be specifically mentioned in the description of items but which are normally used or necessary are to be provided by the contractor without any extra cost.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसीकरण और रासायनिक उद्योग <b>BHEL</b>
		Document No.	Rev	
		Sheet 229 of 242		

#### 14.02.00 **Standards:**

The contractor must comply with all relevant Indian Standards. The equivalent International Standards may be used where these are not lower. Further other standard code of practices and technical literature relating to best practices pertaining to paver block shall be referred. Nothing in this clause shall relieve the contractor of his obligation to provide a higher standard where required and directed.

#### 14.03.00 **Design Criteria For Paver Block:**

##### 14.03.01 Pavers Block Manufacturing Facilities:

The Pavers Block shall be made in factory with following minimum facilities & shall be got these approved before carting materials to site.

##### 14.03.02 Concrete Block Making Machines:

The machine should be capable of producing high quality Colored Rubber mould type interlocking paver blocks by obtaining high level of compaction by application of hydraulic compaction and also by high intensity vibration to the moulds. The machine should have automatic control panel for uniformity in strength.

##### 14.03.03 Concrete Batching & Mixing

The factory should be equipped with automatic control panel for maintaining water cement ratio from batch to batch to obtain concrete of uniform quality and strength.

##### 14.03.04 Curing:

The factory should have well designed curing area to ensure adequate curing of paver blocks.



##### 14.03.05 Laboratory (Desirable but not essential):

The factory should have the following:

- i. Compression testing machine of adequate capacity.
- ii. Other tools and equipment for testing raw materials and pavers blocks.
- iii. Systematic record of test results of various colored Rubber mould type interlocking pavers blocks manufactured in the factory.

#### 14.04.00 **Specifications For Coloured Paver Blocks:**

Colored concrete colored Rubber mould type interlocking paver blocks shall be manufactured as per specifications using approved colour pigment. The colour shade shall be approved by owner before commencement of the

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 230 of 242		

work. White cement shall be used for colored pavers to obtain the desired colour shade. The job also includes providing 50 to 75 mm thick sand bedding to match the level of the pavers block.

The colour of the pavers block shall be guaranteed against fading of colour for period of 12 months from the date of laying of the same at site. Otherwise contractor shall have to replace it without any cost implications. All other technical specifications & Procedure for testing, laying & sampling of colored pavers will be as per specification.

#### 14.05.00 Pavers Block Characteristics:

The concrete pavers should have perpendicularities after release from the mould and the same should be retained until the laying.

The surface should be reasonably smooth and of anti skid and anti glare type. The pavers should have uniform chamfers to facilitate easy drainage surface run off. The pavers should have uniform interlocking space of 2mm to 3mm to ensure compacted sand filling after vibration on the pavers Surface. The concrete mix design should be followed for each batch of materials separately and automatic batching plant is to be used to achieve uniformity in strength and quality. The pavers shall be manufactured in single layer only.

Skilled labour should be employed for laying blocks to ensure line and level of laying, desired shape of the surface and adequate compaction of the sand in the joints. The pavers shall be of cement gray colour without any pigment & for colored pavers refer "specifications for colored pavers."

#### 14.06.00 Pavers Block Dimensions:

Thickness	60mm
Shape	Uniregular (Uniform Shape with no Hollow Or Creaks) Uni, I shape, tri hex or directed by Engineer-in-charge.
Chamfer	4mm to 6mm along top edges
Colour	a. Natural cement grey colour without use of any pigment. b. For colored pavers refer "specifications for colored pavers"
Dimensional Tolerance	(+/-) 2mm for length & width, (+/-) 3mm for Height (Thickness)

#### 14.07.00 Testing Of Colored Rubber Mould Type Interlocking Pavers Blocks:

SR. NO.	* TEST	SPECIFICATION Average Values (Average of Minimum Five Samples/Site)
1	Compressive Strength	Min. 40 N/mm <sup>2</sup> for 60mm thick
2	Flexural Strength	Minimum 4.5 N/mm <sup>2</sup>
3	Abrasion Resistance	Maximum 1.5
4	Water Absorption	Maximum 5.80%
5	Minimum Cement Content	380 Kg/m <sup>3</sup> (Desirable)

Sampling and testing procedure as per specifications

#### 14.08.00 Sampling And Testing Procedures For Paver Blocks:

Sample Size:

Essential — Minimum 2 Blocks per 10000 blocks.

##### 14.08.01 Sampling For Testing

Sampling for testing of colored Rubber mould type interlocking pavers blocks shall be done in accordance with clause-17.07.00

##### 14.08.02 Compressive Strength

Testing for compressive strength shall be undertaken in accordance with standard test as suggested by Owner. The minimum 28 days compressive strength of the blocks tested shall be Min. 40 N/mm<sup>2</sup>.

##### 14.08.03 Abrasion Resistance Testing for abrasion shall be in accordance with IS 1237 (Specifications for Cement Concrete Floor Tiles).

##### 14.08.04 Flexural Strength

Testing for flexural shall be in accordance with IS 1237 (Specifications for Cement Concrete Floor Tiles).



##### 14.08.05 Water Absorption

Testing for water absorption shall be in accordance with IS 2185:1979 Part I (Specifications for Concrete Masonry Units).

#### 14.09.00 Sampling Of Pavers Blocks:

##### 14.09.01 Method of sampling

Before laying pavers blocks, each designated section comprising not more than 50000 blocks, shall be divided into ten approximately equal groups.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 232 of 242		

Three blocks shall be drawn from each group.

#### 14.09.02 Marking and identification

All samples shall be clearly marked at the time of sampling in such a way that the designated section or part thereof, and the consignment represented by the sample, are clearly defined. The sample shall be dispatched to the approved test laboratory taking precaution to avoid damage to the paving in transit. Protect the paving from damage and contamination until they have been tested. The testing shall be carried as soon as possible, after the sample has been taken. As soon as practicable after sampling, the samples shall be stored in water at 20 degree C for 24 hours prior to testing. Payment shall be made after testing result. The cost of testing shall be borne by the contractor. The mode of measurement shall be on Sq.mt. basis.

#### 14.10.00 Measurements:

It is items rate contract. The measurements shall be in square metre of actual area covered.

#### 14.11.00 Rate:

Rate shall include all required labours, materials, designing, drawing conveyance, wastage, supervision, protection till hand over and free maintenance during defect liability period etc. complete.

#### 14.12.00 **PRECAST FACTORY MADE CONCRETE KERB STONES:**

##### 14.12.01 MANUFACTURE:



Pre-cast factory made PCC in M-25 grade concrete and of specified dimensions shall be manufactured in accordance with IS 5758-1984.

##### 14.12.02 SIZES :

The sizes of kerb stones be as per mentioned in Tender drawing. The concrete shall consist of grade M-25 laid to the dimensions, lines and levels shown in the drawing and well compacted by ramming or other means. The kerb stone then the embedded into cement concrete of grade 15 to a minimum thickness of 100 mm all around including filling in joints with C.M. 1:3 and finishing with neat cement slurry etc. complete as specified or as directed by the Engineer. After the line and levels have been checked to be within the specified tolerance the haunching will be placed taking care that the line and level of the kerbs is not displaced during the process. All straight kerbs, circular kerbs, quadrants or other kerbs shall be laid within a vertical or horizontal tolerances of 3mm from the true line or level.

##### 14.12.03 MEASUREMENT FOR PAYMENT :



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 233 of 242		

Measurement shall be in Cu. meter of specified size of kerb stone provided.

#### 14.12.04 RATE:

The unit rate shall include all materials, labour, tools & plants etc. including transportation to site, unloading, excavation, laying, curing, oil painting, disposal off unsuitable material etc. all required to complete the job as per drawing.

### 15.00.00 SCARIFYING METALLED (WATER BOUND) SURFACE

15.01.00 Scarifying: All dirt, dust, cacked up mud, slush, animal droppings, vegetation and all other rubbish shall be removed from the water bound macadam surface.

The macadam surface shall be scarified to a depth of approximately 5 cm with such additional picking of high parts of the road as may be necessary to the required camber and gradient as directed by the Engineer-in-Charge. Any hollows that remain after picking shall be filled with new aggregate 50 mm. nominal size and well consolidated to bring the surface to template.

15.02.00 Finishing: The scarified aggregate shall be racked to bring smaller stones on the top and surface brought to the required camber and grading with tolerance of 12 mm. longitudinally as well as transversely. All rubbish etc., shall be disposed off as directed by the Engineer-in-Charge. Scarifying operation will also include consolidation with road roller, the aggregate received from scarifying, although this aggregate will be consolidated along with aggregate of new wearing course.

#### 15.03.00 Measurements:

The finished work shall be measured between the kerb or channel stones or brick edging etc., as the case may be. Length and breadth shall be measured correct to a cm. The area shall be calculated in square metres correct to two places of decimal.



#### 15.04.00 Rate:

The rate shall include the cost of materials and labour involved in all the operations described above except the cost of stone aggregate which shall be paid for separately.

### 16.00.00 REINFORCED CEMENT CONCRETE PAVEMENTS

#### 16.01.00 Type of Pavements

The following types of RCC pavements shall be provided depending upon the service requirements:

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 <b>BHEL</b>
		Document No.	Rev	
		Sheet 234 of 242		

Type	Service	Concrete Thk.(mm)	Concrete Grade	Reinforcement	Base
Type I	Vehicle Movement areas	200	M - 30	8 dia. 200 c/c both ways	100 Thk. Dry Lean Concrete
Type II	General Operating Areas	150	M - 25	8 dia. 200 c/c both ways	75 Thk. PCC 1:4:8
Type III	Non Operating Areas	100	M - 25	8 dia. 300 c/c both ways	75 Thk. PCC 1:4:8



## 16.02.00 Construction Requirements

- 16.02.01 Sub Grade of Paving areas shall be properly graded and thoroughly compacted to required slopes and grade before laying WBM./compacted sand filling.
- 16.02.02 RCC paving shall be done in alternate cast-in-situ panels not exceeding 3.5M X 3.5 M in size for Type I pavement & 3.0M X 3.0M for other pavements.
- 16.02.03 Complete RCC work shall be done in accordance with IS:456. Construction joint shall be 10 mm wide and 40 mm deep and shall be filled with sealing compound.
- 16.02.04 High yield deformed bars conforming to IS: 1786 shall be used as reinforcement.
- 16.02.05 Around equipment foundations/ structural columns 20 mm wide joint shall be provided upto full depth of the pavement. The joint shall be filled with sand except in top 25 mm which shall be filled with sealing compound conforming to IS: 1834.
- 16.02.06 Expansion joints shall be provided at a maximum spacing of 14 meters c/c. for Type I pavement, 12m c/c for Type II pavement & 15m c/c for Type III pavement. Expansion joints shall be 20 mm wide and shall be filled with premoulded fiber impregnated felt conforming to IS: 1838 except in top 25 mm portion which shall be filled with sealing compound as per IS: 1834. For type I pavement 1 meter long dia. 32 mm dia MS dowel bars 500 mm embedment on both sides shall be provided at 200 mm c/c at expansion joints.
- 16.02.07 The joining sealing compound shall conform to IS: 1834 Type-A.
- 16.02.08 Top surface of the pavement shall be provided with adequate slopes (1:100) as required for the surface drainage.
- 16.02.09 If sand filling is required, sand shall be compacted to 90 % laboratory maximum dry density. The compacted sand filling shall be saturated with water before concreting.

## 17.00.00 CULVERT WORK

### 17.01.00 PIPE CULVERTS



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 235 of 242		

17.01.01 Reinforced concrete pipes shall be provided between the drain pits of storm water drains to cross the roads. These pipes shall be non-pressure type conforming to IS: 458 and class as specified in the nomenclature of the item. The pipes shall be laid between the drain pits with a uniform slope and with proper bedding, if required, as per approved drawings. The reinforced concrete pipes shall be manufactured by centrifugal process. All pipes shall be true to shape, perfectly straight, sound and free from cracks. The pipes shall be free from defects resulting from imperfect grading of the aggregate mixing or moulding.

17.01.02 Reinforced concrete pipes shall be laid, jointed and tested as per IS: 783. Pipes shall be laid true to alignment and gradients over cement concrete bed of 1:2:4 mix and / or encased, if required, as per approved drawings or as directed by Engineer-in-Charge. No deviations from the lines, depths of cuttings or gradients shall be permitted without approval in writing by Engineer-in-Charge. The joint between concrete drain pit wall and concrete pipe shall be done properly to make it water-tight. The pipe joints shall be spigot and socket joint (rigid type) for pipes of 600 mm. diameter and below and collar joint (rigid type) for pipes over 600 mm. diameter. For both types of joints, the annular space shall be filled up with cement and sand mortar 1:2 mix which shall be rammed with caulking tools. After the day's work, any extraneous matter shall be removed from inside of the pipes. Joints shall be cured properly as per IS: 783. Reinforced concrete pipes shall be tested hydraulically as per IS: 783. Refilling of trenches shall not be commenced until the entire length of the pipe has been tested and approved. The excavation of earth in trenches for laying the concrete pipes and refilling shall be done as per IS: 783.



## 17.02.00 BOX CULVERTS

17.02.01 The box-culverts are to be provided across the roads joining the storm water drains on both sides of the road. These box-culverts shall be of either complete reinforced cement concrete construction or brick masonry and reinforced cement concrete construction as specified in the schedule of items. The box-culvert construction shall be carried out as per the approved drawings.

17.02.02 Earthwork, Brick Work, Plain and Reinforced Cement Concrete Work, etc., shall be carried out in accordance with the relevant Sections latest of C.P.W.D. Specifications.

## 18.00.00 STORM WATER DRAINS

18.01.00 The open storm water drains shall be of the size and laid to such gradients and in such locations as may be shown in the approved drawings or as directed by the Engineer-in-Charge. The sides and bottom of the drain or the sides and top of embankment, as the case may be, shall be brought to the required profile, slope and gradient and shall be compacted to a firm and even surface. If the situation demands, and where so required by the Engineer-in-Charge in consideration of the nature of the surface, the necessary back filling may be

<div><p>पी डी आई एल <b>PDIL</b></p></div>	<div><p><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></p><p><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></p><p><b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b></p></div>	PC288/E/001/P-II/5.5	P	<div><p>बी एच ई लि. <b>BHEL</b></p></div>
		Document No.	Rev	
		Sheet 236 of 242		

done with small broken stone, moorum, gravel or ballast well consolidated to proper profile. In case the soil is unreliable and if the nature of the work requires it a 75 mm. thick layer of gravel or ballast may be provided over the prepared surface and well consolidated. In the case of embankments of large heights, suitable design of pitching etc., should be worked out and special specifications framed in each case.

18.02.00 Bricks shall be of 75 class designation bricks conforming to IS: 1077 as described in nomenclature of the item. Pitching shall be half brick in depth or in multiples of half bricks, as specified. Profiles shall be put up by means of pegs and strings or by placing bricks at intervals not more than 15 metres. Bricks shall then be laid on bed width in parallel rows breaking bond and on sides in either parallel rows breaking bond or herring-bone bond pattern as directed. At the top, at the toe and at every 3 metres intervals, brick courses shall be laid with bricks on ends. All bricks shall be laid closely in position and firmly embedded, true to line, gradient and in uniform slope throughout.

18.03.00 The earthwork in excavation, in refilling and disposal of surplus earth for storm water drains shall be carried out in accordance with the Section 2 of C.P.W.D. Specifications maintaining proper alignment, levels and side slopes.

#### **19.00.00 STONE PITCHING:**

The slope of filling shall be protected with stone pitching.

NOTE : When circumstances permit, one rainy season should be allowed to elapse after constructing the slope, to allow for consolidation before pitching is commenced.

##### **19.01.00 Stone:**



The stone to be good, hard, quarry or boulder stone such as will not weather on the surface. It is to be roughly hewn or squared with the hammer to ensure the stones fitting fairly one on the other, so as not to expose the earthwork below.

##### **19.02.00 Laying:**

The stones are to be laid with their broadest faces downwards and firmly bedded on a layer of murum, spalls (or gravel) at least 150 mm in thickness. They are to be packed against each other with the hammer or mallet so as to fit closely for at least 75 mm in height and to lie generally perpendicular to the slope. No pinning is to be allowed between the sides of stones, and the use of chips should be confined to hollow and inequalities in the bed and for packing, after the stones are laid, on the surface, to form a uniform slope. The surface packing should not be allowed to proceed till the previous work is inspected and approved.

##### **19.03.00 Size of Stone:**

The size of stone for pitching shall be not less than 230 mm x 230 mm in size on the face. The topmost course shall consist of roughly dressed headers projecting 230 mm above the face of the pitching and shall be laid in a continuous level line.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 भारत कोयला गैसिफिकेशन लिमिटेड <b>BHEL</b>
		Document No.	Rev	
		Sheet 237 of 242		

**19.04.00 Slope:**



The face slope of the pitching when complete is to be that of the filling.

**19.05.00 Measurement:**

The length and width of the pitching shall be measured correct to a cm and the area shall be measured in sq.metres correct to two places of decimal.



**19.06.00 Rate:**

The rate shall include the cost of materials, wastage, labour involved in all operations, including transportation, overheads, profit, tools and equipment, scaffolding, curing, raking out joints, pointing, including dressing stone, bond stone (if required), cement concrete bond stones (if required), as specified in the item.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 238 of 242		



## ANNEXURE-IX

### QUALITY ASSURANCE PLAN



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 239 of 242		

## QUALITY ASSURANCE PLAN



SL NO.	MATERIAL/ OPERATION	NAME OF TEST	FIELD/ LAB.	TEST PROCEDURE	FREQUENCY OF CHECKING	EXTENT OF CHECKING	REFERENCE DOCUMENT
1.	Earthwork in excavation	Lines, levels & depth	Field	Measurement	As per decision of site engr.	100%	Specn. & approved drg.
2.	Concrete work						Test will be carried out while establishing mix. design
	a) Coarse aggregate	i) % of soft or deleterious materials	Lab.	As per IS 2386 Part IX, 1963	Once for each source/supply & shall be repeated in case source is changed	-do-	Specn. & IS 2386 (Pt.IX) & IS-383
		ii) Particle size distribution	Lab/ Field	As per IS 2386 (Pt.I)	-do-	-do-	IS 383, Specn.
		iii) Specific Gravity	Lab	IS:2386 Part III, IS:456, IS:383	Once in 12 weeks or change of source whichever is earlier	-do-	IS:2386 Part III, IS:456, IS:383
	b) Fine aggregate	i) Silt content	Lab	Appendix -D of CPWD Specn.Vol.I	-do-	-do-	CPWD Specn.
		ii) Particle size distribution	Lab./Field	IS 383	-do-	-do-	Specn. & IS 383
	c) Cement	i) Physical properties	Lab	As per IS 269 & 4031	-do-	-do-	IS 269, 1489, 4031 & test certificate
		ii) Chemical properties	-do-	As per IS 4032	-do-	-do-	IS 4032 & test certificate
	d) Reinforcing bars						
	i) Deformed bars	Physical properties & dimensions	Field /Lab	As per IS 1139	-do-	-do-	IS 1139 & test certificate
	ii) Cold twisted bars	-do-	-do-	As per IS 1786	-do-	-do-	IS 1786 & test certificate
	iii) Hard Drawn Steel Wire Fabric	-do-	-do-	As per IS 1566	-do-	-do-	IS 1566 & test certificate

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 240 of 242		

	iv) TMT bars	-do-	-do-	As per IS 1786	-do-	-do-	IS 1786& test certificate
	v) Placement, laps, hooks, spacers etc.	Physical	Field	As per IS 456	ALL	-do-	IS 456 & approved drawings
	e) Water	Chemical test	-do-	As per IS 3025-64	Single Test	-do-	IS 3025-1964
	f) Tests for concrete	i) Slump test	Field	As per IS 1199	For each batch of concreting	-do-	CPWD Specn. & IS 1199
		ii) Cube test at 7/28 days	Field/L ab.	As per IS 516	No. of cubes to be decided as per given in IS 456/ Specn.	-do-	IS 456,IS 516
	g) Shuttering / Formwork Checking of levels, dimensions, unevenness, joints, cleanliness, oiling etc.	Physical	Field	Measurement	All	-do-	As per drawing, CPWD specifications & instruction of E.I.C
3.	Brick Work/Hollow Concrete Block/ Cement Concrete Block work						
	a) Brick/ Hollow Concrete Block / CC Block work	i) Physical properties & crushing strength	Field/L ab.	As specified in Specn & IS 1077	Once for each source	100%	Specn. / IS 1077
	b) Mortar	Uniformity in mix	Field	As specified in IS 2250	As & when required	-do-	IS 2250
4.	Steel works using tubular, angles, plates, channels etc.						
	i) Structural steel & plates	Dimension, manufacturers, Specn. test certificates	Lab.	IS:226 & 2062	Once for each source/supply	100%	IS Codes & test certificates
	ii) Welding electrodes	-do-	-do-	IS:814 & 815	-do-	-do-	-do-
	iii) Welding	Quality of weld, weld reinforcement, contour etc.	Field	Visual	As per discretion of site engr.	-do-	IS: 823
	iv) Painting on steel works (synthetic enamel paint over 3 coats red oxide coat zinc primer)	Cleaning off rust dirt, grease etc. of coats.	-do-	IS:123 1962	-do-	-do-	IS Code, Relevant Specn.
5.	Providing & laying water proofing on	Thickness, slope etc.	-do-	As per Specn. & IS 2115	-do-	-do-	-do-

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	 <b>BHEL</b>
		Document No.	Rev	
		Sheet 241 of 242		

	roof						
6.	Flooring						
	i) Cement concrete floor	Physical	Field	As per IS 1443	All	-do-	IS 1443
	i) Glazed tiles	Physical	Field	As per IS 13630	All	-do-	IS 13630 & Manufacturer's certificate
7	Pre-coated G.I sheet roofing laying & fixing.	Physical	-do-	As per IS 277 & 513	Once for each source/supply	-do-	IS code, spec. & Manufacturer's certificate
8.	Gypsum board false ceiling/ Prima board Armstrong false ceiling	Physical	-do-	IS 2095 & 2542	All	-do-	IS code, specn. & Manufacturer's certificate
9.	Doors/windows/ventilators						
	i) Glazing	Physical	-do-	IS 1081 & 2835	All	-do-	IS code, specn. & Manufacturer's certificate
	ii) Flush door shutters	Physical	-do-	IS 2095 & 2542	All	-do-	IS code, specn. & Manufacturer's certificate
	iii) Aluminium	Physical	-do-	IS 1948 & 1949	All	-do-	IS code, specn. & Manufacturer's certificate
	iv) Steel	Physical	-do-	IS 1038	All	-do-	IS code, specn. & Manufacturer's certificate
10.	Plastering	Physical	-do-	As per specn.	All	-do-	Specn.
11.	White washing, snowmen, distemper	Physical	-do-	IS 712, 428 & 5410	All	-do-	IS code & specn.
12.	Toiletries & sanitary fixtures						
	IWC, EWC, Urinals, washbasins, G.I pipes & fittings, C.I pipes & stoneware pipes etc.	Physical	-do-	IS 771, 775, 774, 1239, 2065, 781, 1729, 1726,,651,4127 etc.	All	-do-	IS code, specn. & Manufacturer's certificate

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>DESIGN PHILOSOPHY – CIVIL &amp; STRUCTURAL WORKS</b>	PC288/E/001/P-II/5.5	P	
		Document No.	Rev	
		Sheet 242 of 242		

Note: Parameters/guidelines fixed for the quality control in accordance with the contract document, IS Codes/Technical Specification etc. are just the synopsis of the whole constructional activities in a bid to visualise the total involvement at a glance. Mere compliance of the QAP does not relieve the contractor from overall responsibility to render best quality of work in conformity with all the relevant documents and the best engineering practices. In order to minimise the size of QAP, only salient/important features have been taken into account and other small/minor involvement will be dealt with individually as per the provision of contract.



## SECTION – 6.0

### PROJECT EXECUTION PLAN

**PLANT : SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE.**

**PROJECT : SETTING UP OF HIGH ASH COAL-TO-AMMONIUM NITRATE PLANT IN MAHANADI COALFIELDS LIMITED (MCL).**

**CLIENT : BHARAT COAL GASIFICATION AND CHEMICALS LIMITED (BCGCL).**

P	01.03.2024	01.03.2024	Issued for Tender Purpose	AS	SK/DKV	PRS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

## TABLE OF CONTENTS

1.0.	INTRODUCTION.....	3
2.0.	LOCATION.....	3
3.0.	BRIEF SCOPE OF WORK.....	3
4.0.	PURPOSE.....	4
5.0.	COMMUNICATION AND GENERAL CORRESPONDENCE.....	4
6.0.	PROJECT MANAGEMENT & EXECUTION .....	4
6.1.	KICK-OFF MEETING: .....	4
6.2.	PROJECT PROCEDURES AND METHODOLOGY.....	5
6.3.	DETAILED ENGINEERING SERVICES.....	6
6.4.	PROCUREMENT .....	8
7.0.	PROJECT PLANNING, SCHEDULING & MONITORING SYSTEM.....	9
7.1.	OVERALL PROJECT SCHEDULE.....	10
7.2.	DETAILED ACTIVITY NETWORK .....	11
7.3.	PROGRESS MEASUREMENT METHODOLOGY.....	11
7.4.	VENDOR SCHEDULING AND MONITORING.....	11
7.5.	CONSTRUCTION NETWORK .....	12
7.6.	PROJECT SCHEDULE SOFTWARE.....	12
7.7.	PROGRESS REPORTING.....	12
8.0.	PROJECT TIME CONTROL METHODOLOGY.....	13
8.1.	PROJECT TIME COMPLETION .....	13
8.2.	DOCUMENTS REQUIRED ALONG WITH BID.....	14
8.3.	DOCUMENTS REQUIRED AFTER AWARD .....	14
	ABBREVIATION .....	17

## 1.0. INTRODUCTION

Coal India Limited (CIL) as an organized state owned coal mining corporate came into being in November 1975 with the government taking over private coal mines. With a modest production of 79 Million Tonnes (Mt) at the year of its inception CIL today is the single largest coal producer in the world. Operating through 82 mining areas CIL is an apex body with seven wholly owned coal producing subsidiaries and one mine planning and Consultancy Company spread over eight provincial states of India.

Mahanadi Coalfields Limited (MCL) is one of the eight Subsidiary Companies of Coal India Limited (CIL) which is under administrative control of Ministry of Coal. Mahanadi Coalfields Limited was carved out of South Eastern Coalfields Limited in 1992 with its headquarters at Sambalpur.

As per GOI's directive, for 100 Million MT Gasification of coal per annum for end use products like Ammonium Nitrate, Ammonia, Synthetic Natural Gas (SNG) and Petrochemicals, Mahanadi Coalfields Limited (MCL) intend for setting up a Grassroot Coal to Synthesis Gas and Potential Downstream Product(s) Plant at Lakhanpur Opencast Mine, MCL located in Odisha for utilizing Coal as a basic raw material for the production of Ammonium Nitrate.

## 2.0. LOCATION

The proposed project site is under mine lease hold area of Lakhanpur Open cast mines located in Lakhanpur Tehsil, Jharsuguda district of Odisha with coordinates of 21°46'0"N and 83°46'0"E . It comes under Lakhanpur Area of Mahanadi Coalfields Limited (MCL). Site is at a distance of 32.0 Km from Jharsuguda and 81 Kms. from Sambalpur (MCL's Head Quarter), which is well-connected by National Highway 49. Nearest Railway Station is Belpahar at a distance of 10 km. Veer Surendra Sai Airport, Jharsuguda is the closest airport, which is 38 Kms. away.

## 3.0. BRIEF SCOPE OF WORK

Scope of work of the CONTRACTOR shall include Supply of Basic Design and Detailed Engineering, Procurement, Supply, Fabrication, Inspection by Third Party Inspection Agency (TPI) as applicable, Expediting, Route survey for Over Dimensional Consignments (ODCs), Insurance, Transportation of all equipment / materials to work site, Storage,

construction and erection of all civil, mechanical, electrical and instrumentation works, assembly and Installation, obtaining all necessary statutory approvals, Testing, Mechanical Completion, Pre-Commissioning, Commissioning, Sustained Load Test Run, Performance Guarantee Test Run (PGTR), Owners Operator training, including Total Project Management and handing over of the plants and facilities under contractor's scope of work duly completed on single point responsibility basis for SYNGAS PURIFICATION UNIT for setting up of HIGH ASH COAL-TO AMMONIUM NITRATE PLANT at MAHANADI COALFIELDS LTD (MCL), ODISHA.

#### 4.0. PURPOSE

This procedure has been prepared with the objective of:

- Defining systematic and orderly administrative relationship amongst related parties during the execution and the operation of the plant.
- Progress reporting and review of progress of work

#### 5.0. COMMUNICATION AND GENERAL CORRESPONDENCE

PROJECT MANAGER of OWNER/CONSULTANT is the sole contact for all activities of the PROJECT. Therefore all the correspondence between the OWNER/CONSULTANT and CONTRACTOR shall be directly done with/ by the PROJECT Manager or by his authorized representative. The Name, Address, Telephone no, Fax, and email ID shall be intimated during the kick-off meeting and the same shall be included in the contract.

#### 6.0. PROJECT MANAGEMENT & EXECUTION

##### 6.1. KICK-OFF MEETING:

Immediately after the award of job but not later than 2 weeks, a kick-off meeting will be held to finalize and establish the modalities and procedures to be adopted for execution of the contract based on the enquiry document, commitments made by CONTRACTOR and subsequent agreements reached between OWNER /CONSULTANT and CONTRACTOR during negotiations. The Kick-Off Meeting will be attended by key members of OWNER /CONSULTANT and CONTRACTOR. These will address the following details between OWNER /CONSULTANT and CONTRACTOR:

- i) Execution Methodology/ Philosophy, in the line with PROJECT requirement.

- ii) PROJECT execution schedule
- iii) Progress Reporting
- iv) Weekly Review Meetings
- v) PROJECT Co-ordination Procedures.
- vi) Organization Chart
- vii) Construction Site related issues.

## 6.2. PROJECT PROCEDURES AND METHODOLOGY

Detailed Technical Requirements along with the Detailed Scope of Work and overall proposed implementation schedule shall be prepared by CONTRACTOR. These will form the basis for formulation of the Overall PROJECT schedule of the plant by CONTRACTOR. CONTRACTOR is required to organize his services in a systematic manner to ensure execution and completion of the unit as per the schedule. CONTRACTOR is required to submit along with his bid the methodology/procedure proposed by him for this unit together with the organizational set up proposed and bio-data of Key-personnel.

In order to achieve uniformity in execution of various activities of the PROJECT, CONTRACTOR shall develop Engineering Design Basis and PROJECT Procedures/ Methodologies to be adopted by the executing agency. CONTRACTOR is required to carry-out his supply of Know-How, Process Package, Detailed Engineering, Procurement, Tendering, Construction Supervision and Management, Planning Scheduling, Monitoring, Reviewing, Reporting, and Overall PROJECT Management activities in accordance with the job specifications / procedures developed by CONTRACTOR based on the methodologies / procedures. All activities to be performed/services to be rendered by CONTRACTOR under this contract shall be monitored by OWNER/CONSULTANT and will be subject to weekly / monthly reviews by the OWNER /CONSULTANT. CONTRACTOR shall facilitate such reviews/monitoring by OWNER / CONSULTANT.

- 6.2.1.** CONTRACTOR's service for Engineering, Procurement, Tendering, Construction, Supervision and Management, Planning, Scheduling, Monitoring, Reporting, and Overall PROJECT Management shall meet the requirements given in this section.
- 6.2.2.** English language and Metric Units shall be used in all Documents, Drawings, Reports, and Correspondences etc. under this Contract.

**6.2.3.** All the drawings/documents prepared by CONTRACTOR/ Sub-contractors /Vendors shall be submitted to OWNER /CONSULTANT for review/ information purpose. Such review by OWNER /CONSULTANT shall, however, not relieve CONTRACTOR of his responsibilities.

**6.2.4.** For achieving the PROJECT schedule it may be necessary in some cases to prepare the drawings in stages and release it for construction so as to take up simultaneous execution of detail engineering and construction. Any revisions involved for the above is included in the scope of work of CONTRACTOR. Also any change required to meet the siteconditions/statutory requirements shall have to be carried by CONTRACTOR at no extra cost.

### **6.3. DETAILED ENGINEERING SERVICES**

The CONTRACTOR shall provide the Detailed Engineering Services for PROJECT as mentioned in this bid document furnished by the OWNER /CONSULTANT. The services shall cover the detailed engineering required for execution and completion of the PROJECT along with the utilities to be provided inside the battery limit of the Plant as specified in the tender.

All critical drawings / documents to be prepared by CONTRACTOR / Sub-contractors / Vendors as per given in the bid document for review and approval by OWNER / CONSULTANT. Obtaining all such approvals shall be the responsibility of the CONTRACTOR and the same is included in his scope of work. Such review and approval by OWNER /CONSULTANT shall, however, not relieve the CONTRACTOR of his responsibilities.

The CONTRACTOR is required to organize a Task Force of dedicated and experienced specialists from each discipline under a Project Engineering Manager who will be assisted by Engineering Coordinator. An engineering schedule will be prepared and submitted to OWNER /CONSULTANT for approval. This approved schedule shall be used for all engineering activities. The engineering coordinator shall coordinate all design and engineering activities and interact with purchase, inspection, expediting, clearance and transportation, tendering, planning, construction and PROJECT groups. His responsibilities shall include.

- a) Engineering Coordination for Procurement involving:
- Preparation of Material Requisitions (MRs).
  - Technical evaluation of offers received (which may involve technical discussions with vendors and concerned specialists may have to be deputed to vendors works or to OWNER/CONSULTANT's offices as per requirements) and preparation of recommendations.
  - Preparation of Technical Purchase Requisition (PRs) on selection of vendor and submit all PRs to OWNER/CONSULTANT for review / reference.
  - Review/approval of vendor drawings/documents. (This may call for arranging specialist visits to vendor's works for timely approvals of critical items.)
- b) Engineering Coordination for Sub-contractors involving:
- Preparation of schedule of quantities and specifications for various contracts.
  - Technical evaluation and recommendation of offers received. This may involve arranging technical discussions with Bidders at OWNER/CONSULTANT's office if called for due to job requirements.
  - Preparation of technical-agreed variations for incorporation in contracts for the selected Contractor.
- In any case, CONTRACTOR has to take OWNER approval for Sub-contractors list prior to scrutiny and award.
- c) Engineering Coordination for Construction involving:
- Timely issue of approved construction drawings including drawings duly approved by OWNER/CONSULTANT as per requirements.
  - Providing/arranging clarification on drawings and specifications wherever called for including specialists visits to site.
  - Making regular periodic visits to PROJECT site for review of site requirements in respect of engineering activities.
  - Attending/arranging for discussions with statutory authorities such as Chief Electrical Inspector, Chief Inspector of Boiler, Tariff Advisory Committee, etc. to arrive at design basis/documents acceptable to them wherever required for obtaining statutory approvals and any other local approvals.
- d) Monitoring progress of engineering activities and advising PROJECT Manager on shortfalls and corrective actions needed. He will also attend the review meetings.

Detailed engineering and construction shall be based on sound engineering practices. List of applicable codes, standards and mandatory rules to be used in design is also mentioned in bid document.

Drawings/Documents/MRs etc., which are to be generated by CONTRACTOR shall be numbered as per the Documents Numbering Procedure of OWNER/CONSULTANT or mutually agreed procedure.

Head Office engineering support of CONTRACTOR shall be provided to site during construction including deployment of engineering specialists for field engineering as and when required by Contractor.

#### **6.4. PROCUREMENT**

- 6.4.1.** The procurement services to be provided by CONTRACTOR shall cover the purchasing, inspection, expediting, custom clearance and transportation activities & transportation activities and demurrage charges if any.
- 6.4.2.** Purchase: The Purchase activities will cover all equipments and materials required for completion of the PROJECT.
- 6.4.3.** Inspection and Expediting: CONTRACTOR is required to organize a proper inspection and expediting system so as to ensure timely delivery of all the items/equipment meeting the specified quality criteria. This function has to be carried out by appropriate deployment of qualified personnel who have wide experience in their respective fields. OWNER/CONSULTANT will reserve the right to inspect items deemed necessary by them without any additional cost to CONTRACTOR /Sub-contractor / Vendor.
- 6.4.4.** Customs Clearance and Transportation: CONTRACTOR is required to organize a custom clearance and transportation (C&T) system to ensure prompt clearance of imported equipments from customs and transportation of equipments/materials to PROJECT site from Ports/Vendors works.



## 7.0. PROJECT PLANNING, SCHEDULING & MONITORING SYSTEM

CONTRACTOR is required to institute and maintain a proper Planning, Scheduling and Monitoring system and employ professionally qualified and experienced Planning Engineer(s) for the PROJECT. The system shall have latest state-of-the-art technique; to this effect. CONTRACTOR shall implement this system through the Primavera PROJECT Planner.

The system developed should be capable to support and enforce proper control Mechanism in the PROJECT. It should be based on hierarchical breakdown of works with elaborate level of detailing and control. The levels of controls should be such that it supports and foster controls at activity level, function level and management level with greater emphasis on target, scope and commitment at various stages of contract for accountability and action planning. Such multi-level/multi-tier system of Planning, Scheduling and Monitoring, Supports, Effective Information Generation, Assimilation, Summarization and Reporting in proper and adequate manner.

The system shall be predictive type and should constitute pre-warning mechanism to diagnose and anticipate the problem well in advance and provide preventive features/measures. It is required that work breakdown structure should consist of details of systems, work packages, functions, work items and activities from monitoring point of view at micro level and summarization at higher levels. It is expected that the work breakdown structure coding system / methodology to be followed shall be informed / discussed with the successful CONTRACTOR during the kick-off Meeting.

The system is designed to carry out comprehensive functions for timely completion of PROJECT. The following shall be detailed under above mentioned procedure:

- Development of time schedules for execution of PROJECT, consistent with the overall requirement of the PROJECT and execution philosophy reflecting the latest scope of work agreed with OWNER / CONSULTANT & CONTRACTOR. Schedules also include number of intermediate checkpoints based on CONTRACTOR experience on similar PROJECTs.
- Establishment of PROJECT Progress Measurement System.
- Establishment of PROJECT Material Management System.

	SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT PROJECT EXECUTION PLAN	PNPM/PC-288/E/001/ P-II/Sec.-6.0		 
		DOCUMENT NO.		
		REV. P	Page 10 of 17	

- Establishment of monitoring system, which regularly compares the actual performance with the planned one and suggests preventive and corrective measures to ensure timely completion of the PROJECT.
- Development of Billing Schedule
- Monthly measurement certification and invoicing

Following schedules documents/reports shall be prepared and submitted by CONTRACTOR for OWNER/CONSULTANT review at various stages of the PROJECT:

- List of critical drawings.
- Breakdown of work packages to work items level.
- Input requirements of each work item/activities
- Schedule start and finish dates of all milestone/activities in line with overall schedule of the PROJECT.
- Overall system-wise, discipline-wise weightages / Progress Measurement Benchmarks for each item/activity.
- 3 month front end schedule / 90 days look ahead Schedule within a week of award.

In this kick-off meeting, it will be endeavored to reach complete understanding with CONTRACTOR on activities, inputs and logic to establish Planning Documents for Monitoring. Venue of the Kick-off Meeting to be held between the successful CONTRACTOR, CONSULTANT&OWNER, shall be either at CONSULTANT's Office or OWNER's Office preferably at Noida / Site Office and the same would be informed subsequently.

## 7.1. OVERALL PROJECT SCHEDULE

CONTRACTOR shall submit within 30 days of Fax of Acceptance (FOA)/ Letter of Intent (LOI)/ Work Order (WO) / Letter of Award (LOA), the work breakdown structure showing PROJECT work load i.e. preparation of Process Package, tenders, Material Requisitions, Construction Drawings equipments etc. along with a sufficiently detailed overall Project Schedule in the activity network form, clearly indicating the major milestones, inter relationship / interdependencies between various activities such as process, engineering, procurement tendering, manufacture / delivery, construction etc. together with a computer analysis of critical path and floats as well as quantum of work for major activities.

	SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT PROJECT EXECUTION PLAN	PNPM/PC-288/E/001/ P-II/Sec.-6.0		 
		DOCUMENT NO.		
		REV. P	Page 11 of 17	

The schedule will be reviewed by OWNER/CONSULTANT and the comments if any shall be incorporated in the network issued for implementation within 2 weeks from receipt of comments. The network thus finalized shall form part of the Contract and will become the basis for developing further detailed activity Network. This schedule shall not be revised without the prior permission from OWNER/CONSULTANT during the entire period of contract. The changes made during revision of the contract shall be approved by OWNER/CONSULTANT in writing.

## 7.2. DETAILED ACTIVITY NETWORK

CONTRACTOR should develop detailed activity networks (Level 4 / Micro level) for various systems/plant/ unit of the PROJECT, based on approved Overall Project Schedule within 2 months of Fax of Acceptance (FOA) / Letter of Intent (LOI)/ Work Order (WO) / Letter of Award (LOA). Such networks would be computerized for further monitoring and reporting.

## 7.3. PROGRESS MEASUREMENT METHODOLOGY

CONTRACTOR is required to submit during the kick-off meeting, the detail methodology / Progress Measurement Benchmarks of engineering, procurement, manufacturing / delivery, computation of total service/physical progress at the unit-wise level and on the overall basis. The progress basis shall be physical realization of work such as in terms of deliverables and construction quantity/volume accomplished. The amalgamation of such output across the PROJECT to compute overall progress shall be suitably established with proper rational and norms and maintained throughout the PROJECT. OWNER/CONSULTANT reserves the right to modify the methodology in part or in full.

## 7.4. VENDOR SCHEDULING AND MONITORING

CONTRACTOR shall establish schedules for pre-ordering and post ordering for follow up. The vendor monitoring preferably should be on logical networks and commitments at least on critical items in order to monitor them on regular basis for effective control. OWNER/CONSULTANT may demand such follow up procedure and logical networks for the various critical equipment at any time during the course of order execution. The manufacturing schedule shall be established and agreed with the vendors and acceptance shall be brought to the notice of OWNER/CONSULTANT in time.

	SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT PROJECT EXECUTION PLAN	PNPM/PC-288/E/001/ P-II/Sec.-6.0		 
		DOCUMENT NO.		
		REV. P	Page 12 of 17	

## 7.5. CONSTRUCTION NETWORK

CONTRACTOR shall prepare and submit a detailed construction network with full consideration of logistics, construction studies and method for OWNER/CONSULTANT. CONTRACTOR shall describe the resources required and special construction equipments, Tools & Tackles to be mobilized. The network shall be developed subsequent of substantial progress of engineering and ordering with fairly known construction workload and quantities.

## 7.6. PROJECT SCHEDULE SOFTWARE

As indicated elsewhere, Project Schedules as above shall be developed/evolved using the latest version of the Primavera Project Planner Software Package.

## 7.7. PROGRESS REPORTING

CONTRACTOR shall submit the following progress reports on a regular basis for OWNER/CONSULTANT information/review.

### 7.7.1. Monthly Progress Report

This report shall be submitted on a monthly basis within 7 calendar days from cutoff date, or as agreed upon, covering overall scenario of the PROJECT. The report shall include, but not limited, to the following:

- Executive summary - Summary of major events/activities.
- Schedule v/s actual percentage progress and progress curves for detailed Engineering, sub-ordering, manufacturing/delivery, contracting, construction commissioning and overall.
- Areas of concern/problem/hold-ups, impact and recovery action plans/catch-up plan.
- Activities executed achievements during the months and targets for the following month.
- Analysis of critical activities and impact on overall completion.
- Chronological achievements of key events indicating schedules and actual occurrence date.
- Annexure giving status summary for drawings material requisitions, equipment and materials delivery, contracting & construction, Resource requirement & deployment status.

	SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT PROJECT EXECUTION PLAN	PNPM/PC-288/E/001/ P-II/Sec.-6.0		 
		DOCUMENT NO.		
		REV. P	Page 13 of 17	

- Resource requirement deployment status.
- Statutory requirements / compliance status
- Change order status.
- Invoice status.
- Construction photographs.
- Updated ProjectSchedule

### 7.7.2. Weekly Reports

This report will be prepared for Head Office and construction site in summarized fashion and submitted on every Tuesday taking status as of Sunday by the Contractor on weekly basis and will cover following items:

- Activities completed (engineering, procurement, contracting, construction. etc.)
- Program for subsequent week.
- Resource deployed - man and machine.
- Quantities and productivity achieved in key areas of work.
- Progress on procurement activities including material requisition status reports.
- Constraints, if any.

The report/information may be transmitted preferably through mail to OWNER/CONSULTANT.

### 7.7.3. Daily Reports (Site Construction Report)

- Important activities for the day at site.
- Site Safety / HSE Report
- Material/equipments receipts for the day.
- Labor deployment report.
- Next Day Plan Activities

## 8.0. PROJECT TIME CONTROL METHODOLOGY

### 8.1. PROJECT TIME COMPLETION

The time for completion of the complete scope of work shall be strictly as per the time Schedule given in the tender document.

 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT PROJECT EXECUTION PLAN</b>	PNPM/PC-288/E/001/ P-II/Sec.-6.0		 कोयला इंडिया Coal India	 बी एच ई एल <b>BHEL</b>
		DOCUMENT NO.			
		REV. P	Page 14 of 17		

## 8.2. DOCUMENTS REQUIRED ALONG WITH BID

CONTRACTOR shall furnish the following documents along with the bid.

- 8.2.1. An overall schedule in the form of Network, clearly indicating all important milestones in design, engineering, fabrication, procurement construction, testing and commissioning for the plant commensurate with the overall time schedule.
- 8.2.2. Resource deployment schedule indicating mobilization of all critical resources including manpower and machinery for the smooth execution of the job at engineering offices, fabrication shops & construction site. The resource schedule shall also contain various construction aids envisaged to be deployed for execution.
- 8.2.3. Organization structure for effective project management and control, clearly indicating the responsibility center as well as bio-data of the key personnel, who are permanent employees of CONTRACTOR, shall be identified for the PROJECT.
- 8.2.4. CONTRACTOR has to submit Transportation plan for Over Dimensional Consignment (ODC) and heavy weight equipment.
- 8.2.5. CONTRACTOR has to submit procurement & supply plan for Long Lead / Critical Items within the stipulated time frame

## 8.3. DOCUMENTS REQUIRED AFTER AWARD

### 8.3.1. Early Planning Document / Look Ahead Schedule

Immediately after the award of contract and pending finalization of overall project schedule, detailed activity chart/network, functional schedules etc., the CONTRACTOR in consultation with CONSULTANT / OWNER shall prepare a look ahead schedule as a guideline for the activities to be performed during the relevant periods.

Within 30 days of issue of Fax of Acceptance (FOA) / Letter of Intent (LOI) / Work Order (WO) / Letter of Award (LOA) CONTRACTOR shall finalize with OWNER/CONSULTANT the following as:

	SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT PROJECT EXECUTION PLAN	PNPM/PC-288/E/001/ P-II/Sec.-6.0		 
		DOCUMENT NO.		
		REV. P	Page 15 of 17	

### 8.3.2. Overall Project Schedule

Overall ProjectSchedule in line with the agreed milestone and detailed to adequate workbreakdown structure level covering all phases of the work such as supply of know-how,process package, design engineering, procurement manufacturing, shipment, tendering & field erection. This schedule shall also include the interface activities to be provided byOWNER/CONSULTANT and the dates by which such facilities are needed. CONTRACTOR shall get the scheduled submitted & reviewed by OWNER/CONSULTANT and the agreed schedule shall form part of the Contract monitoring document based on which performance would be reported and evaluated. This document shall be signed by both the parties. OWNER/CONSULTANT shall also review the weightage allotted to various activities and method of reporting to be adopted by CONTRACTOR. During the progress of the contract if in the opinion of OWNER/CONSULTANT, desired progress as physically/sequentially is not maintained, it would be obligatory on CONTRACTOR to re-program the work schedule in order to accommodate the backlog and/or provide work front to other agency, without any obligation to OWNER / CONSULTANT.

### 8.3.3. Detailed Activity Network

The CONTRACTOR should develop detailed activity networks for various systems of the PROJECT, based on approved overall projectschedule within two months of Fax of Acceptance (FOA) / Letter of Intent (LOI)/ Work Order (WO) / Letter of Award (LOA). Such networks would be computerized for further monitoring and reporting.

### 8.3.4. Functional Schedules

The CONTRACTOR should prepare resource-based detailed functional schedules in line with detailed activity networks for functional monitoring, scheduling and control. This should clearly reflect strategies and philosophy of execution. OWNER/CONSULTANT reserves the right to check the functional schedule and status of activities at anytime and at any location of performance/execution. Further, the functional schedules shall be submitted by the CONTRACTOR on demand by the OWNER/CONSULTANT.

### 8.3.5. Progress Measurement Methodology

The CONTRACTOR is required to submit during the kick-off meeting, the detail methodology of progress measurement of engineering, procurement, manufacturing,



 <div>पी डी आई एल PDIL</div>	SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT PROJECT EXECUTION PLAN	PNPM/PC-288/E/001/ P-II/Sec.-6.0		 
		DOCUMENT NO.		
		REV. P	Page 16 of 17	

delivery, computation of total service/physical progress at the unit-wise level and on the overall basis. The progress basis shall be physical realization of work such as in terms of deliverables and construction quantity/volume accomplished. The amalgamation of such output across the PROJECT to compute overall progress shall be suitably established with proper rational and norms and maintained throughout the PROJECT. OWNER/CONSULTANT reserves the right to modify the methodology in part or in full.

### 8.3.6. Vendor Scheduling and Monitoring

The CONTRACTOR shall establish schedules for pre-ordering and post ordering for follow up. The vendor monitoring preferably should be on logical networks and commitments at least on critical items in order to monitor them on regular basis for effective control. OWNER/CONSULTANT may demand such follow up procedure and logical networks for various critical equipment at any time during the course of order execution. The manufacturing schedule shall be established and agreed with the vendors and acceptance shall be brought to the notice of OWNER/CONSULTANT in time.

### 8.3.7. Construction Network

The CONTRACTOR shall prepare and submit a detailed construction network with full consideration of logistics, construction studies and method for OWNER/CONSULTANT approval. The CONTRACTOR shall describe the resources required and special construction equipments, Tools and tackles to be mobilized. The network shall be developed subsequent of substantial progress of engineering and ordering with fairly known construction workload and quantities.

### 8.3.8. Construction Worksheets

The CONTRACTOR shall further detail out the construction network into area-wise details in terms of work, quantity and schedule, to firm up basis for area control. The construction schedule should be worked out based on work front generation criteria which will call for availability of input like drawings, materials and access for each/group of activity to be performed. It may be in the form of resource loaded bar chart with 'S' curve. OWNER/CONSULTANT reserves the right to access the same.



### 8.3.9. Construction Contractor Schedule

The CONTRACTOR shall agree upon the construction schedules with sub-contractors for proper mobilization, monitoring and control. OWNER/CONSULTANT reserves the right to ask for such program and status of any time as may be required.

**8.3.10.** CONTRACTOR at any point of time of operating would be permitted to revise the accepted schedule/control documents with OWNER/CONSULTANT without changing the contractual completion date, subject to prior approval by OWNER/CONSULTANT in writing.

**8.3.11.** The review of the performance of work would be made at different levels of management and CONTRACTOR is expected to ensure proper participation for effective reviewing and action plan.

**8.3.12.** CONTRACTOR should ensure availability of professionally qualified Planning Engineer both at Head Office and site deemed adequate by OWNER/CONSULTANT.



**8.3.13.** CONTRACTOR at his own cost should maintain a control room at site highlighting all the features, schedule and achievements of the PROJECT.

**8.3.14.** Weighted percentage (Progress Measurement Benchmark) of each discipline/group of work shall be mutually agreed to between CONTRACTOR and OWNER/CONSULTANT after the award of contract to facilitate compilation of progress.

### **ABBREVIATION**

S. No.	Abbreviation	Description
1.	MR	Material Requisition
2.	C&T	Custom Clearance and Transportation
3.	PR	Purchase Requisition
4.	HSE	Health Safety & Environment
5.	KOM	Kick-Off Meeting
6.	ODC	Over Dimensional Consignment



 पी डी आई एल PDIL	PROJECTS & DEVELOPMENT INDIA LTD.	PNCN/ PC288/E/001/PART-II-SEC -7.0	P	 बी एच ई एल BHEL
		Document No.	Rev	
		Sheet 1 of 135		

## SECTION –7.0



### CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP

**PLANT : SYNGAS PURIFICATION UNIT FOR  
COAL TO AMMONIUM NITRATE.**

**PROJECT : SETTING UP OF HIGH ASH COAL-TO-  
AMMONIUM NITRATE PLANT IN  
MAHANADI COALFIELDS LIMITED  
(MCL).**

**CLIENT : Bharat Coal Gasification and  
Chemicals Limited (BCGCL).**

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	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 2 of 135		

### CONTENTS

SI. No.	DESCRIPTION	NUMBER OF SHEETS
1	General Scope of Works and Services-Construction / Erection	
2	General Scope of Works and Services -Pre-commissioning	
3	Basic Plan for Temporary Services	
4	Mechanical completion	
5	Commissioning	
6	Start up	

### LIST OF ANNEXURES



ANNEXURE NUMBER	DESCRIPTION	NUMBER OF SHEETS
ANNEXURE-7-1	LSTK Contractor's Work Definition	
ANNEXURE-7-2	Detail Technical Scope	
ANNEXURE-7-3	Quality Control Procedures and Inspection Requirement	
ANNEXURE-7-4	Schedule Progress Evaluation and Progress Reporting	
ANNEXURE-7-5	Execution Plan	
ANNEXURE-7-6	Minimum Qualification & Exp. Of Key Supervisory Construction Personnel	
ANNEXURE-7-7	Deployment Schedule of Supervisory Personnel	
ANNEXURE-7-8	Deployment Schedule of Construction Equipment	
ANNEXURE-7-9	Details Of Equipment Proposed to be used for Tendered Work	

	<b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 3 of 135		



## 1 General scope of Work and services - Construction/Erection

LSTK CONTRACTOR shall be responsible for construction and erection of the Plant/ Unit including but not limited to the following:

- 1.1 Construction and erection of Plant/Unit and perform all other activities required to be performed for implementation of the WORK.
- 1.2 Provide and supply in due course all construction Equipment and Materials, tools, and temporary facilities necessary for implementation of the WORK.
- 1.3 Establish and operate adequate material control system in site for receipt, unloading, inspection, maintenance, handling, storage and utilization to ensure all Equipment and Materials are preserved and available as necessary for completion of the Plant/Unit.
- 1.4 Provide and supply all staff, tradesmen and labours for implementation of the WORK.
- 1.5 Establishment of overall construction policy and procedures for the Plant/Unit.
- 1.6 Provision of overall management and control of construction phase of the Plant/Unit.
- 1.7 Ensuring that all parts of the Plant/Unit are constructed and tested strictly in accordance with the specifications and applicable codes and standards set forth in the contract.
- 1.8 Ensuring that construction is accomplished in accordance with the schedules.
- 1.9 Provide transportation of all Equipment and Materials to be provided and supplied by LSTK CONTRACTOR under the CONTRACT either from inside or outside to Site.
- 1.10 Construct, operate and maintain all temporary facilities required for its personnel involved in the WORK.
- 1.11 Provide transportation in the area of the Site and between Site and temporary facilities for all its personnel involved in the implementation of the WORK, including field labour, administrative staff, etc.
- 1.12 LSTK CONTRACTOR manage and supervise its Sub Contractors and field labour for the WORK.
- 1.13 Provide liaison with OWNER/PMC, Sub Contractors, Licensors and Vendors to ensure that the Plant/Unit is constructed in accordance with the respective standard and specifications, set forth in the CONTRACT.
- 1.14 Establish with OWNER adequate procedures, control and reporting systems to provide close control of the progress of the WORK.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 4 of 135		

- 1.15 Provision of labour and facilities for loading, unloading and transportation of the Equipment within the site area.
- 1.16 Performance and/or provision of all other works and/or services required for performance of the WORK.
- 1.17 Execution of the whole civil, structural and building works of the Plant/Unit and/or utilities and off-site facilities.
- 1.18 Prefabrication of piping spools in a shop on the Site.
- 1.19 Erection and installation of EQUIPMENT and auxiliary facilities associated with the Plant/Unit.
- 1.20 Erection and field fabrication of structural steelwork, cladding ladders, handrails, stairs and platform of the Plant/Unit and/or utilities and off-site facilities.
- 1.21 Installation of pipe work including field fabrication at site.
- 1.22 Installation and testing of all instrumentation network and equipment of the Plant/Unit.
- 1.23 Installation and testing of electrical system and equipment of the Plant/Unit.
- 1.24 Installation of rubber lining, refractory brick lining & C-Brick lining, FRP/PVC/HDPE lining, as required for the Plant/Unit.
- 1.25 Painting of steelworks, piping, Equipment and building of the Plant/Unit.
- 1.26 Maintenance of construction equipment, vehicles and tackles of the Plant/Unit, during construction and erection period.
- 1.27 Pre-commissioning, Commissioning and Start-up of the Plant/Unit.
- 1.28 Carrying out Mechanical Completion.
- 1.29 Perform all material identification as per application codes and standards.
- 1.30 Provide winterization during construction.
- 1.31 Provide drawings and documents as required.
- 1.32 Supply to OWNER complete test records within three (3) days after completion of actual testing.
- 1.33 Installation and testing of all underground piping, if any.

	<b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 5 of 135		

## 2.0 General scope of WORK and Services- Pre-commissioning

LSTK CONTRACTOR shall be responsible for the pre-commissioning phase of the Plant.



LSTK CONTRACTOR shall provide at SITE an adequate number of qualified pre-commissioning engineers to direct and control pre-commissioning activities.

LSTK CONTRACTOR shall also ensure that all special tools and test equipment required for pre-commissioning are to be arranged at its own cost.

LSTK CONTRACTOR shall provide adequate construction labour, construction tools and equipment for pre-commissioning.

Pre-commissioning which shall be performed by LSTK CONTRACTOR shall include, but not limited to the following:

- 2.1 Cleaning, flushing, draining blowing out, steaming out, drying and purging of Equipment and their linings and piping systems, including the installation and removal of temporary blinds, strainers, screens etc., and the replacement of all permanent items removed while the WORK is in progress.
- 2.2 Chemical cleaning wherever required, including but not limited to compressor suction piping and lube and seal oil piping, heaters, supply of chemical and disposal of wastes.
- 2.3. Chemical cleaning of feed water systems, and steam systems. Supply of chemical and disposal of wastes.
- 2.4 Chemical cleaning of any other parts, which have corroded to an extent, which, will detrimentally affect Plant/Unit performance or run length for such reasons as increased fouling due to rust. Supply of chemical and disposal of wastes.
- 2.5 Checking, Testing, calibration simulation test and adjustment of instruments, equipment and systems including control valves and safety devices, installation and checking of orifices plates and other sensor devices in so far as this can be done before actual operation of the item concerns of complete system and loops.
- 2.6 Function test and checking out of electrical systems including substations, transformers, cables and switchgear, checking of all interlocks and setting of all relays. This shall include drying out operations, filtering of oil if required.
- 2.7 For motor driven equipment, amperage checking of motors and removal of temporary safety screens.
- 2.8 Cleaning of screens and filters replacement and adjustment of packing and seals and tightening of flanges.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 6 of 135		



- 2.9 Introduction of fuels.
- 2.10 Introduction of lubricants and oil flushing for machinery.
- 2.11 Introduction of chemical into and initial operation of treatment plant.
- 2.12 Boiling out, bringing up to pressure and performing all required code tests on steam generation facilities and associated instrumentation.
- 2.13 Drying out of stacks and all refractory lined equipment.
- 2.14 For all piping systems, installation and removal of temporary blinds as required, circulation and commissioning of systems including process systems, services, effluent and drainage, utilities distribution, relief and blow down and interconnecting lines.
- 2.15 Test running of all other rotating equipment for 24 hours wherever possible.
- 2.16 Adjustment of all piping expansion and support devices.
- 2.17 Air-drying of Plant/Unit, which is required to be water-free.
- 2.18 Testing (including running, tightness and vacuum) of systems, as necessary to ensure that the sections and components of Plant/Unit are ready for operation.
- 2.19 All such further works which LSTK CONTRACTOR judges to be necessary or in the reasonable opinion of OWNER is necessary to bring the Plant/Unit to a state of readiness for the introduction of feedstock into Process Plant/Unit for processing requirements and for safe commencement of operation.

### 3.0 Basic Plan for Temporary Services

#### Temporary Construction Facilities

The LSTK CONTRACTOR shall arrange following facilities at his own cost for Construction/Erection purpose. Demolition and cleaning of temporary facilities developed for construction purpose shall also be under LSTK Contractor's scope.

1. 1 No. 11 kV or 3.3 KV or 415 V Feeder depending upon temporary load requirement at Existing Substation shall be made available. Tapping of Construction Power Cost from this feeder (including supply & erection of all required materials like structural supports for cable tray, cable trays, power cables, control cables, protection & metering, cable termination etc. as well as underground cabling work) and further distribution shall be in LSTK Contractor's scope.
2. Construction Water shall be made available at single point on chargeable basis.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 7 of 135		

3. Construction sheds
4. Construction offices
5. Temporary Communication facilities
6. Office furniture
7. Labour colony during construction outside OWNER premise.

### 3.1 Sewage & Refuse Disposal

All temporary building like site office, canteen etc. shall be provided with individual septic tanks and soak pits for treatment and disposal of sanitary sewers. Construction site shall be provided with a network of temporary drain for disposal of rain water.

### 4.0 Mechanical Completion

Mechanical Completion means the time when all construction, erection & installation work per finally approved P&ID after HAZOP study and pre-commissioning related to the Plant is completed in accordance with the Project drawings and specifications, and all mechanical and pressure tests, including but not limited to hydro-testing, non-operating adjustments, cold alignment checks, final cleanup, hot bolting, refractory drying, field calibration of safety valves, calibration of all instruments, instrument loop checking and testing, monitoring / control / safety systems checking and testing, and all pre-commissioning activities have been completed, all incoming & outgoing services and utilities have been connected to each unit of the PLANT, interconnections of process lines and interconnection are completed and the Plant/Unit is ready in every respect for commissioning and for the first introduction of feed materials.

When OWNER is satisfied that Mechanical Completion of the plant has been achieved, OWNER shall issue certificate of Mechanical Completion to LSTK CONTRACTOR in accordance with the CONTRACT for Owner's Approval.

In order to meet this, LSTK CONTRACTOR shall perform all necessary mechanical works, tests and checks.



### 5.0 COMMISSIONING

#### 5.1 Schedule for Commissioning

LSTK CONTRACTOR shall prepare a schedule for commissioning, start-up, and performance testing and initial operation in conjunction with OWNER. This shall be issued at least three months before pre commissioning of the first facility.

This schedule shall include all activities as detailed herein and any other special activities, which require to be performed during commissioning.



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 8 of 135		

## 5.2 Commissioning



LSTK CONTRACTOR shall be responsible to perform commissioning of the Plants and to provide necessary facilities during commissioning of the Plant including the Performance Tests. LSTK CONTRACTOR shall provide commissioning engineers and supporting staff and adequate commissioning labour. LSTK Contractor shall associate OWNER's engineers and operating staff with the commissioning work.

## 6.0 START UP

LSTK CONTRACTOR shall be responsible to perform start-up of the Plant/Unit. LSTK CONTRACTOR shall provide necessary facilities and for Start Up of the PLANT.

### NOTE:

Detail CONTRACTOR'S scope of work in relation with the construction / erection, and pre-commissioning, commissioning and start-up from the point of scope of execution as well as performing way are described in detail in the following Sub-Annexes of Section-7.0.

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 9 of 135		

### **Sub-Annexure:**

Annex 7 - 1 : LSTK Contractor's Work Definition



Annex 7 - 2 : Detail Technical Scope

Annex 7 - 3 : Quality Control Procedures and Inspection Requirement

Annex 7 - 4 : Schedule Progress Evaluation and Progress Reporting

Annex 7 - 5 : General Notes

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	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 10 of 135		



## **ANNEXURE-7-1**

### **LSTK CONTRACTOR'S WORK DEFINITION**

**LSTK CONTRACTOR shall perform/provide the following activities but not limited to:**



1. LSTK CONTRACTOR scope of work shall broadly consist of construction / erection, refurbishing, pre-commissioning, commissioning and Start Up of the Plant under the management of commissioning team it includes but not limited to civil works, fabrication & erection of structural steelwork, field assembly, mechanical erection and / or assembly and installation of all equipment and machinery, piping, electrical systems and network, instrumentation, insulation, painting, etc., except in so far as "Contract" otherwise provides, the provision of all temporary facilities, staff, tradesmen, labour, tools, tackle, construction equipment and materials, insurance, consumables and everything whether of temporary or permanent nature necessary and required in and for the work, so far as the necessity for providing the same is specified or reasonably inferred in or from the contract.
2. Perform all civil and building works as per Annex7 - 2A, titled civil and building works.
3. Perform all structural steel works as per Annex 7 - 2B, titled structural steelwork.
4. Perform all piping fabrication and erection works as per Annex7 - 2C, titled piping fabrication and erection work.
5. Perform all equipment erection works as per Annex 7 - 2D, titled equipment erection work.
6. Perform all electrical works as per Annex7 - 2E, titled electrical work.
7. Perform all instrumentation works as per Annex 7 - 2F, titled instrumentation works.
8. Perform all insulation works as per Annex 7 - 2G, titled insulation works.
9. Perform all painting works as per Annex 7 - 2H, titled painting Specification/work.  
  
Supply the materials in order to execute WORK as per CONTRACT.
10. LSTK CONTRACTOR shall be responsible for providing services and materials for construction of all temporary facilities, which are essential for successful completion of construction and erection.

The LSTK CONTRACTOR shall establish, operate and maintain all temporary facilities, such



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 11 of 135		

as, but not limits to:

- a) Labour camp/officers camps
  - b) Fabrication shops/yard
  - c) Workshop for maintenance of construction/testing equipment.
  - d) Field drawing office
  - e) Temporary warehouses, including open storage yards.
  - f) Construction offices (including facilities for photocopying, drawing reproduction, etc.)
  - g) First aid.
  - h) Lab facilities, including NDT, for testing calibration, etc.
  - i) All temporary or approach roads for carrying out the WORK including temporary approach roads for access to LSTK CONTRACTOR'S site office/workshop/camp, etc. ground preparation for heavy lifts including approaches to cranes for heavy lifts. OWNER does not take any responsibility for making temporary roads.
  - j) Canteen & catering facilities for all LSTK CONTRACTOR'S work force.
  - k) All drainage around the facilities created for his WORK, and sewage disposal arrangements for labour camps/officers camps, site offices, etc.
  - l) Necessary transport for movement of its personnel, construction Equipment and Materials, consumables, etc.
  - n) Watering of roads through water tankers for dust suppression.
  - o) All temporary lighting for working during night.
  - p) All temporary hutments, sanitary & potable water and domestic sewerage requirements of LSTK Contractor's work force.
11. Supply to OWNER complete survey report within three (3) working days after completion of any survey.
  12. All excess soil shall be disposed of by LSTK CONTRACTOR outside the premises in a location designated by OWNER representative.
  13. Perform all nondestructive, hydrostatic and pre commissioning testing required.

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 12 of 135		

14. Supply to OWNER complete test records within three (3) days after completion of actual testing.
15. Perform all welding including radiography required.
16. Provide drawings and documents as required.
17. Provide mobilization and demobilization, temporary material and temporary facilities and utilities required for executing work.
18. Provide winterization during construction, if required.
19. Provide scheduling, planning and reporting as per CONTRACT.
20. Keep complete administration and control of work, specified in CONTRACT.
21. Provide maintenance on all construction and permanent plant material as required during the CONTRACT period.
22. Perform all material identifications as per CONTRACT.
23. Perform all transportations as required.
24. Perform quality assurance, control and supply quality control documentation.
25. Perform all pre-commissioning activities as defined in the CONTRACT.
26. Provide and supply all procedures for execution of the work in accordance with drawings specifications, and applicable codes and standards.
27. Perform all other works and activities and supply all other materials which are required for completeness of the Work either mentioned in the CONTRACT or they are necessary for completeness of the Work, in compliance with highest available standards and good quality.



	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 13 of 135		

## ANNEXURE- 7 - 2

### DETAIL TECHNICAL SCOPE

See accompanying by discipline

Annexure-7 - 2A	Civil and Building work
Annexure-7 - 2B	Structural steel work
Annexure-7 - 2C	Pipe prefabrication and Erection
Annexure-7 - 2D	Equipment erection
Annexure-7 - 2E	Electrical work
Annexure-7 - 2F	Instrumentation work
Annexure-7 - 2G	Insulation work
Annexure-7- 2H	Painting work (For detail refer <b>TS-2001</b> )

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 14 of 135		

## **ANNEXURE- 7 - 2A**

### **CIVIL AND BUILDING WORK**

#### **1.0 SURVEYING**

- 1.1 Base line and base elevation will be furnished to LSTK CONTRACTOR. LSTK CONTRACTOR will furnish all surveys from this base line and elevation.
- 1.2 OWNER shall have the authority at anytime to determine, in accordance with the drawings or written directives, the correctness on completeness of the lines in use by LSTK CONTRACTOR.

- 1.3 Any erroneous WORK shall be corrected to OWNER'S satisfaction at LSTK CONTRACTOR'S expense.

#### **2.0 SITE**

Finish grading elevation to be as shown on drawing.  
LSTK CONTRACTOR'S access to the WORK areas shall be via existing roads.  
Any other roads required by LSTK CONTRACTOR are to be developed by LSTK CONTRACTOR.

#### **3.0 EXCAVATION AND BACKFILL**

##### **3.1 Excavation**

- Provide all excavation by machine or by hand according to the specifications.
- Excavation is to be executed by LSTK CONTRACTOR in a manner that will provide adequate space for performance, inspection and timely completion of the WORK. Supply dewatering as required. The method of dewatering shall be subject to Approval by OWNER.
- Temporary water drainage routing requires prior Approval by OWNER.



##### **3.2 Backfill**

All backfills shall be according to the specifications.

All excavations shall be kept dry and workable prior to and during backfiring and compacting.

Material that LSTK CONTRACTOR excavates in the course of WORK and which can be used for backfill, must be approved by OWNER prior to use. All other backfill material as required in this scope of work, drawings and specifications, shall be supplied by LSTK CONTRACTOR.

Back filling shall be to ground level as shown on drawing. The placing of backfill may only

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 15 of 135		

start after approval by OWNER.

LSTK CONTRACTOR will inform OWNER to arrange for the required proctor tests. Tests shall be done by OWNER on his account.

#### 4.0 **PILES AND CONCRETE FOUNDATIONS**

4.1 Install Piles and major and minor concrete foundations in accordance with the specification and drawings.

#### 4.2 **Blinding to Underside Foundation Work**

Prior to placing a blinding layer of concrete, LSTK CONTRACTOR shall supply, place, compact and prepare the surface of excavated area. After this LSTK CONTRACTOR shall supply a blinding layer of concrete. Blinding layer to be in accordance with specifications and / or drawings.

#### 4.3 **Reinforcement of Concrete**

Cut and bend to bar bending schedules, all type of reinforcing bars.

Store and protect all reinforcing bars against corrosion and any other deleterious effects prior to placing.

Installation of reinforcement including installation of spacers, supports, tying, wire in accordance with the specifications and drawings.

#### 4.4 **Anchor Bolts**

Install all anchor bolts, in accordance with the specifications and drawings.

The following WORK is included but not limited to LSTK CONTRACTOR'S scope for installation of anchor bolts:



- Deliver of all templates.
- Store and protect against corrosion and any other deleterious effects.
- Place anchor bolts accurately in formwork or by templates, if required, or in pockets.
- Clean and grease anchor bolts threads after Concrete pour and protect bolts after greasing with plastic covers.

#### 4.5 **Inserted and Embedded Item**

Install all concrete inserts and embedded items, including but not limited to the following items in accordance with the specifications and to the detail drawings to be furnished by LSTK CONTRACTOR.

- Cement - In sockets.
- Cinch anchors.



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 16 of 135		

- Steel sleeves, various size angle.
- Channel shapes with anchors. Curb angles and steel plates.
- Anchor rails.
- Pipe sleeves of heavy duty PVC pipe.



The WORK shall include but not limited to:

Store and protect against corrosion and damage place accurately in Formwork or by templates, if required, or by temporary bars for proper positioning.

4.6 The following WORK is included but not limited to LSTK CONTRACTOR'S scope for installation of major and minor foundations:

- All excavation, including sheet piling, if required, backfill, compacting and the transportation of surplus material, neatly stockpiled at a location, chosen by LSTK CONTRACTOR and approved by OWNER. The supply, installation and maintenance of a complete concrete batch plant, including concrete testing laboratory. Installation of selected backfill material, if required. Supply and delivery and installation of all formwork, assembly and disassembly of all reusable formwork, inclusive if any and all required supporting, bracing, pockets, cutouts, recesses, etc.
- Bending and installation of concrete reinforcement bars to the requirements and supply of items as defined in 4.3 above.
- Installation of all anchor bolts (including fabrication of templates), to the requirements and supply of items as defined in 4.4 above.
- Installation of embedded and inserted items, to the requirements and supply of items as defined in 4.5 above.
- Installation of construction and expansion joints where required.
- Mixing, delivery and pouring of concrete in accordance with specifications. Stripping of formwork and removal of all surplus material to LSTK CONTRACTOR'S yard or locations designated by OWNER.
- All temporary storage of formwork at SITE shall be of an orderly nature. In case storage does not comply with the above-mentioned rule, OWNER shall have the right to remove formwork from SITE within forty eight (48) hours after first warning and back charge LSTK CONTRACTOR for all related costs. OWNER shall not be held responsible for any of LSTK CONTRACTOR'S losses.
- The finishing of concrete, where required to a finish in compliance with the specifications.

A copy of all-concrete mix truck delivery slips if applicable.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 17 of 135		

Concrete composition analysis of the concrete batch plant.

All scaffolding required.

All required dewatering to keep the excavations / backfill dry for the WORK.

## 5.0 CONCRETE STRUCTURES AND ELEVATED SLABS

Install concrete structures, in accordance with the specifications and drawings.

6.0 The following work is included but not limited to LSTK CONTRACTOR'S scope for installation of concrete elevated slabs:

See 4.6; however with -following exceptions: No-excavation, no backfill and- no dewater

## 7.0 YARD PAVING AND FINAL SURFACING



### 7.1 Excavation

Setting out and grading by machine and/or by hand for yard paving to the shape and depth in accordance with the specifications and drawings.

Disposal of all excavated material and neatly stock piling to a location chosen by LSTK CONTRACTOR and approved by OWNER.

### 7.2 Concrete Yard Paving

- Mix and install concrete for heavy duty paving areas, in accordance with the specifications and drawings.
- Mix and install concrete for light and medium duty paving areas in accordance with the specifications and drawings.
- The following work is included but not limited to LSTK CONTRACTORS scope for installation of concrete yard paving: See 4.6 above
- Surface preparation, including the supply and placing of waterproof building paper or similar waterproof material, well lapped at joints, laid on top of the well compacted sand layer and before pouring concrete.
- Reinforcement for heavy duty paving at top and bottom face and for light duty paving at top face only, with square mesh fabric reinforcement including protection against corrosion, the cutting, the bending and placement.
- Mixing and pouring of concrete in accordance with specifications, sufficient vibrating. Stopping clear from bases, plinths and piers and forming around surface and lay to give levels and falls.
- Installation of construction / expansion joints.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 18 of 135		

### 7.3 Unpaved Areas

Install gravel, tiles or crushed stone on leveled unpaved areas, all in accordance with the specifications and drawings.

### 7.4 Concrete Tiles for Walkways

Install well compacted sub-base layer and install the tiles on the sub-base all in accordance with specifications and drawings.

### 8.0 CONCRETE PIPE SLEEPERS

Fabricate and install reinforced concrete sleepers for pipe, complete with foundations in accordance with the specifications and drawings.

### 9.0 MANHOLES AND CATCH BASINS, TRENCHES

9.1 Fabricate and install pre-cast or formed and poured in situ concrete manholes and catch basins and trenches in accordance with the specifications and drawings.

9.2 The following work is included but not limited to LSTK CONTRACTOR'S scope for installation of manholes and catch basins. All excavation including sheet piling of required, backfill, compacting and the transportation of surplus material, neatly stockpiled at a location, designated by LSTK CONTRACTOR and approved by OWNER.



#### For Poured in Site

- Delivery and installation of all formwork, inclusive if any and all required supporting, bracings, pockets, cutouts recesses etc.
- Bending and installation of concrete reinforcement bars to the requirements and supply of items as defined in 4.3 above.
- Fabrication and installation of embedded and inserted items, if any, to the requirements and supply of items as defined in 4.5 above.
- Mixing and pouring of concrete in accordance with specifications.
- Stripping of formwork and removal of all surplus material to LSTK CONTRACTOR'S yard or locations designated by OWNER.
- All required dewatering to keep the excavations / backfill dry for installation work.
- Install cast - iron manhole frames and solid cover and fabricate and install steelwork catch basin grating and frames in accordance with specifications.

### 10.0 COLLECTION BASINS, PITS, SUMPS, RETAINING WALLS AND CULVERTS

10.1 Fabricate and install concrete collecting basins in accordance with the specifications and drawings.

10.2 Fabricate and install concrete sumps and pits in accordance with the specifications and drawings.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 19 of 135		

10.3 Fabricate and install concrete walls around tanks and other retaining walls in accordance with the specifications and drawings.

10.4 Fabricate and install concrete pipe and bridge culverts including head walls in accordance with the specifications and drawings.

#### 11.0 **DITCHES AND TRENCHES**

11.1 Fabricate and install earthen and concrete ditches and trenches including connection pipes and boxes in accordance with the specifications and drawings.

#### 12.0 **STEEL SLIDING PLATES AND PTFE SLIDING PLATES**

##### 12.1 **Steel Sliding Plates**

- Fabricate and install steel sliding plates in accordance with specifications and drawings.
- The following work is included, but not limited to LSTK CONTRACTOR'S scope for fabrication and installation of steel sliding plates
- Pick up materials, storage and protection against corrosion and any other deleterious effects.
- Fabricate, place in pockets, level and grout, protect against possible damage and corrosion.

##### 12.2 **PTFE Sliding Plates**

- Install sliding plates, in accordance with the specification and drawings.

The following work is included but not limited to LSTK CONTRACTOR'S scope for installation of sliding plates pick up materials, transport, store and protect

- Place in pockets, level and grout, protect against possible damage.



#### 13.0 **GROUTING**

13.1 Mix and install grouting in accordance with the specifications and drawings.

13.2 LSTK CONTRACTOR shall grout under all structural steel columns and under all equipments, as specified.

13.3 The following work is included but not limited to LSTK CONTRACTOR'S scope for installation of grouting:

- Prepare top surface of base and /or plinth, pockets, sleeves etc., prior to placing grout.
- Mix and install grout mortar in accordance with specifications.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 20 of 135		

- Grout mortar shall be used between steel base plate and concrete foundations.
- Mix and install non-shrink grout between reciprocating rotary equipment base frame including the filling of the equipment steel frame, if required, and concrete foundation in accordance with manufacturer specifications and project specifications.

13.4 Grouting of equipment shall proceed only when equipment setting has been accepted by OWNER.

#### 14.0 **ASPHALT PAVING**

14.1 Mix and install asphalt paving over base courses installed by LSTK CONTRACTOR, in accordance with the specifications and drawings.

- Roads/ Driveways/ Parking areas/ Sidewalks/ Tank pads



14.2 The following work is included but not limited CONTRACOR'S scope for installation of asphalt paving to.

- Installation of all materials necessary to make a complete installation.
- Installation of sub-grade, sub-base and base courses all properly compacted.
- Delivery and installation of all formwork, inclusive if any and all required supporting, bracing, pockets, cutouts, recesses, etc.
- Installation of expansion joints where required and/or construction joints
- Stripping of formwork and removal of all surplus material to LSTK CONTRACTOR'S yard or locations designated by OWNER.
- Mixing, delivery, installation, spreading and compaction of asphalt paving mixture in accordance with specifications.
- Any and all measures for proper asphalt paving installation and curing.

#### 15.0 **ROAD REPAIR AND MAINTENANCE**

15.1 Supply and deliver necessary materials, equipments and labour to repair and maintain all plant roads, as necessary.

- Repair work shall be in accordance with the specifications.
- LSTK CONTRACTOR shall be responsible for repair of roads, all on the indication of OWNER due to the damage to the roads, caused by LSTK CONTRACTOR'S activities and construction operations, or due to faulty construction by LSTK CONTRACTOR. LSTK

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 21 of 135		

CONTRACTOR is not entitled for compensation for such repair work.

## 16.0 REPAIR OF DYKES, SLOPES AND DITCHES

16.1 Supply and deliver necessary materials, equipment and labour to effect repairs on dykes, slopes and ditches as necessary.



- Repair WORK shall be in accordance with the specifications.
- LSTK CONTRACTOR shall be responsible for repair of dykes, slopes and ditches all on the indication of OWNER'S representative, due to damage to the dykes, slopes and ditches caused by LSTK CONTRACTOR'S activities and construction operations, or due to faulty construction by LSTK CONTRACTOR.
- LSTK CONTRACTOR is not entitled for compensation for such repair work.

## 17.0 UNDERGROUND SEWERS AND PIPING SYSTEMS

17.1 Install the underground piping systems, in accordance with the specifications and drawings.

17.2 The following work is included but not limited to LSTK CONTRACTOR'S scope for installation of underground piping systems.

- Excavation including sheet piling, if required, backfill, compacting and the transportation of surplus material, neatly stockpiled at a location designated by LSTK CONTRACTOR and approved by OWNER.
- Installation of sand backfill if required
- Receiving unload, inspect and transport LSTK CONTRACTOR'S supplied materials and store and protect.
- Installation of piping materials necessary for a complete installation.
- The installation of above ground fire hydrants, fire monitors and standpipe as well as the underground firewater system.
- The fabrication and installation of supports and thrust blocks for the piping as required.
- Surface preparations and installation of coating and wrapping of the underground piping, if required as per Technical specification Mentioned in **Annexure- 7 - 2C**
- Installation of glass fiber reinforced epoxy piping in accordance with manufacturer's instructions as well as the specifications.
- Hydrostatic pressure testing of the underground piping systems including test apparatus,

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 22 of 135		

test piping, test blinds, bolts and gaskets in accordance with the specifications.

### 17.3 Hydro Testing of Sewers and Underground Lines



- Tests all sewers and underground piping systems as per test instructions. Testing is to be witnessed and approved by OWNER. A test schedule by test system shall be prepared by LSTK CONTRACTOR. Testing and completion shall be in accordance with project system priorities.
- Piping systems shall be tested with suitable water.
- Develop test system procedures and follow priorities established by OWNER. LSTK CONTRACTOR shall prepare detailed schedules based on this data for submittal to OWNER for his approval.
- The water for testing purposes is to be provided by LSTK CONTRACTOR.
- Inexpensive temporary gaskets shall be used in place of permanent gaskets where test blinds are located for hydrostatic testing. On successful completion of a test, the permanent gasket shall be installed when the blinds are removed.
- After hydro testing, LSTK CONTRACTOR shall perform the following activities:
  - Flushing
  - Remove temporary blinds
  - Install permanent gaskets.
  - Flange connection bolts tightened.
  - Coat and wrap welds.
  - Holiday testing and coating repairs.
  - Backfill and compaction.

### 18.0 CIVIL PART FOR UNDERGROUND ELECTRICAL GROUNDING SYSTEM

- 18.1 Excavation of the routing for the direct buried cables, for the road crossing and for the branch conduit and sleeves in accordance with layout and detail drawings.
- 18.2 Transport of the excavated soil, neatly stockpiled to location chosen by LSTK CONTRACTOR and approved by OWNER.
- 18.3 Installation of all protection conduits and installation materials in accordance with the specification, and design and detail drawings.
- 18.4 Transport of excavated soil and backfill including compacting of the round up to finished plant level.



### 19.0 CIVIL PART FOR UNDERGROUND CABLE TRENCHES (AND CABLE) CIVIL PART



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 23 of 135		

- 19.1 Excavation of the routing for the concrete cable trenches for the direct buried cables, for the crossings and for the branch conduit and pipe sleeves by machine or by hand as dictated by local conditions.
- 19.2 Transport the excavated soil, properly stockpiled to a location off chosen by LSTK CONTRACTOR and approved by OWNER.
- 19.3 Installation of the concrete cable trenches in accordance with the specification and the design and detail drawings.
- 19.4 For scope of installation of concrete cable trenches see item 11.
- 19.5 Installation of the road culverts, protection sleeves and cable ducts at road crossing in accordance with layout and detail drawings. For scope of installation see item 10
- 19.6 Transport of the excavated soil and backfill of the surrounding area of the concrete trenches up to finished plant level.
- 19.7 Transport of the excavated soil and backfill of road crossing up to road including the supply and installation of the repair of the paving and / or asphalt road covering.
- 19.8 Transport and backfill of the trenches with a layer of clean sand, free from stones equalized up to the bottom level of the first (bottom) cable layer.
- 19.9 Transport and backfill of the layer of clean sand between cable. Layers and above top cable layer.
- 19.10 Transport of excavated soil and backfill including compacting of the ground up to the layer of concrete tiles or trench covers.
- 19.11 Installation of the cable protection covers and/or trench covers and /or cable routing colored marking tape.
- 19.12 Transport of the excavated soil and backfill including compacting of the ground above the layer of concrete tiles up to finished plant level.
- 19.13 Installation of the cable route designated, trench markers.
- 20.0 **STORAGE TANK PADS AND DYKES**
- 20.1 Install tank pads as specified and as quantified on the specifications and drawings.
- 20.2 Install tank dykes and ramps as specified and as quantified on the specifications and drawings.



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 24 of 135		

20.3 Install impervious clay layer inside the dyked tankage areas in accordance with specifications and drawings.

## 21.0 PERMANENT PLANT FENCING

21.1 Install permanent plant fencing, including personnel gates and truck gates as located, specified and quantified in the specifications and drawings.

## 22.0 SCAFFOLDING

22.1 Supply and erect all scaffolding for WORK.

22.2 Scaffolding shall be supplied, erected and maintained in strict accordance with local and governmental regulations as well as OWNER'S safety requirements. If there are conflicts, the more stringent shall prevail.

LSTK CONTRACTOR shall dismantle all its scaffolding at the completion of its WORK.

## 23.0 TESTING

23.1 All necessary tests in order to control the quality of the field works shall be done and all such test certificates should be kept in record, such as but not limited to

- Soil compaction tests.
- Concrete testing
- Asphalt testing
- Reinforcing bars testing

23.2 If any test fails LSTK CONTRACTOR shall replace those items, which do not meet the requirements.

All costs for replacements shall be borne by LSTK CONTRACTOR.



## 24.0 WELDING PROCEDURES SPECIFICATIONS AND WELDING PROCEDURE QUALIFICATION RECORDS

24.1 Provide within two months before starting the construction execution, its welding procedures (for A.G, U.G piping and any structural steel) for comment and approval. Approval of welding procedures by OWNER is required before the start of welding.

24.2 Prior to start of filed welding LSTK CONTRACTOR shall submit one (1) copy of all welders' qualification paper and applicable welding procedures approved and stamped by regulating authorities to OWNER.

## 25.0 DRAWINGS AND DOCUMENTS

25.1 LSTK CONTRACTOR will carry out all construction activities directly from the AFC construction drawings and specifications.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 25 of 135		

25.2 LSTK CONTRACTOR shall submit reports of each test or inspection within three (3) days after actual test or inspection. Failure to comply with the above rule may result in OWNER arranging for additional tests or inspections. Costs of which will be back charged to LSTK CONTRACTOR.

25.3 LSTK CONTRACTOR shall submit material certificates and quality records of the materials, as specified in previous sections and the applicable engineering specifications and standards.

25.4 LSTK CONTRACTOR shall also furnish a concrete installation record within two (2) weeks after completion of the WORK indicating, date of installation and quantity of concrete of each foundations, floor slab, elevated slab, frames, columns, etc.

This concrete installation record shall also show a reference with the concrete compression test certificates of the respective concrete pours and the concrete delivery slip numbers.

Failure to comply with the above time may result in the preparation of the documents by OWNER in which case all related costs will be back charged to LSTK CONTRACTOR.

## 26.0 MISCELLANEOUS

26.1 LSTK CONTRACTOR shall be fully responsible for the correct and accurate setting out of all elevations, positions, dimensions, alignments, profiles. etc, of all parts of the WORK and for the provision of all necessary instruments, appliances and labour in connection therewith The checking of any such matter by OWNER shall not relieve LSTK CONTRACTOR of its responsibility for the correctness thereof.

26.2 If during the construction or maintenance of WORK, any error is discovered in WORK, LSTK CONTRACTOR shall at its own cost rectify such error to the satisfaction of OWNER. LSTK CONTRACTOR shall in such case take all necessary actions such as overtime, etc. in order not to endanger the agreed upon time schedule.



26.3 All dimensions shown on the plans and drawings are given in the SI system, unless otherwise stated.

26.4 All costs for setting out the earthwork and for assisting OWNER in checking the various points, lines, levels, profiles, etc. shall be deemed to be included in the price.

26.5 LSTK CONTRACTOR shall under no circumstances extend its operations outside the limits of the area appropriated for WORK. LSTK CONTRACTOR will ensure that its operations shall not interfere in any way with properties of others.



26.6 No excavation work shall be started before the exact positions of the WORK have been marked by means of stakes controlled and approved by OWNER.

26.7 OWNER shall notify LSTK CONTRACTOR of all known existing underground pipes, cables,

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 26 of 135		



drains, manholes, etc, in current use, together with the approximate locations and hazards involved and LSTK CONTRACTOR shall ensure that they will not be broken or damaged in any way by the execution of WORK. Hand labour shall be used for excavation within a horizontal distance of 1.5 meters from existing utilities.

- 26.8 Any damage as referred to above AT 26.7 shall be reported by LSTK CONTRACTOR. LSTK CONTRACTOR shall repair the damage.
- 26.9 The discovery of any unregistered pipes, drains, cables, etc., shall be promptly reported to and dealt with as directed by OWNER. Excavation, as required to determine the exact location of existing underground pipes, drains, cables etc. shall be considered as a part of WORK.
- 26.10 LSTK CONTRACTOR shall take precautions i.e. mats, lining with timber, etc. not to cause damage to permanent plant roads curbing and sidewalks with its construction equipment.
- 26.11 LSTK CONTRACTOR shall provide and be responsible for the construction of all temporary dewatering. Drainage, sheet piling, timbering etc. to ensure the stability of slopes, trenches, embankments, etc. during excavation work and that all areas are adequately drained to the satisfaction of OWNER.
- 26.12 LSTK CONTRACTOR is responsible for all soil slides that may occur during the execution of the WORK and for any detrimental effect of the same. LSTK CONTRACTOR shall as directed by OWNER either correct or repair the damage to the satisfaction of OWNER at its own expense or pay for the cost of repair by others of all damage caused to the WORK or adjacent property. No additional payments shall be made to LSTK CONTRACTOR to compensate the financial consequences of soil slides.
- 26.13 Collapse, cave-in, or movement of excavations, trenches, or the like shall be the responsibility of LSTK CONTRACTOR. LSTK CONTRACTOR acknowledges this responsibility and instructions of the OWNER.
- 26.14 Trenches, excavations, and the like shall be maintained in strict accordance with the requirements of the applicable national and local regulations.
- 26.15 LSTK CONTRACTOR shall be held entirely responsible for any effect or damage, which the execution of any of the earthwork may have upon, or which may be caused to any portion of WORK or any of the surrounding property.
- 26.16 Excavation will proceed until all unsuitable material is removed.
- 26.17 LSTK CONTRACTOR is responsible for the excavation required to installing bottom of footings at elevations as shown on drawings. The removal of a poor soil below the intended bottom of excavation is included in the CONTRACT. Any unnecessary over excavation will be in LSTK CONTRACTOR'S account.
- 26.18 Backfill shall be to the elevation shown on the approved drawings or as directed in writing

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 27 of 135		



by OWNER.

- 26.19 Special care must be taken in compaction operations over underground pipelines.
- 26.20 LSTK CONTRACTOR shall furnish all field engineering, surveying, layout, and checking to properly install all foundations to meet all requirements of the drawings and specifications, on completion of each foundation LSTK CONTRACTOR shall mark all foundations with a clear center line, locating both North, South, East and West and a bench elevation mark. LSTK CONTRACTOR shall stencil or by other means, paint equipment and column designation and coordinates, to all foundations installed by LSTK CONTRACTOR. All markings shall be located above high point of paving. These markings shall be preserved for use by others.
- 26.21 LSTK CONTRACTOR shall design concrete mix specification and furnish by means of reports from OWNER'S laboratory, proof that the materials and mixes for concrete conform to the specifications and codes prior to pouring the first concrete on SITE. LSTK CONTRACTOR shall furnish all field labour to make concrete tests and fill cubes quality of concrete aggregates and mix design will be checked by OWNER'S laboratory regularly.
- 26.22 All aboveground concrete for supports for steel structures must be smooth finished, and exposed edges of concrete to have a chamfer.
- The top of the foundations shall be poured so as to ensure true surfaces and designated slopes in all cases. LSTK CONTRACTOR is to avoid damage or movement of already installed reinforcement and/or other structures, formwork, etc., when pouring concrete.
- 26.23 All concrete pours for a given element must be monolithic, except where noted on the drawing or approved by OWNER.
- 25.24 If pouring cannot be finished within normal working hours, necessary actions shall be taken, sufficiently in advance for requesting permits for overtime. All pouring must be continued until the element is complete. OWNER shall be informed at least twenty-four (24) hours in advance.
- 26.25 Damaged formwork must be repaired in such a way as not to mark the concrete finish. All formwork must be braced adequately and be of a rigid construction. Gravel nests, surfaces crack, honeycombs, etc., and shall be repaired to the satisfaction of OWNER.
- 26.26 LSTK CONTRACTOR shall use immersion-vibrating equipment but it needs to be of a type approved by OWNER prior and also during use. Vibration of formwork and fresh concrete WORK is not allowed. OWNER will have the right to require replacement of inadequate during all phases of the WORK. A must condition shall be maintained after pouring as set forth in specifications. The WORK involved in this is to be included in the pricing.
- 26.27 OWNER reserve the rights to reject any WORK already poured which is not in accordance with drawing and specifications and of adequate quality.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 28 of 135		

Serious inclusions appearing in concrete shall be reason for the rejection of WORK and LSTK CONTRACTOR requested to repair or replace at his own expense.

- 26.28 All costs involved in demolition, removal and replacement of rejected WORKS shall be the responsibility of LSTK CONTRACTOR all materials, equipment or auxiliaries not accepted by OWNER shall be removed immediately from the OWNER'S property.
- 26.29 Ready - mixed concrete shall be delivered without segregation. The concrete batch plant has to be approved by OWNER. Small quantities of concrete may be made at SITE after approval of OWNER.
- 26.30 The pouring of any reinforced concrete may only start after having obtained Approval of OWNER.
- 26.31 LSTK CONTRACTOR shall provide, during the period of this CONTRACT, temporary drainage ditches in WORK so that water will not be ponded and so that all areas are adequately drained to the satisfaction of OWNER.
- 26.32 LSTK CONTRACTOR shall provide, during the period of this WORK, systems for the dewatering of all its WORK areas as required to properly execute the WORK. All dewatering methods shall be subject to the approval of OWNER.
- 26.33 All excavated boulders will be removed from SITE by LSTK CONTRACTOR.
- 26.34 Manholes are to be marked with M.H. Number.
- 26.35 Underground service lines have to be marked at their installation limits to aboveground piping, indicating line size, and service and line number.
- 26.36 Prefabricated concrete -items are to - be marked with date of fabrication, size, Length, identification code and installation north arrow.
- 27.0 **BUILDINGS**
- 27.1 LSTK CONTRACTOR shall do the construction of the buildings, including all activities and installations as specified, in drawing and specifications including the fabrication of all items that are not standard hardware components.
- 28.0 Quality of all civil and building materials shall be approved by OWNER before usage in the PLANT.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 29 of 135		

## **ANNEXURE- 7-2B**

### **STRUCTURAL STEELWORK**

1. Delivery of all materials and fabricated structural steel to SITE, including all required transport, storage, intermediate storage, etc., including loading and unloading of materials.
2. LSTK CONTRACTOR will carry out all construction from the AFC construction / erection drawings and specifications.
3. LSTK CONTRACTOR shall be held entirely responsible for any effect or damage, which the erection of the structural steel may have upon, or which may be caused to any portion of WORK or any of the surrounding property.



#### **4. Erect Structural Steel-Structure Frames**

This item covers all activities required to erect prefabricated structural steel framing for single and multilevel structures.

It includes, but is not limited to, the following :

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Shimming of foundations and joints.
- ◆ Erecting.
- ◆ Cutting, drilling, welding and bolting to achieve fitment.
- ◆ Rectification required, if any.
- ◆ Final levelling, aligning and bolting (including torquing).
- ◆ Grouting of components and areas supplied unpainted or requiring finish coats, as per specifications.
- ◆ Touch up painting of damaged areas.
- ◆ Also included in this item are all clips plates, stiffeners, gussets, and connection material supplied loose for field installation.



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 30 of 135		

## 5. Fabricate and Erect Structural Steel-Structure

This item covers all activities required to fabricate and erect structural steel framing for single and multilevel structures, from raw steel, if any, sections, plates, rounds, etc. It including, but is not limited to the following:

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Preparation of detailed fabrication drawings and getting them approved from Owner.
- ◆ Shimming of foundations and joints.
- ◆ Measuring, cutting, bending, bolting and / or welding.
- ◆ Erecting.
- ◆ Cutting, drilling, welding and bolting to achieve fitment.
- ◆ Final levelling, aligning, bolting and /or welding (including torquing )
- ◆ Grouting of support piers.
- ◆ Painting as per specifications.

## 6. Fabricate and Erect Ladder and Safety Cages

This item covers all activities required to fabricate, assemble and erect ladders and safety cages in steel structures, from raw steel (unpainted) sections, plates rounds, etc.

It includes, but is not limited to, the following:



- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Preparation of detailed fabrication drawings and getting them approved from Owner.
- ◆ Measuring, cutting, bending, bolting and / or welding.
- ◆ Assembly and erecting including cutting, drilling, bolting, welding to achieve fitment.
- ◆ Cutting, drilling, welding and bolting to achieve fitment.
- ◆ Final Bolting and / or welding in position.
- ◆ Fabrication and installation of safety barrier rail and gate.
- ◆ Installation of raw bolts and forming of concrete pads, or connecting to a lower platform.
- ◆ Painting as per specifications.

## 7. Fabricate and Erect Platform and Walkways

This item covers all operations required to fabricate erect platforms and walkways on vessels, towers, structures, etc or on the ground from raw steel (unpainted ) sections, plates, rounds, etc.

It includes, but is not limited to, the following :

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Preparation of detailed fabrication drawings and getting them approved from Owner.
- ◆ Measuring, cutting, bending, bolting and / or welding.
- ◆ Erecting including any, cutting, drilling, welding for fitment.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 31 of 135		

- ◆ Final levelling, bolting and / or welding.
- ◆ Installing anchor bolts and grouting.
- ◆ Painting as per specifications.

Not including is the installation of flooring or the erection of handrail.

8. **Fabricate and Erect Welded Handrail**

This item covers all operations required to fabricate and erect double rail handrail and tope plate of all welded construction, from raw steel (unpainted) sections, plates rounds, etc.

It includes, but is not limited to, the following :

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Preparation of detailed fabrication drawings and getting them approved from Owner.
- ◆ Fabrication including cutting, bending, welding, etc.
- ◆ Erecting of posts, top and middle rails toe plate including any cutting, trimming for figment and welding.
- ◆ Grinding smooth of all cut edges and welds.
- ◆ Painting as per specifications.

9. **Fabricate and Erect Galvanized Tubular Handrails**



This item covers all operations required to fabricate and erect double rail tubular galvanized hand railing including all standards, fittings, bends, etc., from raw steel (unpainted) sections, plates, tubes, etc.

It includes, but is not limited to, the following :

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Fabrication including cutting, trimming edge stripping to required size & shape.
- ◆ Erecting into position.
- ◆ Bolting and/or welding.
- ◆ Trimming to suit platform structure and providing openings for pipe or cable, etc.
- ◆ Making good edges, and touch up painting including cold galvanizing of cut or welded parts.
- ◆ Painting of unpainted steel sections

10. **Fabricate and Install Floor Grating**



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 32 of 135		

This item covers all activities required to fabricate and install galvanized floor grating from large sheets ready for cutting, trimming, etc., to platform shapes.

It includes, but is not limited to, the following :

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Fabrication including cutting, trimming, edge stripping to required size & shape.
- ◆ Erecting into position.
- ◆ Bolting and/or welding.
- ◆ Trimming to suit platform structure and providing openings for pipe or cable, etc.
- ◆ Making good edges, and touch up painting including cold galvanizing of cut or welded parts.

#### 11. **Fabricate and Install Chequer Plate Flooring**

This item covers all activities required to fabricate and erect chequer plate flooring, from sheets.

It includes, but is not limited to, the following:

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Fabrication including cutting, trimming edge stripping to required size & shape.
- ◆ Erecting into position.
- ◆ Bolting and/or welding.
- ◆ Cutting to suit platform structure and providing opening for pipe or cable, <etc.

#### 12. **Erect Davits**

This item covers all activities required to erect fabricated davits on exchangers, vessels or in structures.

It includes, but is not limited to, the following :



- ◆ Delivery of davits and all other materials.
- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Erecting up painting of damaged areas.

#### 13. **Roof and Wall Sheeting**

This item covers all activities required to erect by bolting of roof and wall sheeting.

It includes, but is not limited to, the following :

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Cutting and fitting of sheeting including all shrilling, trimming and notching to facilitate openings.
- ◆ All flashing of ridges, corners gables, door jambs, etc.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 33 of 135		

#### 14. Down pipes and Gutters

This item covers all activities required to install metal downpipes and gutters.

It includes, but is not limited to, the following :

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Erecting including fitting, trimming supporting and jointing.

#### 15. Roof or Ridge Ventilator

This items covers all activities required for the erection of roof or ridge ventilators on a steel clouded building.

It includes, but is not limited to, the following :

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Erecting on roof including any trimming or figment.

#### 16. Install Gantry Crane Rails

This item covers all activities required to install rails.

It includes, but is not limited to, the following :

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Erecting jointing levelling, aligning, and bolting or welding in passion.

#### 17. Install Gantry/Overhead Travelling Crane

This item covers all activities required to erect and complete the installation of overhead cranes.



It includes, but is not limited to, the following :

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Erecting into rails.
- ◆ Installing all controls, both mechanical and electrical.
- ◆ Testing and running of crane.

#### 18. Install Travelling Trolleys

This item covers all activities required for the installation of beam mounted travelling trolley.



It includes, but is not limited to, the following :

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 34 of 135		

- ◆ provision of all tools, equipment and consumables used in the course of the work.
- ◆ Erecting into position.
- ◆ All levelling and shimming of trolley beam as required.
- ◆ Marking of all beams and trolley with safe Working Load.
- ◆ All testing and running as required.

#### 19. **Inspection and Testing**

- ◆ Inspection of steel structure shall be in accordance with the codes and standards.
- ◆ LSTK CONTRACTOR shall provide NDE services acceptable to OWNER. NDE inspection shall be carried out in accordance with standards, codes and specifications .
- ◆ LSTK CONTRACTOR shall be responsible for the repair of faulty welds and for all required extra radiography and inspection of the faulty welding work. In case of a faulty weld, 100% radiography on LSTK CONTRACTOR'S account can be done as per code.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 35 of 135		

## **ANNEXURE- 7 – 2C**

### **PIPE PREFABRICATION AND ERECTION**

#### **1.0 PIPING**

##### **1.1 Magnitude of Piping**

LSTK CONTRACTOR shall prefabricate, install and test all piping as shown on the plan drawings and isometrics.

#### **2.0 PIPING FABRICATION AND ERECTION**

2.1 Piping systems and pipe supports shall be designed, fabricated, inspected, and tested in accordance with rules, codes, specifications and drawings.

2.2 Miscellaneous piping materials for vents, drains, instrument connections, etc. on equipment shall be installed using P & ID'S and equipment drawings.

2.3 The fabrication and erection of piping includes field welds. It is LSTK CONTRACTOR'S responsibility to choose the number and location of field welds to ensure efficient transportation and handling during erection. Furthermore LSTK CONTRACTOR shall locate the field welds in such a way that final adjustment for fit-up purposes will be possible.



For alloy piping that has to be stress relieved after welding the number of filed welds shall be kept to a bare minimum. LSTK CONTRACTOR shall thoroughly evaluate the need for each field weld in alloy piping he deems necessary.

2.4 LSTK CONTRACTOR will furnish OWNER with a marked up set of isometrics identifying all spool pieces, and weld numbers. All piping spools shall be clearly identified, per isometric by means of stainless steel tags affixed with wire.

2.5 LSTK CONTRACTOR shall erect all prefabricated and straight run piping as required by the drawings and specifications.

The erection and installation of the piping shall include but not be limited to the following

- Control valves.
- Safety valves
- Rapture disks.
- Level instrument and gauges.
- External level displacers.
- Special fittings.
- Breaching of vents, drains, instrument connections, etc.
- Rota meters.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 36 of 135		

- Orifice flanges.
- Orifice plates.
- In - line instruments.
- Steam tracing.
- Steam traps.
- Extension stems. Valve operators.
- Bellows, expansion joints and similar specialty items.
- Thermowells (flanged, screwed and weld Ins.).
- Sample coolers.
- Instrument connections (up to and including the first block valve).
- Spring hangers and spring supports.
- Installation of miscellaneous piping and instrumentation supplied by equipment vendor.
- Temporary piping for drying, flushing and hydrostatic testing if necessary.
- Connection of piping to equipment.
- Connection of aboveground piping to underground piping.
- Pipe supports.

This shall include any necessary work to the piping to correct equipment misalignment.

2.6 Fastening of floor supports on concrete will be done with expansion type foundation bolts, if no anchor bolts are provided.



2.7 LSTK CONTRACTOR is responsible for the installation of steam tracing of piping, valves fittings and instruments where required, in accordance with the specifications and drawings. In general steam and condensate headers will be indicated on the piping plans. Lines to the traced will be indicated on P& ID'S and lines lists. Details of steam and condensate headers will be shown on separate drawings. Identification of steam tracers shall be by aluminum tag noting circuit number. Each end of system should be tagged.

A method of identification and tagging of the other various systems shall be established, subject to approval by OWNER and is for account of LSTK CONTRACTOR.

2.8 LSTK CONTRACTOR is responsible for the fabrication and erection of pipe supports, hangers, anchors and guides, as required by the drawings and specifications.

Spring pots and spring hangers, which shall be provided by LSTK CONTRACTOR as will be assembled, installed, adjusted and unlocked by LSTK CONTRACTOR after hydrostatic testing of the line. The required angle iron, will be decided in the field and supplied by LSTK CONTRACTOR.

2.9 LSTK CONTRACTOR shall install and remove all temporary strainers required for WORK defined herein. The removal of these items will be directed by OWNER. OWNER may decide to leave temporary strainers in during commissioning.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 37 of 135		

- 2.10 LSTK CONTRACTOR shall be responsible for the fabrication, installation and dismantling of temporary spool pieces and blinds required for control valves, safety valves and in - line instruments during testing and cleaning. Requirements for these shall be minimized. Requirements for these will be prescribed by OWNER.

In general, in-line instruments, safety valves and control valves may be installed for fit-up purposes if available to avoid the use of temporary spool pieces. They shall be removed for flushing and testing and reinstalled as directed by OWNER. In the case of safety valves these must be installed for fit - up, taken down for calibration by LSTK CONTRACTOR, and reinstalled before mechanical completion. All open flanges and valves shall be blinded or plugged off.

- 2.11 LSTK CONTRACTOR is responsible for the installation and testing of all piping and steam, electrical tracing and all materials including all items necessary to completely close the systems in strict accordance with the established test system procedures and priorities as directed by OWNER.

- 2.12 **Wrapping & Coating:-** Surface preparations and installation of Wrapping & Coating of the underground piping with Cold tape (Materials for line coating and wrapping shall be of Tape coating system (Polyethylene backed tape with butyl rubber based adhesive system), if required

- 2.12.1 Protective coating shall consist of a coating system employing Primer, Inner Wrap and Outer Wrap.
- 2.12.2 The coating system shall be mechanically applied by an approved type of wrapping machine utilizing constant tension brakes except at tie-in welds, repair patches and at other locations where mechanical application is not practicable..
- 2.12.3 Coating and wrapping materials shall be handled, transported, stored and applied strictly in accordance with the manufacturer's instruction.
- 2.12.4 Wrapping Coating material is Cold tape type from **Polyken/Denso/Atla** shall be used.



## 2.13 Flushing and Cleaning Of Piping Systems

- i) Sections fabricated in LSTK CONTRACTOR'S workshop shall be fitted with plastic end caps to seal pipe ends, and jointing surfaces shall be suitably protected.

These caps shall not be removed until sections are in the course of erection after delivery at SITE and then shall be removed for refuse.

- ii) During fabrication and erection the sections shall be inspected or internal cleanliness.
- iii) The water which will be used for testing and flushing of the piping system shall be recollected per instruction given by OWNER.

- v) Piping systems shall be flushed with suitable water as supplied by LSTK Contractor

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 38 of 135		

unless designated for nitrogen or air testing or otherwise specified by licensor. OWNER'S approval is required before start of flushing.

- v) LSTK CONTRACTOR shall supply all equipment, pumps, gauges, etc. required for flushing and testing of the piping systems.
- vi) For hydro testing and flushing the piping LSTK CONTRACTOR shall weld and caps and install drain plugs, remove end caps after successful hydro test.

### 3.0 HYDRO TESTING

3.1 Inspection and hydro testing of the piping systems shall be in accordance with the drawings and specifications and in strict witness by OWNER representatives.

3.2 Atmospheric pressure systems shall be:

- Visually inspected that all joints are properly made.
- Filled with water for a 24 hours leakage test under atmospheric conditions.

If any leakage occurs in the system during testing, repairs must be made without extra costs to OWNER.

3.3 LSTK CONTRACTOR shall test all piping systems as per the project test diagrams. Testing is to be witnessed and approved by OWNER and where applicable by the appointed (independent inspection authority) filed inspector. A test schedule by test system shall be prepared by LSTK CONTRACTOR and shall be submitted to OWNER for Approval.

3.4 Testing and completion shall be in accordance with project system priorities.

3.5 All equipment, pumps, gauges, pressure recorders temporary piping and fittings, test gaskets and bolting, required for testing of the piping systems and part of LSTK CONTRACTOR'S supply. Before testing LSTK CONTRACTOR shall calibrate its testing equipment.

3.6 LSTK CONTRACTOR shall supply and install blind flanges when required to enable testing of the lines.



3.7 Inexpensive temporary gaskets supplied by LSTK CONTRACTOR, shall be used instead of permanent gaskets where test blinds are located for hydrostatic testing. On successful completion of a test the permanent gasket shall be installed when the blinds are removed.

3.8 Piping systems shall be tested with suitable water. Extreme care shall be taken that suitable water is used for stainless steel systems. For stainless steel the water must be approved by OWNER and shall have a content of chlorides  $\leq 50$  mg/L

3.9 The water for testing purposes will be furnished by LSTK CONTRACTOR.

3.10 LSTK CONTRACTOR is to perform the testing in a sequence so as to allow sufficient time for



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 39 of 135		



insulation and/or painting to complete within the time frame of the project schedule.

- 3.11 A formal system of documentation will be developed by LSTK CONTRACTOR and approved by OWNER for use by LSTK CONTRACTOR to certify this testing phase of the piping erection. This system will also include a section for supplying OWNER'S "But list" comments.
- 3.12 Erected piping shall be hydrostatically tested in test systems, but not through equipment, control valves etc. except where piping is welded to equipment.
- 3.13 LSTK CONTRACTOR remains responsible for ensuring that no item of equipment, or instrument, is damaged by the test pressure or the test fluid. Suitability of test fluid to be Approved prior to testing by the OWNER.
- 3.14 It is emphasized that the installation of temporary strainers prior to testing shall be part of WORK. OWNER shall be contacted concerning installation of temporary strainers.
- 3.15 When lines are pressure tested, valves at the end of the lines must be covered with a test blank for safety reasons. A record, preferably on the test diagrams, shall be kept by LSTK CONTRACTOR indicating which sections have been completed.

Note : Testing against closed valves is not allowed (spades to be used)

- 3.16 All material damaged during tests shall be replaced on LSTK CONTRACTOR'S account. All joints broken after testing for installation of strainers, orifice flanges, safety valves, etc. must be remade tightly; labour is for LSTK CONTRACTOR'S account.
- 3.17 After testing the piping systems, they shall be completely flushed and drained. OWNER will approve when a line is considered flushed and drained by LSTK CONTRACTOR.
- 3.18 When each section or circuit has been pressure tested and passed, a certificate prepared by LSTK CONTRACTOR on LSTK CONTRACTOR'S furnished forms showing details must be signed by LSTK CONTRACTOR and OWNER, when the test has been completed and the system drained, test blanks must be removed by LSTK CONTRACTOR.
- 3.19 The following activities by LSTK CONTRACTOR are included for the reinstatement of piping after hydro testing:
- LSTK CONTRACTOR installed temporary testing blinds to be pulled.
  - Temporary spool pieces taken out.
  - Gaskets renewed, temporary replaced with permanent.
  - Flange connection bolts tightened.
  - Post hydro punch list items corrected.



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 40 of 135		

- Temporary strainers installed.
- Chemical cleaning performed.
- Supports and hangers checked if in final position.
- Rotating equipment cold alignment checked.
- Reinstallation of control and safety valves and in - line instruments which LSTK CONTRACTOR has removed for hydro-testing.

3.20 Nondestructive testing of welds and systems is to be performed in accordance with standards, codes and specifications prior to perform any hydro-test.

#### 4.0 PIPING MATERIAL IDENTIFICATION AND PAINTING

4.1 All piping materials are supplied by LSTK CONTRACTOR and shall be properly stamped and color-coded to ensure that the correct materials are used as required by the drawings, specifications, codes and regulations.

4.2 All materials will be adequately marked as to its specifications. Should LSTK CONTRACTOR be required to cut same or otherwise render piece(s) to have no marking, LSTK CONTRACTOR'S transfer or replacement of proper identification marking to the pieces involved, must be done according to approved stamping method and to be counter stamped by LSTK CONTRACTOR. Paint alone is unacceptable.



4.3 The governing principle shall be that in the installed piping systems, all components can be identified and their origin and complete specifications can be determined. The method for identification and stamping or tagging of the various components of the system shall be worked out in coordination with OWNER and only be implemented after approval.

LSTK CONTRACTOR shall be held responsible for this requirement as a minimum, and any other requirements of local codes and regulations as to identification and documentation of materials.

4.4 Surface preparation and paint application of piping system by LSTK CONTRACTOR, shall be per paint specification.

4.5 LSTK CONTRACTOR shall assure that no welds are covered by prime coats prior to acceptance of hydro test.

4.6 LSTK CONTRACTOR must ensure that all stamping such as code stamps, registration spool identification, charge numbers etc. shall be visible after paintwork.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 41 of 135		

## 5.0 WELDING

5.1 All welding shall be carried out according to codes and specifications.

5.2 Welder's qualification

5.2.1 All welders including those with valid qualifications will be required to submit a test conducted by OWNER prior to start of welding.

Welders that have a certificate which is still valid for the type of material and in accordance with ASME IX will not be tested by OWNER.

5.2.2 A current list of qualified welders must be maintained by LSTK CONTRACTOR and a copy furnished to OWNER each time a revision is made.

5.3 Welders' identification stamps shall be provided by LSTK CONTRACTOR. Each weld shall be clearly stamped with welders identification. All welding including tack welding shall be carried out by qualified welders. Unstamped welds shall be removed and replaced at LSTK CONTRACTOR'S expense.

5.4 Job SITE fabrication shall be carried out under cover where possible.

5.5 Weld spatter shall be knocked off around all welds leaving a smooth clean surface.

5.6 Where openings for branches are cut in run of pipe, all material, which may drop inside the pipe, shall be completely removed before the branch line is welded in place.

6.7 The interior welds of orifice flanges shall be ground smooth.

## 5.8 Electrodes, Rods, Wires and Fluxes



Electrodes shall be stored in the makers' airtight containers until required for use. Electrode heaters shall be used on Job SITE, for low hydrogen types of electrodes.

Electrodes and filler wires to be used at site in this job shall be procured from the approved vendors only. Electrodes and filter wires shall be **D&H, Advani Orlikon or ESAB, Mailam and Bohler group make only**

## 5.9 Open Air Welding

Where welding in the open air is unavoidable, WORK must be discontinued where the quality of the weld may be impaired by weather conditions. Including but not limited to airborne moisture, sand or high winds. After rain the metal surfaces shall be dried. For metal temperature below 5 °C joints to be preheated.

## 5.10 Welding Procedure Qualification

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 42 of 135		

LSTK CONTRACTOR shall supply welding procedure specifications and qualification in accordance with the rules as set by OWNER.

5.11 Fees for inspection required for welding procedure and welders qualifications, supply of equipment required for the qualification test of welders and welding procedures are for account of LSTK CONTRACTOR.

#### 5.12 **Inspection and Testing**

5.12.1 Inspection of welds shall be in accordance with the instructions of OWNER and/or the requirements of codes and standards.

5.12.2 LSTK CONTRACTOR shall be responsible for the repair of faulty welds and for all the required extra radiography and inspection of the faulty welding work. In case of a faulty weld, 100% radiography, on LSTK CONTRACTOR'S account, shall be done on the weld performed as per code.

OWNER shall have absolute discretion in the selection of the welds, which are to be radio graphed.

5.12.3 LSTK CONTRACTOR shall provide NDE service, acceptable to OWNER.

NDT inspection shall be carried out in accordance with codes for all lines as indicated in the piping specification.

#### 6.0 **STRESS RELIEVING**



6.1 LSTK CONTRACTOR shall provide stress-relieving service acceptable to OWNER. Spool pieces shall be stress relived in an approved furnace equipped with thermostatic control and temperature recorder. Field welds to be stress relieved with electric resistance heaters. Temperature cycles to be monitored with portable temperature recorder.

6.2 Stress relieved welds shall be hardness tested by approved procedure and must meet criteria spelled out in specifications.

#### 7.0 **TRANSPORTATION**

The following various categories of transportation of pipe, pipe fittings and prefabricated pipe spools will be performed by LSTK CONTRACTOR. All categories include loading and unloading materials. Categories will consist of but not limited to:

- From LSTK CONTRACTOR'S warehouse to LSTK CONTRACTOR'S pipe prefab shop.
- From LSTK CONTRACTOR'S pipe prefab shop to LSTK CONTRACTOR'S painting shop.
- From LSTK CONTRACTOR'S pipe prefab or painting shop to LSTK CONTRACTOR'S

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 43 of 135		

storage area or working area located on site or any other location on SITE.

- All transportation required performing nondestructive testing of prefabricated pipe spools.

## 8.0 LIFTING, LIFTING EQUIPMENT AND GEAR

8.1 Rigging and hoisting shall be executed as per construction specification and local requirements and safety rules, as manufacturer's instructions. If there are stringent one shall prevail.

## 8.2 Testing And Certification

All LSTK CONTRACTOR furnished cranes, lifting appliances and lifting gear must be properly tested, examined and/or inspected before being used on SITE, and at the intervals specified in the applicable regulations. Copies of the relevant certificates must always be available on SITE for inspection on request by OWNER or other authorities.

## 8.3 Operation

8.3.1 LSTK CONTRACTOR shall not permit a lifting appliance to be operated otherwise than by a person trained and competent to do so.

8.3.2 LSTK CONTRACTOR shall take express steps to ensure that all personnel employed by LSTK CONTRACTOR are competent and experienced for their assigned tasks.

## 9.0 DRAWINGS AND DOCUMENTS

LSTK CONTRACTOR shall fill in checklists as required by OWNER.



## 10.0 MISCELLANEOUS

10.1 LSTK CONTRACTOR shall furnish all field engineering surveying layout, and checking to properly install all above ground piping to meet all requirements of the drawings and specification. OWNER is authorized to reject any WORK already installed, which is not in accordance with drawing and specifications and of adequate quality.



10.2 All costs involved in demolition, removal and replacement of rejected works shall be the responsibility of LSTK CONTRACTOR. All materials equipment or auxiliaries not accepted by OWNER shall be removed immediately from SITE.

10.3 Underground service lines are marked at their installation limits to above ground piping, indicating line size, service and line number.

10.4 During storage, fabrication and erection, care must be taken to ensure that sand, scrap materials, welding rods, items of clothing and other foreign bodies are not allowed to enter piping.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 44 of 135		

- 10.5 All connections which are left open by LSTK CONTRACTOR shall be well protected, so that no sand, dirt or any foreign object come into the system.
- 10.6 In certain instances special bolting torques might be required on critical connections. LSTK CONTRACTOR will arrange WORK in accordance with these requirements.
- 10.7 Flanged piping connections to vessels or equipment shall be aligned and shall be properly fitted before bolting up. Piping may be heated to bring it into alignment only when approved by OWNER. Extreme care should be exercised to avoid damage. Heating, welding and flame cutting on equipment will not be permitted.
- 10.8 No cold springing or pre- stressing of piping will be allowed other than indicated on piping drawings, isometrics and manufacturer's instructions (e.g. for expansion joints).
- 10.9 Flange faces shall be clean and free from foreign matter before assembly. Damaged flange faces may be dressed with a medium cut file only if the damage does not require new facing. This shall be decided by OWNER.
- 10.10 During erection care shall be taken to remove all dirt, seals, sand and foreign matters from inside the pipe.
- 10.11 Since LSTK CONTRACTOR is responsible for both the prefabrication and the erection of all the piping, it is LSTK CONTRACTOR'S sole responsibility to ensure that all piping to be installed fits properly prior to lifting. LSTK CONTRACTOR is to check all equipment and underground piping to be piped to, for proper location and orientation. OWNER will not entertain any claims for extra work for :
- i. Taking piping down for rework after it is lifted
  - ii. Re-lifting piping after it is reworked.
- 10.12 Final hookup of piping to equipment such as pumps and compressors shall be done together with the final alignment of this equipment and shall include checking of dimensions. Piping must fill these flanges without inducing any strain on equipment.
- 10.13 In all cases, all designated support and hangers should be in unlocked / cold position before final alignment. LSTK CONTRACTOR will be expected to expedite this critical phase of construction.
- 10.14 Certain small vessels will be considered to be piping items and shall be fabricated as such by LSTK CONTRACTOR.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 45 of 135		

## **ANNEXEURE- 7 -2D**

### **EQUIPMENT ERECTION**

#### **1.0 SURVEYING**

- 1.1 Baseline and base elevation will be furnished to the LSTK CONTRACTOR. LSTK CONTRACTOR will furnish all surveying from this baseline and elevation.
- 1.2 OWNER shall have the authority at any time to determine in accordance with the drawings or written directives, the correctness or completeness of the lines in use by LSTK CONTRACTOR.
- 1.3 Any erroneous WORK shall be corrected to OWNER'S satisfaction at LSTK CONTRACTOR'S expense.

#### **2.0 RIGGING STUDIES AND PLANS**

- 2.1 LSTK CONTRACTOR shall supply rigging studies and plans as specified.

#### **3.0 EQUIPMENT HANDLING**

- 3.1 The handling of all equipment shall include, but not limited to the following activities by LSTK CONTRACTOR:
- 3.1.1 Submittal to OWNER of detailed rigging studies and plans for lifting, transporting and setting of equipment 4 weeks in advance of work for OWNER to review and approval. Complicated lifts shall be started in the morning and completed the same day.

The transportation plans are to include as a minimum:



Type of equipment to be used to transport each piece.

The planned route of the movement.

The estimated duration of the movement.

The obstructions to the route to be temporarily removed.

- 3.1.2 Receive, inspect, store, protect and perform preventative maintenance on all equipment in accordance with the specifications and drawings and/or equipment manufacturer's instructions.
- 3.1.3 Prepare foundations, pipe sleeves, paving, concrete structures and steel structures for

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 46 of 135		

setting equipment.

3.1.4 Transport form warehouse or point of unloading and install equipment on foundations, paving or structures.

3.1.5 Plumb level and align equipment with coordinates in accordance with the specifications and drawings.

#### 3.1.5.1 **GENERAL**



All of the equipment must be plumbed, leveled and aligned with the coordinates specified on the drawings both in plan and elevation and to the tolerances called out in the specifications, specific manufacturer's instructions or recommended manufacture's practices.

- LSTK CONTRACTOR will be required to verify field conditions and will be responsible for final alignment of mechanical items for this project. LSTK CONTRACTOR will check the anchor bolt locations against the equipment. Any deviation must be reported to OWNER in writing.
- LSTK CONTRACTOR will be required to supply and install shims required for all equipment erection. All cinch anchors required for equipment and supports will be supplied and erected by LSTK CONTRACTOR.

Prior to the placement of the equipment on a foundation, the surfaces of the foundation shall be cleaned of oil, grease, excess concrete and foreign matters by LSTK CONTRACTOR.

- Prior to setting the equipment on the foundations, the underside of the equipment base plate or supports will be cleaned free of oil, grease and other loose materials by LSTK CONTRACTOR.
- Anchor bolts shall be checked for damage to the thread and the threaded part shall be properly greased.
- Damaged anchor bolts must be replaced by LSTK CONTRACTOR and brought to the attention of OWNER.
- The openings between the anchor bolts and sleeves have to be cleaned of foreign materials to full depth of the opening by LSTK CONTRACTOR.
- All steel wear plates and guide keys shall be coated by CONTRACT with proper lubrication, prior to setting the equipment.
- Equipment shall be set true to line. at correct elevation and in proper orientation as shown and noted on the drawings.





	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 47 of 135		

- Maximum allowable setting tolerances shall be in accordance with manufacturer's requirements or with the specifications, whichever is more stringent.
- All equipment, unless otherwise specified, shall be leveled with shims at each anchor bolt (shim on both sides of each anchor bolt) and at intermediate points as required to prevent distortion of the equipment. Shims shall have square cut edges (not trimmed or sheared) and shall be of various thicknesses to minimize the number of shims required. Shims shall be supplied by LSTK CONTRACTOR.
- The equipment shall be set, leveled, aligned and inspected with precision tools (steel straight edge, graduated machinist levels, dial indicators, theodolites, water level instruments, turbine levels, etc.). Setting, leveling and alignment shall be according to manufacturer's recommended tolerances and specifications.
- There may be a number of items not installed by the manufacturer, i.e. seals, packing, lubricators, gauges, miscellaneous piping and tubing, thermometers, etc. that will come separately packed from the equipment itself that must be identified, stored, preferably inside in accordance with project criteria, and finally installed. LSTK CONTRACTOR is responsible for these activities.
- LSTK CONTRACTOR shall remove all temporary shipping supports or erection materials.
- LSTK CONTRACTOR shall do surface preparation for, and apply coating and wrapping on buried vessels before installation.

Equipment supported on legs or on saddles shall be set to the tolerances specified in specifications of the required elevation measured on the flange of the largest diameter pipe-connecting nozzle.

- For equipment with sliding type supports, LSTK CONTRACTOR will remove dirt, grease or other foreign matter and will coat with graphite grease supplied by LSTK CONTRACTOR on the support.
- The anchor bolt nuts will be placed so as not to restrict the longitudinal movement of the sliding end.
- Vessels, drums, etc. shall be aligned, where applicable and leveled per shown or drawing.
- Shims shall be placed approximately evenly spaced under the support ring of vessels, drums, tanks.
- Towers with two or more pieces shall be assembled and welded at site by LSTK



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 48 of 135		

CONTRACTOR.



- LSTK CONTRACTOR is responsible to check and inspect at these equipments in the vendor's shop.
- All costs are included in the lump sum price.

### 3.1.5.2 Rotating Equipment

- Rotating equipment will be installed in accordance with manufacturer's instructions.

Align drivers with all rotating equipment.

- LSTK CONTRACTOR shall install all ancillary equipment such as, but not limited to, drivers, guards, harness piping and all other interconnecting piping, casing drains, base plate drains and all necessary supports.
- The measurements for the positioning and leveling of mechanical equipment will be made on the suction flange.
- LSTK CONTRACTOR to install permanent packing, seals lubricating oils, greases and circulated oil systems.
- Services of manufacturer's technical representative by LSTK CONTRACTOR shall be used to the fullest extent.
- Rotating equipment base plates will be supported for positioning and leveling on shims located as follows.
- For bases with four (4) anchor bolts. one set of shims will be placed adjacent to each anchor bolt.
- For bases with six (6) or more anchor bolts, two (2) sets of shims will be placed adjacent to each anchor bolt, one on each side of the anchor bolt.
- In addition shims shall also be placed directly under those parts of the base plate carrying the greatest weight and shall be placed closely enough to give uniform support.
- When the base plate is level in all directions as indicated by an accurate instrument on the machined pads, the anchor bolt nuts shall be brought down evenly, but not too firmly. The unit is now ready for grouting. After the grout has adequately set, pull the anchor bolt nuts down tight and recheck the base for levelness.
- Release for grouting of base plates must be approved by OWNER.
- After completion of the electric installation to the motor, the direction of rotation of the

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 49 of 135		

motor will be determined. Prior to checking the direction of rotation, the coupling between the motor and the equipment will be disconnected for the test run of motor by LSTK CONTRACTOR.

- Rough aligning of the centrifugal units and their respective drivers shall take place after the equipment has been put on the foundation.
- Coupling alignment
- Dial indicators shall be used and where possible optical alignment equipment.

Peripheral alignment shall be checked by using one dial reading peripheral differences between coupling halves as they are rotated together.

Face alignment shall be checked using two dials reading face-to-face differences between coupling halves.

- Tolerances shall be in accordance with manufacturer's instructions with and without pipe work connected.
- Manufacturer's representative shall check that the final alignment of equipment is satisfactory before any running takes place. For small equipment. Where it is agreed by OWNER that the services of a manufacturer's representative are not required, manufacturer's written instructions shall be followed.
- The final checks will be supervised by LSTK CONTRACTOR and the results recorded by LSTK CONTRACTOR and signed by OWNER and LSTK CONTRACTOR.



Final alignment shall be carried out in two stages.

- After piping is complete with all bolts removed from the flange connections.
- Final alignment with piping assemblies 100% complete and all flanges bolted up to ensure that no unforeseen vertical or horizontal pipe loading is imposed on the unit.
- The final aligning supervised by OWNER to make sure that the detailed instructions furnished by the equipment suppliers are carried out to the full satisfaction.



LSTK CONTRACTOR to supply qualified personnel in the final alignment activities.

- Prior to putting pumps, etc. into operation, loose equipment such as guards and gauges shall be installed by LSTK CONTRACTOR.

- 3.1.6 Mount the drivers to the rotating equipment in case of turbines and any large motors that are shipped separately.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 50 of 135		

- 3.1.6.1 In case electric motors have to be installed in the field, this shall be done after leveling of base plate, but prior to grouting.  
Chrome / nickel shim material, supplied by LSTK CONTRACTOR shall be used for alignment of drivers and pumps and shall be installed under the entire footing of the driver.
- 3.1.6.2 Equipment and drivers shall be doweled to bed plate if required by manufacturer's instructions.
- 3.1.7 Assembly whenever required for the items / package unit like Auxiliary Boilers, Waste Heat Boilers, Air - cooled exchangers, furnaces , compressors ,Turbo generators etc. units as part of the scope of WORK of installation by LSTK CONTRACTOR.
- 3.1.7.1 Compressor seal oil and lube oil systems and control panels are included in LSTK CONTRACTOR'S installation of compressors.
- 3.1.7.2 When equipment is delivered in two or more sections for site welding the weld preparation must match accurately on mating sections before assembling.
- 3.1.7.3 LSTK CONTRACTOR shall assemble and erect items, whether skid mounted or supplied in individual components as specified in the requisition or indicated on drawings in order to make a completed unit.
- 3.1.7.4 Installation, assembly and alignment of the various components shall be done by LSTK CONTRACTOR.
- 3.1.7.5 Installation of air - cooled exchangers includes the erection of structural steel on the pipe rack, which will support the tube bundles must be done by LSTK CONTRACTOR.
- 3.1.7.6 Walkways, platforms, stairs, ladders shall be installed for the items / package unit like Auxiliary Boilers, Waste Heat Boilers, Air - cooled exchangers, furnaces, compressors, Turbo generators etc. by LSTK CONTRACTOR.
- 3.1.7.7 Drying out systems, refractory and linings is included in LSTK CONTRACTOR scope of work.
- 3.1.8 Install ladders, platforms, davits, pipe supports and pipe guides in accordance with drawings and specifications.
- 3.1.9 Open man ways. Inspect. clean and close man ways of all tanks, towers. vessels and other equipment as directed by specification or manufacturer.
- 3.1.10 Install all trays and vessel internals and support for same shipped loose. in accordance with drawings, specifications and manufacturer's recommended installation instruction.
- 3.1.11 Under the supervision of OWNER and respective manufacturer's representative LSTK CONTRACTOR shall load the first loading of chemicals.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 51 of 135		

- a) There will be certain items of equipment such as filters and package equipment that come with cartridges filled with -desiccants, resins, etc. Their items will be installed by LSTK CONTRACTOR if they are shipped separately from the equipment.
- b) Installations include the pick-up of these chemicals from the place of storage and transportation to point of installation.

3.1.12 Under the supervision of OWNER, LSTK CONTRACTOR install the first loading of catalysts. Installations include the pick-up of these catalysts from the place of storage and transportation to point of installation.

3.1.13 Touch - up of painting on new equipment after erection.

3.2 LSTK CONTRACTOR shall install grout under all equipment as required.

3.3 Grouting will be as per the specification per the equipment manufacturer's recommendation, whichever is more stringent.

3.4 The following work is included but not limited to LSTK CONTRACTOR'S scope for installation of grouting:

3.4.1 Prepare top surface of base and/or plinth, pockets, sleeves etc., prior to placing grout.



3.4.2 Install grout mortar consisting of one part Portland cement and one part of clean sand and sufficient clean water for workability.

This grout mortar shall be used between steel base plate and concrete foundations.

3.4.3 Wherever non-shrinkage grout is specified on the drawings, the same shall be supplied by LSTK CONTRACTOR and installed in accordance with manufacturer's instructing.

3.5 Install non-shrink grout between reciprocating / rotary equipment base frame including the filling of the equipment steel frame if required, and concrete foundation in accordance with manufacturer specifications and project specifications. Type of non-shrink grout to be approved by OWNER. After grouting, shims used in leveling equipment will not be removed except where removal is specifically required by manufacturer's instructions.

3.6 Unless indicated otherwise on drawings vessels supported on skirts and support rings will be grouted using a stiff mix under the support ring so as to obtain full bearing, Grout will be placed within the area of the skirt the high point of ground at the vertical axis of the tower (or vessel), sloping downward to the support ring with four (4) weep holes under the support ring sufficiently large to ensure drainage.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 52 of 135		



## 4.0 MATERIAL HANDLING SYSTEM

### 4.1 ERECTION & COMMISSIONING

- 4.1.1 The complete material handling system including its all equipment shall erected at site and commissioned in accordance with the best engineering practice.
- 4.1.2 Packing, forwarding, transportation, unloading and storage at site, safety and protection of various components at site, insurance etc. shall be the responsibility of the LSTK Contractor / supplier.
- 4.1.3 All men, material and tools required shall be arranged by the LSTK Contractor at his own cost. The LSTK Contractor shall also arrange for the safe handling, storage, protection and security of his good at site.
- 4.1.4 The purchaser shall be responsible for supplying his part of material only as covered by the clause pertaining to the work to be excluded from LSTK Contractor's scope of supply.
- 4.1.5 After erection at site, the belt conveyors and related equipment shall be tested for satisfactory operation for mechanical completion and full-load performance run. The LSTK Contractor shall carry out performance test as per mutually agreed procedure. The details of the procedure shall be submitted by the LSTK Contractor for purchaser's approval.

### 4.2 MECHANICAL COMPLETION

- 4.2.1 Mechanical completion shall be considered as achieved when the system is mechanically complete along with the pre-commissioning activities and is ready for feeding. This shall include but not limited to the following :
1. The installation as per FINAL PROPOSAL is complete in all respects in accordance with the drawings, specifications including any approved changes thereto and in accordance with all applicable codes and laws.
  2. The machinery, conveyors and all drives are aligned and run or cycled under no-load conditions.
  3. The electrical system is installed and tested in accordance with applicable codes and specifications. All wiring is checked for correct hook-up. Motor rotation is checked and power system protective devices are set.
  4. Painting is completed to the extent that the incomplete work does not prevent plant start-up and commissioning.
  5. Successful completion of no-load test of all the equipment and the complete system.
  6. Temporary construction facilities are removed to the extent necessary to permit the plant start-up and commissioning.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 53 of 135		

4.2.2 The OWNER shall inspect and certify that the LSTK Contractor executed the job in accordance with drawings and specifications.

4.2.3 When the complete belt conveyors and related equipment have been fully erected at site, LSTK CONTRACTOR shall request OWNER for his agreement to start the No-load Test Run. Owner shall, within 72 hours of receipt of such request, issue his agreement or advise LSTK Contractor in writing of any deficiencies noticed in the equipment.

4.2.4 Omissions / rectifications of minor items, if any, not affecting commissioning shall not withhold MECHANICAL COMPLETION as long as the LSTK Contractor agrees to supply / rectify the same within the specified period. The decision of the OWNER is final in this regard.

### 4.3 COMMISSIONING AND GUARANTEE TEST

4.3.1 After issue of Mechanical completion certificates by Owner, LSTK CONTRACTOR & OWNER shall mutually decide the date of commissioning of the equipment. From the date of commissioning, the equipment shall be gradually brought up to full load or any other load at the discretion of OWNER, and thereafter the equipment shall be run for a minimum period of 5 days. OWNER shall have the right to reduce this period where deemed necessary because of OWNER's difficulties. During this period of 5 days of operation or the reduced period, the system shall run at an average of 90% of rated capacity. If the LSTK CONTRACTOR is not able to bring the load to 90% of the rated capacity as mentioned above within 2 (two) months, OWNER shall, without prejudice to any of his rights under the contract, has the right to take over the equipment and to proceed with modifications / rectifications / additions as he considers necessary at LSTK CONTRACTOR's cost and risk to achieve this sustained load run.

### 5.0 PREPARE EQUIPMENT FOR OPERATION

5.1 Immediately prior to turnover, LSTK CONTRACTOR will make all the equipment ready for operation. This includes, but is not limited to such activities as:



5.1.1 Removal of preservatives and rust preventatives.

5.1.2 Installation of seals or removal of steel covers.

5.1.3 Removal of moisture absorbing materials.

5.1.4 Draining of oil reservoirs and the flushing and filling of the initial charge.

5.1.5 If required by OWNER for the final inspection the opening and closing of man ways of vessels and tanks.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 54 of 135		

- 5.1.6 Assisting equipment manufacturer's representatives by final checkout of equipment.
- 5.1.7 Remove all temporary supports, bracing, or other foreign objects that were installed in vessels rotating equipment or other equipment to prevent damage during shipping, storage, transport and erection.
- 5.1.8 Conduct all flushing, blowing and chemical cleaning required by the specifications.
- 5.1.9 Check and run in all rotating equipment, i.e. compressors, pumps.
- 6.0 Scaffolding Sufficient amount of scaffolding required for good performance of the WORK shall be supplied by LSTK CONTRACTOR.



## 7.0 DRAWINGS AND DOCUMENTS

- 7.1 LSTK CONTRACTOR will carry out all construction and any required procurement activities directly from the AFC construction drawings and specifications and forming part of the CONTRACT. No additional design work or development e.g. completion of drawings will be required from LSTK CONTRACTOR.**

However, the plan type drawings called out to be supplied by LSTK CONTRACTOR in previous subsections of this section are included in LSTK CONTRACTOR'S scope of WORK.

- 7.2 All of LSTK CONTRACTOR'S drawings, calculations, documents, test reports, and test certificates are to be submitted to OWNER for approval in 6-fold. After receiving approval LSTK CONTRACTOR to submit for final approval all of the above and one (1) soft copy in CF format. LSTK CONTRACTOR drawings receiving "Approved as Noted" stamp may be worked on provided all notes are incorporated. It is understood that OWNER'S approval shall not receive in no way LSTK CONTRACTOR from any of his obligations and further more shall not relieve LSTK CONTRACTOR from his obligations to timely complete the WORK according to approved project schedule by OWNER.
- 7.3 LSTK CONTRACTOR'S drawings shall be clearly marked with titles, equipment numbers or other item identification.
- 7.4 Approval of drawings and calculations by OWNER in no way absolves LSTK CONTRACTOR from its responsibility for the accuracy or for the design, construction and timely performance of the WORK.
- 7.5 LSTK CONTRACTOR shall promptly submit reports of each and every. test or inspection.
- 7.6 LSTK CONTRACTOR shall submit quality records of the materials, as specified in previous sections and the applicable engineering specifications.
- 7.7 LSTK CONTRACTOR shall furnish an equipment installation record indicating date of installation and tag number of each piece of equipment.
- 7.8 LSTK CONTRACTOR shall furnish an equipment maintenance record indicating date and type or maintenance of each piece of equipment during the LSTK CONTRACTOR period.



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 55 of 135		

7.9 LSTK CONTRACTOR shall fill out checklists as required by OWNER.

## 8.0 LIFTING, LIFTING EQUIPMENT AND GEAR

8.1 Rigging and hoisting shall be executed in accordance with construction specification local and governmental requirements and safety manuals, as well as specific equipment manufacturer's instructions. If there are conflicts. the more stringent shall prevail.

8.2 LSTK CONTRACTOR shall only perform the lifts and movements in accordance with approved LSTK CONTRACTOR submitted rigging studies and plans.

8.3 Preferably, equipment will be lifted in accordance with manufacturer's instructions, if include, using lifting trunnions, lifting lugs if provided, or by slings attached to or around the equipment, with adequate protective measures to prevent damage to equipment. No temporary lifting lugs shall be used without the written approval of OWNER.

8.4 No nozzles or other appurtenances not intended for lifting shall be used for attachment of slings.

8.5 Equipment shall be handled with sufficient care to prevent damage. Slings shall have adequate protection to prevent marring the surface of equipment. Where necessary, sling spreaders shall be used to prevent crushing or other damage to the equipment.

## 8.6 Testing And Certification

All LSTK CONTRACTOR furnished cranes, lifting appliances and lifting gear must be properly tested, examined and /or inspected before being used on site and at the intervals specified in the applicable regulations. Copies of the relevant certificates must always be available on site for inspection on request by OWNER or proper authorities.

## 8.7 Operation

8.7.1 LSTK CONTRACTOR shall not permit a lifting appliance to be operated otherwise than by a person trained and competent to do so.

8.7.2 LSTK CONTRACTOR shall take express steps to ensure that all personnel employed by LSTK CONTRACTOR are competent and experienced for their assigned tasks.



## 9.0 WELDING

Welding of or on equipment shall only be permitted with the approval or OWNER.

## 10.0 EQUIPMENT PAINTING & INSULATION TOUCH

Rotating and special equipment to be erected by LSTK CONTRACTOR will be delivered to SITE finished painted. LSTK CONTRACTOR is responsible to apply remedial / touch up painting for any damages to paint, or protective coatings on equipment handled by it in connection. With any aspect of this operations such as unloading. transport, handling and erection as per Annexure mention in ITB Section.



	<b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 56 of 135		

## ANNEXURE- 7 - 2E

### ELECTRICAL WORK

#### 1.0 **SCOPE : ELECTRICAL WORK COVERS**

- 1.1 Installation and erection of the following equipment (items) consists of the preparation for installation, connection, testing and pre-commissioning etc. as per specifications and as per drawings.
- 1.2 Provision of all tools, equipment and consumables used in the course of the work.
- 1.3 The installation of the following systems (items) shall consist of the connection, testing and pre-commissioning etc., so that the systems are ready for use as per specifications and as per drawings.
- 1.4 Transport, store and protect supplied materials to the construction location.

#### 2.0 **ELECTRICAL ITEMS**

- 2.1 Generators / Motors
- 2.2 Control panels
- 2.3 Transformer

**Note :** Installation of all accessories, tanks, levelling and fixing in place are also considered.

#### 2.4 **Switch Gears**

**Note :** Bolting together sections where supplied separately and installation of panels, levelling and fixing in place are also considered.

#### 2.5 **Bus Ducting**



**Note :** Jointing and securing the associated switch boards / transformers are also considered.

- 2.6 Battery charger, battery sets and UPS unit.

- 2.7 Cables in trench / conduit / tray / Rack.

**Note :** Following items are also necessary .

- a) Measuring and cutting of cable and protection of cut ends.



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 57 of 135		

- b) Identification of cables
- c) Fixing of cable to tray / rack

- 2.8 Cable Glands
- 2.9 Cable terminations
- 2.10 Earthing cable in trench / conduit / tape on tray / Rack
- 2.11 Earth cable tape terminations
- 2.12 Lightening protection
- 2.13 Lighting/ fittings / supports
- 2.14 Earth Rod PRT and cover
- 2.15 Cable tiles
- 2.16 Trench marker posts
- 2.17 Air craft warning
- 2.18 Underground electrical grounding system

**Note :** All bellow items are also considered :

- a) Pulling of grounding cable in trenches, through culverts, protection sleeves and cable ducts as per grounding cable supplier installation instruction, project specifications and layout and detail drawings.
- b) Coil up and clearly designate the final destination of the cable ends, especially if cables have to be continued their routing underground or overhead via cable tray or otherwise to their final destination at a later date.
- c) Install, including the provision of the required tools, the required through branch and end connections.
- d) Installation of all grounding electrodes including inspection pits as per specification and the layout and detail drawings.
- e) Return of the cable drums to the storage area including a clear make up of cable lengthleft on the reels of drums that are not empty.
- f) Measure cable resistance for grounding continuity and grounding resistance of ground rods, record data and submit the rest result reports to OWNER prior to commissioning of the installation.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 58 of 135		

- g) Check cables are in proper trenches and ground rods at their location.
- h) Perform all test; witnessed by OWNER'S REPRESENTATIVES of the founding installation including the provision of all OWNER approved testing equipment and measuring devices.

2.19 Miscellaneous Electrical equipment

2.20 Earth resistance testing including earth resistance rods for grounding, continuity of grounding, installation resistance testing for electrical cables and HL-POT testing for electrical cables.

2.21 Elevator

2.22 LSTK CONTRACTOR shall install the fire alarm including sensors, cabling, local panels, mimic panels and host system. In accordance with:

- Project engineering specification and codes and standards.
- Cabling between panel and detectors, alarms, switches etc. as described above.
- Installation of all junction / terminal boxes, cable terminations and connections, supporting brackets for cabling as described above.

### 3.0 TESTING AND COMMISSIONING



Testing and commissioning consist of the complete testing prior to commissioning, including provision of required testing apparatus and testing documents as requested and as specified in the testing specifications.

- All test results shall be recorded on the test form and submitted to OWNER. Each test record shall include. date of test, ambient temperature, climatic conditions, instruments used with serial numbers, names of test personnel and witnesses, identifications of equipment, ground electrode or circuit tested.
- Testing shall be scheduled at least 24 hours in advance and OWNER is to be notified by LSTK CONTRACTOR. LSTK CONTRACTOR will notify all necessary interested parties including manufacturer's representatives.



High potential tests shall not be repeated without authorization by OWNER.

### 4.0 DRAWINGS AND DOCUMENTS

4.1 LSTK CONTRACTOR will carry out all construction and any required erection activities directly from the AFC construction drawings and specifications.

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 59 of 135		

- 4.2 LSTK CONTRACTOR shall promptly submit reports of each and every test or inspection.
- 4.3 For more details LSTK CONTRACTOR shall follow **Electrical design philosophy elsewhere mentioned in ITB.**

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 60 of 135		

## ANNEXURE- 7 – 2F

### INSTRUMENTATION WORK



#### 1.0 GENERAL

- 1.1 Instrumentation symbols and identification of functions shall be based on the current edition of ISA S5.1.
- 1.2 Specifications for instruments and items of control equipment are shown on data sheets to be issued as they become available.
- 1.3 All materials and connections for control valves, relief valves, level controllers and similar equipment shall comply with applicable requirements for valves and fittings as noted in the piping specification.
- 1.4 LSTK CONTRACTOR shall install all shim plates, fixing material such as but not limited to anchors, red heads, etc.
- 1.5 LSTK CONTRACTOR shall install all instrument equipment tag plates.

#### 2.0 FIELD INSTRUMENT INSPECTION AND CALIBRATION AND INSTALLATION

- 2.1.1 This item covers all activities and supply of all materials to import calibration of instruments. It includes, but is not limited to, the following:
  - 2.1.1 Provision of all tools, equipment and consumables used in the course of the work.
    - Calibration of instruments and provision of all necessary test equipment gauges, materials and ancillary items. All necessary testing instruments to be used must be certified by Govt. recognized testing laboratories.
    - Check orifice plates and control valves.
    - Protection of instruments to maintain cleanliness at all times.
    - Mark instrument to indicate status of calibration.
    - Return instruments, after calibration and checking to lay-down areas and / or stores including all packaging.
    - Pressure and leak test including the provision of all necessary test equipment gauges materials and ancillary items.

Note : The calibration of all instruments within the packages is also the responsibility of LSTK

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 61 of 135		

Contractor.

2.1.2 LSTK CONTRACTOR shall install all instruments as listed in the instrument index and further per the relevant installation specifications, documents and drawings.

2.1.3 Field instrument installation includes, but is not limited to:



Mounting of instruments and related equipment, supports protection boxes, manifolds, junction boxes, nameplates, etc.

Installation of measuring elements (probes, sensors, detectors, etc) including their auxiliaries as required (thermo wells, supports, valves, etc.) unless done by others

Installation of on-line instruments (by piping)

The following is a typical list of on-line instruments:

- Safety blow down valves.
- Control valves (all types)
- Motor - operated valves.
- Safety shut - down valves (including solenoid valves).
- Safety / relief valves.
- Pressure / vacuum relief valves.
- Self - regulating valves.
- Level gauges.
- Level displacer chambers.
- Orifice assemblies.
- Orifice plates.
- Venturies.
- Turbine meters, annubars, magnetic flow meter.
- Positive displacement meters.
- Variable area meters (rotameters)



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 62 of 135		

- Stilling Wells.
- Thermo wells and etc.
- Installation of process connections, impulse lines and capillaries.
- Installation of purge and flushing supply tubing, filter blocks and rotameters.
- Installation of air supply lines.
- Supply and installation of instrument nameplates for field instruments.

## 2.2 Cable, Supports and Fixing Wire pins, Conduit



LSTK CONTRACTOR shall use for cable installation for indoor and outdoor use the materials such as tubing, cable trays, etc. as called in the specifications.

- 2.2.1 Cable tray ladder rack and tubing systems shall be installed to ensure electrical continuity throughout the run and such that water cannot collect or remain in any part of the system. Cable tray shall be laid as per cable tray lay out drawing and as required to install cables. Required supporting shall be in LSTK CONTRACTOR. No cable or cable portion shall be laid without cable tray.
- 2.2.2 Pulling of the cables into the trenches, through culverts, protection sleeves and cable ducts as per cable supplier installation instructions and layout drawings, cable lists, trench sections and reel schedules.
- 2.2.3 Installation of the cable separation tiles, if specified.
- 2.2.4 Coil up and clearly designate the final destination of the cable ends, especially if cables have to be continued their routing underground or overhead via cable tray or otherwise to their final destination at a later date.
- 2.2.5 Installation of the sealing shrouds to avoid water ingress after cable cutting.
- 2.2.6 Installation of the cable markers stamped with cable number by LSTK CONTRACTOR as per cable list.
- 2.2.7 Installation of cable splicing if required.
- 2.2.8 Return of the cable drums to the storage area including clear markup of the cable length left on the reels of cable drums that are not empty.
- 2.2.9 Check if cables are spaced as specified.
- 2.2.10 Measure cable resistance and cable insulation, record data and submit the test result reports prior to commissioning of installation.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 63 of 135		

- 2.2.11 Check whether all cables are installed in the proper trenches/ cable trays.
- 2.2.12 Perform all tests, witnessed by OWNER of the underground cable installation including the provision of the OWNER'S approved testing equipment and measuring devices. However, it is recommended to use only overhead cable tray for instrumentation cable installation.
- 2.2.13 Record of actual installed cable lengths and location of cable splices.
- 2.2.14 where cables required to be installed through or across the edges of tray or other metal work the edge of the lips shall be smoothed painted and lined with a protective sleeving to avoid cable damage.
- 2.2.15 Supporting steelwork shall be fabricated and installed by LSTK CONTRACTOR. The material shall be primed in accordance with the painting specification by LSTK CONTRACTOR.
- 2.2.16 Storage and handling of cable before and during installation shall be carried out with due regard to manufacturer's recommendations. Cable drums shall be rotated only in the direction indicated by drum markings, and open ends of cables are to be effectively sealed immediately after cutting to prevent the ingress of moisture.
- 2.2.17 At all times, the utmost care shall be exercised to avoid damaging the protective sheathing to cable or of causing excessive bending or twisting which may result in damage to core insulation, sheaths armor and so on.
- 2.2.18 The bending radius of a cable either during or after installation shall not be less than manufacturer's recommended minimum.
- 2.2.19 Cables shall be run in continuous unbroken lengths and joints shall not be permitted.
- 2.2.20 Cables installed above ground shall be routed to avoid high-risk areas, e.g. high fire risk areas, and those areas where accidental leakage or spillage may occur and cause damage to cables and supports.
- 2.2.21 During installation, the ends of cables shall temporarily be protected using compound, tape, heat shrink seals or similar approved methods to avoid damage or entry or moisture until they are permanently terminated.
- 2.2.22 Pre-cast concrete members should not be drilled for any reason. Fixing shall always be by means of clamping brackets in the most efficient way and in consultation with OWNER.
- 2.2.23 Under no circumstances shall welding be carried out to any process plant equipment, vessels, pipelines, or structures or to any protected surface unless specifically indicated on the drawings and documentation and then in strict accordance with a procedure subject to Approval of OWNER.



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 64 of 135		

2.2.24 Fixings to the above shall normally be made where brackets and so on, have already been provided or when agreed by the use of purpose built clamps.

2.2.25 On trays horizontal cable runs shall be fastened with aluminum strip at every 1200 mm, vertical cable runs every 600 mm.

#### 2.2.26 **Grouping**

The cables employed to convey electricity shall be grouped according to the signal kinds. The main group kinds are but not limited to the followings

- a) Intrinsically safe signals.
- b) Signal cables not intrinsically safe.
- c) Instruments power supply cables.
- d) Coaxial cables or telephone cables used as serial data buses.
- e) Analog input/output signals, Digital input signals
- f) Digital output signals
- g) Inter-Panel cable between electrical MCC room and instrumentation system

2.2.27 All cable trays, ladders, tubing and supports and fixing material for indoor and outdoor use shall be installed by LSTK CONTRACTOR.

2.2.28 All cables shall always be installed and connected in such a way that no forces can act on terminals. Further, all instrument and power supply cables inside and outside buildings shall be installed in accordance with both cable lists and drawings by LSTK CONTRACTOR.

Carbon steel coated cable stub ups shall be installed by LSTK CONTRACTOR for all cables from sand trenches to 500 mm above ground, in accordance with electrical connection detail drawings.



#### 2.2.29 **Conduit system**

Single pair cables shall be used to connect field mounted instruments to local junction boxes. Single cables shall be armoured type laid laid open cable trays, However any unarmoured type cable shall be laid in galvanized carbon steel / aluminium pipes with open ends or on closed cable trays. In order not to damage the cable, a plastic annular cap shall cover the pipe end.

Multipair cables shall be used to connect above said local junction boxes to the control room. Multipair cables shall be armoured type and shall run over head in closed cable trays / ladders supported on the pipe racks.

#### 2.2.30 **Wire Pins**

All stranded cable conductors shall be fitted with crimped taper pins (bootless type), amp (or equivalent) and all screens with lugs. Installation of all amp wire pins and screen lugs by LSTK CONTRACTOR.

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		Document No.	Rev	
		Sheet 65 of 135		

Further, in general, all standby conductors shall be wired to terminals.

#### 2.2.31 **Cable Marking**

All instrument cables, conductors and the instrument screen/earth wires shall be tagged on both sides in accordance with the instrument connection list for local and central control room signals by LSTK CONTRACTOR.

2.2.31a Cross ferruling shall be used for wire termination at each end.

#### 2.2.32 **Cable Entry Sealing**

##### - **General**

After installation of all cables and on direction of OWNER, LSTK CONTRACTOR shall seal off all cable entries and passages.

##### - **Outside walls**

All cable entries in outside walls and below grade level shall be watertight sealed. Method of sealing shall be supplied by LSTK CONTRACTOR.

##### - **Separation walls**

All cable entries in separation walls of buildings shall be sealed with a fire resistant sealing as described hereafter.

##### - **Control Room Floors**

All cable and cabinet entries in floors shall be sealed with polyurethane foam.

##### - **Fire - resistant sealing**

All fire resistant sealing shall be class H-30.



Small openings in walls shall be sealed with CSD -F (or equal) in luminescent foam.

Large openings in walls and between computer floor and cable basement shall be sealed by inserting CSD-F (or equal) in luminescent plates under between and above the cables. The remaining openings shall be sealed with CSD-F (or equal) in luminescent foam.

#### 2.3 **Alarm Systems**

DELETED

#### 2.4 **Analyzers Installation**

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 66 of 135		

LSTK CONTRACTOR shall install all analyzers and sampling conditioning systems in the analyzer house (analyzer house shall be air conditioner and shall be design and constructed by LSTK Contractor) as well as in the field consisting of, but not limited to:

- Installation of all vents and drains from analyzers.
- Installation of calibration gas bottles as well as regulators and connecting tubing, as required.
- Installation of required tubing and cabling in cable tray from analyzer house to tapping point.
- Cable installation between Analyzer panel to DCS/ESD/other control system panel for hardwire signal communication.

### 3.0 LOCAL PANELS

LSTK CONTRACTOR shall install local panels, consisting of, but not limited to:



- a) Mounting, aligning and fixing to the foundation or steelwork. Uncoil, install and terminate underground cable ends. Install and terminate all aboveground cable to / from panels.
- b) Install and connect air supply and air signal piping and tubing to 'from panels.
- c) Install cabling and connect alarm horns.
- d) Identification / tagging of all equipment, terminals, cables and tubing which is not installed by panel vendor. Tag plates to be installed by LSTK CONTRACTOR.
- e) Installation of brackets / supports for cable, etc. and installation material as required to complete the installation.
- f) Cable installation between Local panel to DCS/ESD/other control system panel for hardwire signal communication.

### 4.0 TERMINATION OF CONTROL CABLES FROM THE LV SWITCH ROOM

The control cables running from the switch room shall be installed and connected in the marshaling cabinet by LSTK CONTRACTOR.

### 5.0 CONTROL BUILDING INSTRUMENT INSTALLATION

- 5.1 LSTK CONTRACTOR shall install all control building instrumentation in accordance with the relevant installation specifications and drawings.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 67 of 135		

## 6.0 CABINETS AND CONSOLES

6.1.1 LSTK CONTRACTOR shall install align and anchor all equipment cabinets and consoles in accordance with design drawings and seller's installation instructions.

6.1.2 The false floor shall be completely installed by LSTK CONTRACTOR.

All panels, cabinets, tables, boxes, computers etc. located on the instrument equipment layout shall be place and installed by LSTK CONTRACTOR.

6.1.3 Where cable passage is required according to installation drawings, LSTK CONTRACTOR to indicate locations of holes and passages.

6.1.4 FCS/ESD/PLC cabinets and data base unit:

These groups / cabinets shall be installed in place and bolted together by LSTK CONTRACTOR.

Internal wiring / cabling and / or connections between these groups of cabinets shall be done by LSTK CONTRACTOR in accordance with the instructions of the system vendor's representative.

### 6.1.5 FCS Consoles

The consoles shall be installed in place and bolted together by LSTK CONTRACTOR, including installation of special table with peripherals.

Internal wiring and cabling and/or connections between consoles shall be done by LSTK CONTRACTOR in accordance with the instructions of the system vendor's representative who will be present during these operations.

6.1.6 Communication racks with the same work description as specified elsewhere in Tender documents.

6.1.7 Main processor cabinets (data base units) with the same work description as as specified elsewhere in Tender documents.



### 6.1.8 Marshaling Cabinets

Cabinets shall be installed in place and bolted together by LSTK CONTRACTOR.

Cross wiring between these assembled sections shall be done by LSTK CONTRACTOR.

6.1.9 DELETED

6.2 Handling and installation. Termination and Connection of Cabling

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 68 of 135		

Cables entering instrument room are installed under false floor and laid in cable tray. These cable shall be handled, cut to length, stripped and after installation of the cabinets be terminated and connected by LSTK CONTRACTOR.

LSTK CONTRACTOR shall leave slack in the cables and provide markings.

### 6.3 Installation of System Cables

LSTK CONTRACTOR shall install, plug in and support all system cables. Cable supporting rail in cabinets is installed by cabinet / console vendors, but in any case LSTK CONTRACTOR is responsible.

- System cable shall be installed by LSTK CONTRACTOR under false floor in auxiliary room. System cables are covered by instrument cable list.

### 6.4 Conduits Cable Tray / Trucking. Support Frames and Brackets

All cable trays, cable trucking, supports / brackets, etc. if required , shall be installed by LSTK CONTRACTOR. For cable tray installation see respective part.

### 6.5 Auxiliary Cable Installation and Termination.

LSTK CONTRACTOR shall install, terminate, support and connect all auxiliary cables.

Auxiliary cables are all cables covered by instrument cable list and instrument cable layout for control room.



LSTK CONTRACTOR shall open / remove and close parts of the false floor as required for cable installation.

### 6.6 Communication Cables

LSTK CONTRACTOR shall install and support communication cables. The connection of the cables in the consoles and cabinets shall be done by LSTK CONTRACTOR, under direct supervision of system vendor. LSTK CONTRACTOR shall open / remove and close parts of the false floor as required for cable installation. Communication cables are listed on instrument cable layout for control room and the system cable list.

### 6.7 Power Supply Cabling

LSTK CONTRACTOR shall install. terminate and connect all power supply cables between power distribution boards and cabinets, consoles, printers and other instrument equipment when listed on the power supply list

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 69 of 135		

## 6.8 Earthing System

LSTK CONTRACTOR shall install and connect the insulated earthing cabling / wiring from the earth buses to the cabinets, consoles and all other instrument equipment.

All cabinets and consoles shall be fitted with earthing bus bars and earthing connection bolts by the vendors and under supervision of LSTK CONTRACTOR.

LSTK CONTRACTOR shall install utility, shield and dedicated earth (clean earth) cabling and connections including tags at both ends.

LSTK CONTRACTOR shall check and test earthing system in accordance with relevant documents.

LSTK CONTRACTOR shall provide required nos. of earth pit. Earth pit shall be separate for electrical and instrument requirement.

## 7.0 LIFTING

7.1 Major instrument equipment shall be rigged from points designated or suitable to accept rigging. When available, LSTK CONTRACTOR shall utilize lugs on equipment.

7.2 When establishing hoisting loads, riggings plans and crane capacities, LSTK CONTRACTOR shall adhere to the requirements and instructions as defined in the specifications and as instructed by OWNER. Any equipment handling machine i.e Hydra, cranes etc. required at that time, same shall be provided by LSTK contractor.

## 8.0 TESTING AND PRECOMMISSIONING (FUNCTION TEST)

8.1 Testing and pre-commissioning consist of the complete testing and pre-commissioning prior to commissioning, including provision of required testing apparatus and testing documents, comprising, but not limited to:



8.1.1 Check for completion and conformance to specifications.

8.1.2 Check the accessibility of all instruments and components for field adjustments, routine maintenance and removal for overhaul, and relocate as necessary.

8.1.3 Perform pressure test on all air sub headers as required by the line specifications.



8.1.4 Clean all instrument air sub headers, transmission tubing and control tubing by blowing with dry, filtered air prior to connection of instrument components

8.1.5 Leak test pneumatic transmission and control tubing, using an approved method acceptable to OWNER

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 70 of 135		

- 8.1.6 Perform hydrostatic or, where appropriate, pneumatic pressure tests on all instrument process piping, as required by the respective line specifications. Drain and below free of water, as necessary after test.
- 8.1.7 Check continuity and identification of transmission and control systems for each instrument to ensure proper hookup. Perform megger and continuity tests for instrument electrical wiring. Check correct source of power, polarity and earthing (take into account intrinsically safe technology of this procedure).
- 8.1.8 Check the bore of the orifice plates and flow direction during and after installation.
- 8.1.9 Check (on/off valve and) control valves for direction of flow and proper operation, e.g. travel, action with air failure, etc.
- 8.1.10 Calibrate all instruments (including the instruments in the fire and gas system) and synchronize transmitter and receiver readings for each instrument loop. Check the orifice plates and flow nozzles. Set air pressure regulators.
- 8.1.11 Install pressure and temperature gauges after line flushing.
- 8.2 Check fuses, perform voltage checks and energize all electrically powered instruments, alarm and shutdown system, etc. Maintain power supply.
- 8.3 Set pneumatic and electronic type switches and local control by simulation of input signals.
- 8.4 Check thermocouples and resistance thermometer circuits from element to measuring instrument by simulation.
- 8.5 Check and adjust calibration of all other field and panel mounted instruments.
- 8.6 Complete loop functional test of all instruments, including the instruments in all package units and in the fire and gas system. Functionally test complete control loops alarm and shutdown systems and partial process sequence, etc., to verify capability to measure, operate and stroke final control elements in the direction and manner required by the process application. All test results shall be recorded and submitted to OWNER. Each test record shall include date of test, ambient temperature, climatic conditions, instruments used with serial numbers, names of test personnel and witnesses, identification of equipment, ground electrode or circuit tested.
- Testing shall be scheduled at least 24 hours in advance and OWNER is to be notified by LSTK CONTRACTOR. LSTK CONTRACTOR shall advise OWNER prior to testing, of make, type and accuracy of test equipment used for above-mentioned items. All required test certificates should be of a recent date not exceeding 6 months.
- 9.0 **PAINTING**  
Surface preparation and application of all required paint layers shall be executed in accordance with paint specifications and related standards.



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 71 of 135		

## 10.0 WELDING

LSTK CONTRACTOR shall perform welding in accordance with the normal accepted industrial standards.

## 11.0 MECHANICAL COMPLETION

LSTK CONTRACTOR shall advise OWNER in writing when erection is completed.

Mechanical completion date shall be the date when the activities have been accomplished by LSTK CONTRACTOR as dictated by the construction schedule, which shall be submitted by LSTK CONTRACTOR and approved by OWNER on due time.

## 12.0 QUALITY ASSURANCE, QUALITY CONTROL, INSPECTION, CALIBRATION TEST AND MATERIAL CERTIFICATES

12.1 LSTK CONTRACTOR shall perform quality control, inspect, calibrate required testing, pre-commissioning and supply certificates.

12.2 LSTK CONTRACTOR shall submit reports of each and every test or inspection within three (3) days after actual test or inspection is made.

12.3 Calibration and Testing.

12.3.1 Calibration and testing to be executed by LSTK CONTRACTOR in accordance with respective specifications.

Local instruments such as transmitters, converters, receivers and so on, will be preset by bench testing by LSTK CONTRACTOR in accordance with the specifications before installation on the process, so that no new settings will be necessary for loop acceptance tests.



12.3.2 LSTK CONTRACTOR shall inspect all materials up on receipt for damage and completeness. In case of damage incomplete material, LSTK CONTRACTOR shall modify/replace with new one and immediately inform OWNER.

12.3.3 LSTK CONTRACTOR shall carry out all tests included in this paragraph shall fill out the installation checklists and shall submit all required test certificates and documentation as required.

12.3.4 All tools and test gear necessary to carry out described tests shall be provided by LSTK CONTRACTOR.

12.3.5 Inspection and testing shall be phased with construction and installation in such a manner as to involve the minimum necessary concentration of effort and manpower and the minimum loss of time in reaching the pre-commissioning stage.



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 72 of 135		

- 12.3.6 All inspection and testing shall be witnessed and approved by OWNER / authorized representative.
- 12.3.7 LSTK CONTRACTOR shall be responsible for the complete loop continuity check of the field and control room installation, including the parts of the package units, which have been connected by others.
- 12.3.8 OWNER reserves the rights whenever distinguished package Plant(s)/Unit(s) vendor's representative to be present at site LSTK CONTRACTOR shall be responsible to arrange this WORK.
- 12.3.9 LSTK CONTRACTOR shall be responsible for the loop continuity checks from the marshaling cabinets or direct connected cabinet cables in the control room (termination point of underground multi core cable). The loop continuity checks shall be performed on a complete loop, including all parts of the loop as indicated on the instrument loop diagrams (ILD'S).
- 12.3.10 The communication equipment between field and control room building and/ or other buildings shall be the responsibility of LSTK CONTRACTOR.
- 12.3.11 Only complete loops shall be accepted, signed by OWNER after all calibration / function checks have been demonstrated successfully completed and recorded.
- 12.3.12 For all package units and systems supplied by LSTK CONTRACTOR, installed or partly installed and connected by LSTK CONTRACTOR.

LSTK CONTRACTOR shall perform a normal wiring and loop check of signals and supplies to and from these systems.



The following systems apply:

- Analyzer system
- Bentley Nevada system
- Flow metering system
- Fire, smoke and gas detection system
- Tank gauging
- FCS / ESD / PIC system, etc.
- Machine monitoring system
- Public address system (PA system)

For more details LSTK CONTRACTOR shall follow **Instrument design philosophy elsewhere mentioned in ITB.**

### 13.0 **Miscellaneous**

LSTK CONTRACTOR shall remove all waste and debris from the SITE.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 73 of 135		

## **ANNEXURE- 7 - 2G**

### **INSULATION WORK**

#### **1.0 GENERAL**



#### **1.1 SCOPE**

This standard covers the requirement for supply and application of materials for thermal insulation of equipment, piping and other items.

#### **1.2 REFERENCE STANDARDS**

The design shall be in accordance with established codes, sound engineering practices and shall conform to the statutory regulations applicable to the country. The main codes, standards and statutory regulations considered as minimum requirements are as follows:- (Latest revision of these shall be followed)

IS 14164	Code of Practice for Industrial Application and finishing of thermal insulation material at temperature -80 <sup>0</sup> C and up to 750 <sup>0</sup> C.
IS 737	Wrought aluminum and aluminum alloys, sheet, strip
IS 1254	Specification for corrugated aluminum sheet
IS 1322	Bitumen felts for waterproofing and damp proofing
IS 3069	Glossary of terms, symbols and units relating to thermal insulation materials.
IS 8183	Specifications for bonded mineral wool.
IS 9743	Thermal insulation finishing cements
IS 12436	Specification for Preformed Rigid Poly-urethane (PUF) and Poly-isocyanurate (PIR) Foams for Thermal Insulation
IS 13205	Code of practice for the application of polyurethane insulation by the in-situ pouring method.
ASTM C921	Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
ASTM C1029	Specification for Spray-Applied Rigid Cellular Polyurethane Thermal Insulation
ASTM C1696-16	Standard Guide for Industrial Thermal Insulation Systems
ASTM C411	Standard Test Method for Hot-Surface Performance of High - Temperature Thermal Insulation

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 74 of 135		

ASTM C450	Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging
ASTM C871	Test Methods for Chemical Analysis of Thermal Insulation Materials for Leachable Chloride, Fluoride, Silicate, and Sodium Ions
ASTM C1338	Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.
ASTM C1055	Guide for Heated System Surface Conditions that Produce Contact Burn Injuries
ASTM C1139	Specification for Fibrous Glass Thermal Insulation and Sound Absorbing Blanket and Board
ASTM D1622	Test Method for Apparent Density of Rigid Cellular Plastics
ASTM C680	Standard Practice for Heat Loss or Gain and Surface Temp.

1.3

#### Deviations:

Should unforeseen difficulties arise to comply with requirements of this standard.

Alternative material and application techniques superior to the requirements of this standard be submitted with complete details for approval of owner.

In case of any conflict / deviations amongst various documents, the order of precedence shall be as follows:

1. Statutory regulations.
2. Job specifications.
3. Engineering design basis.
4. Standard specification.

1.4

#### LIMITATIONS

##### Temperature Limits.

This standard deals with insulation applied externally on piping equipments etc. as per the table below:-

Maximum Operating Temperature	Type of Insulation
60 <sup>0</sup> C to 750 <sup>0</sup> C for C.S., A.S. & S.S.	HOT
- 180 <sup>0</sup> C to 20 <sup>0</sup> C	COLD



1.5

#### THICKNESS DESIGN BASIS

Thickness calculation method as per procedure given in ASTM C-680

##### 1. Hot Insulation

Design Ambient Temperature : 35<sup>0</sup>C

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 75 of 135		

Design Surface Temperature	: 45°C
Permissible Heat Loss	: 100 kcal./m <sup>2</sup> hr.
Permissible Wind Velocity Outside	: 1 m/sec
Permissible Wind Velocity Inside	: 0.25 m/sec

## 2. Cold Insulation

Design Ambient Temperature	: 35°C
Design Surface Temperature	: 2 °C below ambient/ 0.5 Deg C above the Dew Point
Permissible Heat Gain	: 10-12 kcal/m <sup>2</sup> hr
Relative Humidity	: 85%
Permissible Wind Velocity Outside	: 1 m/sec.
Permissible Wind Velocity Inside	: 0.25 m/sec.

## 1.6 GENERAL REQUIREMENTS

### 1.6.1 Information to be supplied

- Material of construction / dimension of equipments / pipes required to be insulated.
- Temperature
- Location of equipment (Indoor/Outdoor/Elevn.)
- Requirement of removable box type insulation if any
- Special requirements if any regarding type of insulation material and other properties.
- These information shall be supplied in form of insulation schedule.
- Design calculations, drawings and insulation material schedule.
- Material Test certificate's.
- Insulation works execution schedule.
- Detailed procedure for all types of execution works.
- Bill of Quantities, Initial material take-off, final material take off and material requisition.
- QA/QC plan.

### 1.6.2 STORAGE OF MATERIAL



Insulation material shall at no time be stacked directly on the ground; instead it will be stored at a level higher than ground level. It should not only be covered by tarpaulin but other effective protections against weather are also to be provided. The contractor shall provide a properly covered storage to the satisfaction of engineer-in-charge (Refer IS: 10556).

### 1.6.3 HYDROSTATIC TEST FOR PIPES

Before taking up insulation job on piping or vessels it shall be ensured that hydrostatic test of the concerned equipment / piping is completed. Where it is felt necessary to take up the insulation job before such testing are performed all welded and mechanical joints shall be left un-insulated for a length of at least 150mm on either side of the joint.

### 1.6.4 PROTECTION OF INCOMPLETE JOBS

Any part of insulation job which is not provided with final weather proofing will be adequately protected by means of tarpaulins and other aids. After the day's work similar protection should be provided for the partially completed jobs to be continued the next day to avoid any absorption of rain / moisture during the night.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 76 of 135		

## 2.0 INSULATION SUPPORTS (CLEATS) TO BE PROVIDED BY EQUIPMENT SUPPLIER

Suitable supports (cleats) in the form of rings, lugs, studs or pins shall be provided on equipment by equipment supplier, however should any additional supports or anchorage be felt necessary for insulation works, the same shall be also considered in LTSK's scope, including all allied work necessary for the same. These will be installed by the contractor free of any extra cost. Owner shall be informed about the same in advance, so also design/drawings shall be updated accordingly.

## 3.0 MATERIAL REQUIREMENTS

### 3.1 INSULATION MATERIALS

#### 3.1.1 General

Whenever reference to any Standard is made it is presumed that the latest revision as on date should be considered unless otherwise specified.

#### 3.1.2 Specification and other requirements

Specification and other requirements will be as per below mentioned table:-



#### Hot Insulation:

For operating temperature Upto 400 deg.C,	Rockwool Mattress of density 120 kg/m3 conforming to IS:8183.
For operating temperature 401-450 deg.C,	Rockwool Mattress of density 150 kg/m3 conforming to IS:8183.
For operating temperature 451-500 deg.C,	1 <sup>st</sup> layer insulation shall be 25mm Ceramic Fibre Blanket of density 128 kg/m3 conforming to IS :15402 and balance layers with Rockwool Mattress of density 150 kg/m3 conforming to IS:8183.
For operating temperature 501-550 deg.C	1 <sup>st</sup> layer insulation shall be 50mm Ceramic Fibre Blanket of density 128 kg/m3 conforming to IS :15402 and balance layers with Rockwool Mattress of density 150 kg/m3 conforming to IS:8183.
For operating temperature 551-600 deg.C,	1 <sup>st</sup> layer insulation shall be 75mm Ceramic Fibre Blanket of density 128 kg/m3 conforming to IS :15402 and balance layers with Rockwool Mattress of density 150 kg/m3 conforming to IS:8183.

Bands/Wires for securing insulation shall be of ASTM 8209 Alloy 3003 H16 or 18-737 designation 31000 (old NS3) condition H3 or 18/8 Stainless steel.

For securing cladding on insulation on piping, aluminium band 12mm (min) X 24 SWG thick shall be used. For securing cladding on insulation on equipment, aluminium band 20mm wide X 24 SWG shall be used.

Other insulating materials may be used provided they have the same or better properties and durability aspects.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 77 of 135		

Insulation thickness of insulating materials shall be based on design calculation of thermal conductivity, insulation class, etc. Same shall be submitted to the Owner with necessary design calculations, drawings, test certificates and durability parameters.

### For Valves, Turbines & Compressors Insulation



Prefabricated factory made Ceramic Fibre pad to be used made out of Ceramic Fibre Blanket of density 128 kg/m<sup>3</sup> encased in high temperature resistant cloth. The minimum thickness of the pad shall be –

- |    |           |    |           |        |
|----|-----------|----|-----------|--------|
| 1. | 0 Deg.C   | to | 300 Deg.C | = 25mm |
| 2. | 301 Deg.C | to | 400 Deg.C | = 50mm |
| 3. | 401 Deg.C | to | 500 Deg.C | = 75mm |

Removable insulation for flanges and valves, like tailor made jackets or pre formed insulation boxes, shall be suitable for quick removal and reinstallation. All tailor made jackets shall fit the actual valve/flange/equipment and secure adequate overlap to incoming insulated pipes.

Technical data sheet of the Ceramic Fibre Pad is as below:

A.	Purpose/Application This Engineering specification is for Fabric jacketed supercera ceramic Fibre insulated flexible reusable covers/pad for application on pipes: pipe fittings, valves, flanges etc vessels & equipments, tubes etc in hot services.				
01	Dimension (mm)	As per drawing/sketch provided by OEM.			
02	Thickness (mm)	25-100			
1. Specification of Protective jacketed material					
i	Vest Cover	Liner Fibre Glass Fabric			
ii	External Top Cover Fabric (for cold face)	Polymer Coated Fibre Glass fabric Temp. resistance 300 Deg. C, oil & water resistant			
iii	External Bottom Cover fabric (for hot face)	High silica cloth for Temp Resistance up to 900 Deg C			
2.	Specification of insulation Material	Ceramic Fibre Blanket (As per IS 15402)			
i	Classification Temperature	1260 degree Celsius			
ii	Thickness	25 – 100mm			
iii	Bulk Density	128kg/m3			
iv	Shot content on 70 mesh (%)	<30			
v	Tensile strength (KPa)	>40			
vi	Mean Fibre Dia (Micron)	2-4			
vii	Linear Shrinkage (%) At 1200 Deg. C for 24 Hrs	3.5			
viii	Thermal Conductivity (W/mK) Max.	1000C	2000C	3000C	5000C
		0.046	0.072	0.078	0.150
ix	Chemical composition	SiO2%		49-58	
		Al2O3%		41-48	
		ZrO2%		0-7	
		FeO3%		<0.1	

	<b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 78 of 135		

3	Hardware & Non Metal fastening	
i)	Buckle/Draw Stings	Stainless steel (min SS 316), High Temp Braided Chord of fibre glass
ii)	Stic Pins	Stainless Steel (min SS 316), Pins to prevent the insulation from movement inside the cover
iii)	Stitching	Double sewn with Teflon coated Fibre glass wrapped stainless thread. The sewing thread shall not resolve or decompose in typical chemical plant environment.
iv)	Belting	High Temp Fabric same as used in hot face cover
4	Other Properties	
i	Fire Resistance (As per BS 476 Part-4)	Non-Combustible
ii	Chemical Stability/Resistance of Corrosion/water	Good
iv	Shock Resistance	Excellent

Rockwool Insulation shall be of water Repellent Grade and tested as per BS: 2972 for Water Absorption. Maximum water absorption is 0.5 kg/m<sup>2</sup> in 48 hours duration.

Precautions must be implemented in the design and fabrication of the insulation jackets to avoid the insulation material from sagging causing reduction of the insulation properties of the jackets.

#### Cold Insulation:

Insulation material and specifications for cold insulation for operating temperatures up to (-) 180°C and dual temperature (cold/hot) service where, upper temperature limit is 125°C shall be as given below for all sizes of piping/equipment:

##### - Polyurethane Foam

Preformed pipe section's and radial lags (for higher diameter pipe) of polyurethane foam of self-extinguishing type shall be in accordance with ASTM C591 TYPE-II Grade 2. The physical requirement of bulk density, chloride content, thermal conductivity and PH value of the material shall be as follows:



Temp. Limit Bulk density:	Upto (-)180°C & 120°C (max) 35.0 to 39.9kg/m <sup>3</sup>
Chloride content :	20 ppm (max)
Thermal conductivity :	0.221 mw/cm°C at mean temp. 10 deg C
PH Value :	Neutral.
Closed cell content :	95% (min)

High density polyurethane foam block of bulk density more than 300 Kg/m<sup>3</sup> shall be used for supports.

##### - Polyurethane Foam Cast-in-Situ

Cast-in-Situ Polyurethane Foam of density 42±2 kg/m<sup>3</sup> conforming to IS: 13205 shall be used. High density polyurethane foam block of bulk density more than 300 Kg/m<sup>3</sup> shall be used for supports.



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 79 of 135		

Temp. Limit : Up to (-) 45°C and 120°C (max.)

**- Polyisocynaurate**

Temp. Limit : Up to (-) 180°C and 125°C (max.)

Other insulating materials may be used provided they have the same or better properties and durability aspects.

Insulation material specification/ thickness/application mentioned in this document are the minimum requirements. Insulation specification/ thickness/ application shall be based on design calculation of thermal conductivity, insulation class, relevant IS/ ASTM codes etc. Same shall be submitted to the Owner with necessary design calculations, drawings, test certificates and durability parameters. LSTK shall submit detailed material specifications, durability parameters assured, test certificates and application procedure to OWNER/ PMC approval.

### 3.2 AUXILIARY MATERIALS FOR CLADDING

**a) Aluminium Cladding**

**- Horizontal Vessels**

Aluminium sheet as per IS-737 (designation 31000, condition H3 for flat sheet & 31500/51300, H4 for corrugated sheets)) shall be used for cladding. Insulation on overall piping, vessel and equipment, cladding will be coated on the side in contact with insulation with 3 mil thick polysurlyn film.

Specifications for aluminium Cladding material shall be as follows:



Material	Reference Code / Standard	Thickness	Application
Aluminium sheet with applied moisture barrier of 3 mil thick Polysurlyn coating	IS : 737 / ASTM C-653	22 SWG (0.71mm)	For all piping, tanks, vessels, heat exchanger, flanges, valves, equipments etc. upto 24" outside dia
		20 SWG (0.91mm)	For piping, tanks, vessels, heat exchanger, flanges, valves etc. above 24" outside dia
Removable cover for flanges, valves etc. shall be made out of minimum 18 SWG thickness Aluminium Sheets.			

**- Vertical Vessels**

Cladding material for vessels with insulation O.D. 900 mm and less shall be same as for pipes. For vessels above 900 mm insulation O.D. 22 SWG corrugated aluminium sheet as per IS-1254 or ribbed aluminium sheet 32 mm x 5 mm deep corrugations may be used.

Aluminium Foil to protect stainless surfaces in Temperature below 0 deg c shall be 0.1 mm (42 SWG) thick per ASTM 8209 alloy 3003 H16 or IS-737 designation



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 80 of 135		

31000 (OldNS3) condition H3. For securing aluminium foil on stainless steel surface 24 SWG thick x 20mm wide aluminium bands shall be used.

- b) **Screws**  
Screws used with aluminium sheeting shall be of self tapping type, A No.8x12mm long cadmium plated / SS of high quality at intervals of 150mm.
- c) **S-Clips.**  
Aluminium, 20x1.5mm or 25mm wide stainless steel banding bent to form a shape of "S" provide a minimum lap of 50mm.
- d) **Bands for securing cladding.**  
Aluminium of dimensions 12mm width x 0.56 mm thick (24 SWG) for pipes. Stainless Steel bands Type 304, 0.4mm thick x 13mm wide for large dia pipes (above 24") and cylindrical equipment up to outside dia 900mm, 0.5mm thick x 19mm wide for cylindrical equipment above 900mm outside dia meter.
- e) **Quick release clips for removable covers.**  
Suitable quick release clips will be made as shown in fig. 7 from 20Cm width x 20 SWG aluminium sheet and some fig.7 from 20mm width x 20 SWG aluminium sheet and some suitable rectangular ring.
- f) Sealant for cladding joints with Foster 95-44 /TIKI F9544.
- g) The vapour barrier mastic shall be Foster 60-38/39 /TIKI M6038/39
- h) Adhesive for cold insulation shall be Foster 81-33 /TIKI P8133
- i) Vapour Stops at pipe support location shall be Foster 90-66 /TIKI F9066
- j) **Rivets:** Aluminium 'POP' blind eye type / Stainless Steel 9.5mm long x 5mm dia meter.
- k) Filler material shall be PUF dust or mineral wool mixed with specified adhesive shall be placed lightly so as to fill irregular voids and sealant shall be Foster Foam Seal Sealer 30-45. Glass cloth to be used for vapour barrier reinforcement shall be open weave 10 mesh having glass fibre thickness of 5 mils.



Galvanised steel sheets/ Annealed galvanised steel sheets/ Galvanised colour coated sheet are strictly **PROHIBITED** for use in cladding works. Other cladding materials (except G.I.) may be used provided they have the same or better properties and durability aspects, after prior approval from Owner/PMC.

Cladding material / auxiliary material specification/ thickness/ application mentioned in this document are the minimum requirements. Cladding material/ auxiliary material specification/ thickness/ application shall be based on design calculation of thermal conductivity, insulation class, corrosion aspects, durability, relevant IS/ ASTM codes, etc. Same shall be submitted to the Owner with necessary design calculations, drawings, test certificates and durability parameters.

LSTK shall submit material specifications, durability parameters assured, test certificates and application procedure to OWNER/PMC approval.

#### 4.0 **INSPECTION.**

##### 4.1 **General**

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 81 of 135		

All insulation material shall be subject to inspection by owner before application. In case of doubt, Owner's representative will have the liberty to get the material tested by the contractor at any approved test laboratory. Any material not meeting specified requirement will be rejected and the rejected material shall have to be replaced by the contractor with material of specified type and quality. Insulation found to be improperly installed shall be removed and reinstalled properly by the contractor.

Contractor shall maintain detailed log of various insulation works and same shall be updated on daily basis. QA/QC checks of work done and materials shall be also registered in the daily logs. Owner will have the liberty to check the logs.

#### 4.2 Inspection

Inspection of materials and / or installation by owner shall not relieve the contractor of his responsibility to ensure that finished insulation conform to specified requirements and is free from defects, contractor shall correct any defects due to poor workmanship. Contractor shall maintain test certificates and other relevant data from manufacturer.

#### 4.3 Test for thickness

Test for thickness shall be carried out after application. Thickness at any point shall not be less than 2mm than the indicated designed thickness and excess thickness up to 115% of the designed thickness is permissible. .

#### 4.4 Testing for bulk density

Testing of bulk density of the insulating materials shall be carried out before the application of insulation. This should be within  $\pm 15\%$  of the specified value. Test location shall be selected by owner and its repair shall be done by contractor.

### 5.0 APPLICATION

#### 5.1 General

Insulation thickness shall be as per design calculations as specified in the drawings/ insulation schedule/ specification/isometric drawings prepared for equipments/piping.

Contractor shall submit detailed calculations and procedure for different insulation works based on relevant IS / ASTM codes.

#### 5.2 No. of Layers

When insulation thickness exceeds 75 mm, the insulation shall be applied in multi-layers with all joints staggered. Each layer will be separately secured with metallic bands/wires.



No. of layers shall be as follows:

##### Insulation Thickness

Up to 75mm  
76 to 150 mm  
151 and above

##### No. of Layers (Min.)

1 Layer  
2 Layers  
3 Layers or more.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 82 of 135		

### 5.3 GENERAL REQUIREMENTS

#### 5.3.1 Surface preparation

- Surface to be insulated shall be cleaned of all dirt. Oil loose scale etc. by wire brushing. Insulation works shall commence only after necessary clearance from QA/QC for painting works as per painting specification. All insulation shall be applied at ambient temperature and both the metal surface and insulation material shall be dry prior to application of insulation.
- The surface for cold insulation shall be then coated with a bitumen emulsion or a mastic coating.
- If the vessel is made of stainless steel, it shall be wire-brushed. with stainless steel wire brush.

#### 5.3.2 Expansion / contraction joint

Depending on the type of insulation used the operating temperatures and nature of the material it may be necessary to provide expansion/contraction joints on vessels or pipes to prevent the insulation from rupturing/buckling when the surface expands/contracts. Joints are to be designed as per relevant IS / ASTM codes.

#### 5.3.3 Filling of Voids

All voids, irregularities and joints shall be packed with loose insulation material/insulation cement trowelled smooth whichever is applicable.

### 6.0 MEASUREMENT OF INSULATION WORK.

6.1 Measurement of insulation works shall be as per IS: 14164.

### 7.0 GUARANTEE

- There shall be a surface temperature recording as mentioned in the Design Parameter to be performed with the help of Thermography Camera, post the line/ equipment is charged in operating conditions. The same shall be in LSTK's scope and LSTK shall give a detailed report of the same.

-The guarantee test shall be carried out when plant is fully operative.



-The surface temperature, reading shall be taken at six points per pipe line and at each point it shall be taken on all four sides in top, bottom, left side and right side.

-The above reading shall be taken at 2 hours intervals and shall be taken for 18 hours starting from 11 a.m. in the morning.

- Simultaneously ambient temperature shall be taken as per IS: 14164

- A graph shall be plotted between ambient and surface temperature reading



- From this graph the surface temperature against ambient temperature shall be found out

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 83 of 135		

- The ambient and surface temperature shall be measured by the instrument provided by the contractor. The instrument shall be calibrated to the satisfaction of owner/consultant.
- The contractor is required to guarantee the surface temperature of 60°C (max.) for equipments and piping in case of Hot Insulation. For cold insulation of equipments and piping, the difference between skin temperature and ambient temperature shall not exceed 2 °C.
- Ambient temperature and surface temperature shall be measured by duly calibrated instruments provided by CONTRACTOR.
- The CONTRACTOR shall undertake immediate replacement of insulation material damaged in transit, storage or application, at no additional cost to Owner.
- LSTK shall produce required number of copies of test certificates as per relevant IS/ASTM Standard. LSTK shall certify/ensure that Test to be done are from NABL approved laboratory, approved by Owner.
- All materials are new and unused and are as per specifications called for in this standard.
- The operating thermal conductivity shall be as specified
- The workmanship shall be in accordance with good practice.
- **Other terms & conditions of the guarantee clause shall be as per NIT / purchase order / Commercial documents of ITB.**

#### **Insulation Contractor List**

M/s Lloyd Insulations (India) Limited, New Delhi
M/s Poiner Insulation ,Ghaziabad
M/s Insulrifef, Mumbai
M/s Polybond Insulation Pvt Ltd, Chhattisgarh (India)
M/s Minwool Rockfibers Ltd, Hyderabad
M/s Murugappa Morgan Thermal Ceramics Ltd, Chennai
M/s Associate Insulation Co.
M/s HIL, Hyderabad

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 84 of 135		

## ANNEXURE- 7 - 2H

### PAINTING SPECIFICATION (TS-2001)

#### 1.0 GENERAL

#### 1.1 Scope

This specification covers the technical requirements for shop and site application of paint and protective coatings and includes; the surface preparation, priming, application, testing and quality assurance for protective coatings of mechanical equipment, structural steelwork, plate work, tankage, guards, pipe work, handrails and associated metal surfaces, which will be exposed to atmospheric for the Project.

#### 1.2 Definitions

C.S	-	Carbon steel and low chrome (1- <sup>1</sup> / <sub>4</sub> Cr through 9 Cr) alloys
S.S	-	Stainless steel, such as 304, 316, 321, 347,
Non-ferrous	-	copper, aluminium and their alloys.
High Alloy	-	Monel, Inconel, Incoloy, Alloy 20, Hastelloy, etc.
DFT	-	Dry Film thickness, the thickness of the dried or cured paint or coating film.

#### 1.3 Safety Regulations

Protective coatings and their application shall comply with all national, state, and local codes and regulations on surface preparation, coating application, storage, handling, safety, and environmental recommendations.

Sand or other materials producing silica dust shall NOT be used for any open-air blasting operations.



#### 1.4 Material Safety Data Sheets

The latest issue of the coating manufacturer's product datasheet, application instructions, and Material safety data Sheets shall be available prior to starting the work and shall be complied with during all preparation and painting / coating operations.

#### 1.5 Materials

All paints and paint materials shall be obtained from the company's approved manufacturer's list. All materials shall be supplied in the manufacturer's containers, durably and legibly marked as follows.

- Specification number
- Colour reference number
- Method of application
- Batch number
- Date of Manufacture
- Shelf life expiry date
- Manufacturer's name or recognised trade mark.

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 85 of 135		

## 2.0 CODE AND STANDARDS:

Without prejudice to the provision of Clause 1.1 above and the detailed specifications of the contract, the following codes & standards shall be followed. Wherever reference to any code is made, it shall correspond to the latest edition of the code.

### 2.1 Indian Standards:

IS-5: 1994	Colors for ready mixed paints and enamels.
IS-2379: 1990	Color codes for identification of pipe lines.
IS-2629: 1985	Recommended practice for hot-dip galvanizing on iron and steel.
IS-2633: 1986	Methods for testing uniformity of coating of zinc-coated articles.
IS-8629: 1977	Code of practice for protection of iron and steel structures from atmospheric corrosion.
IS:110	Specification for Ready Mixed Paint, Brushing, Grey Filler, for Enamels, for Over Primers
IS:101	Methods of test for ready mixed paints & enamels.

### 2.2 Other Standards:

#### 2.2.1 Swedish Standard: SIS-05 5900-1967 / ISO-8501-1-1988



(Surface preparations standards for Painting Steel Surface).

This standard contains photographs of the various standards on four different degrees of rusted steel and as such is preferable for inspection purpose by the Engineer-in-charge.

#### 2.2.1 DIN: 53151 Standards for Adhesion test.

### 2.3 The paint manufacturer's, instructions shall be followed as far as practicable at all times. Particular attention shall be paid to the following:

- Instructions for storage to avoid exposure as well as extremes of temperature.
- Surface preparation prior to painting.
- Mixing and thinning.
- Application of paints and the recommended limit on time intervals between coats.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 86 of 135		

### 3.0 SURFACE PREPARATION

#### 3.1 Metal Surface Preparation

##### 3.1.1 Safety

All work in adjacent areas, which may negatively affect the quality of blast cleaning, and/or impose safety hazards, must be completed or stopped before the blasting operation starts.

##### 3.1.2 Pre-cleaning

Prior to surface preparation all weld spatter shall be removed from the surface, all sharp edges ground down and all surfaces cleaned free of contaminants including chalked paint, dust, grease, oil, chemicals and salt. All shop primed surfaces shall be water washed by means of suitable solvent, by steam cleaning, with an alkaline cleaning agent if necessary or by high-pressure water, to remove contaminants prior to top-coating

##### 3.1.3 Surface Decontamination

Surface decontamination shall be performed prior to paint application when uncoated surface is exposed to a corrosive environment or existing paint work is to be repaired.

Existing coatings shall be removed by abrasive blast cleaning, and then high pressure potable water shall be used to clean steel surfaces.

Prior to application of coatings, the surface shall be chemically checked for the presence of contaminants. A surface contamination analysis test kit shall be used to measure the levels of chlorides, iron salts and pH in accordance with the kit manufacturer's recommendations.

Swabs taken from the steel surface, using cotton wool test swabs soaked in distilled water shall not be less than one swab for every 25m<sup>2</sup> of surface area to be painted.

Maximum allowable contaminant levels and pH range is as follows:

Sodium chloride, less than 50 microgram / cm<sup>2</sup>;



Soluble iron salts, less than 7 microgram / cm<sup>2</sup>; and

If the results of the contamination test fall outside the acceptable limits, then the wash water process shall be repeated over the entire surface to be painted, until the contaminant test is within the specified levels.

##### 3.1.4 Abrasive Blasting

All C.S. materials shall be abrasive blast cleaned in accordance with Codes (Ref. Clause 2.0). To reduce the possibility of contaminating S.S., blasting is not usually specified. However, for coatings which require a blast-cleaned surface for proper adhesion, S.S. may be blast cleaned using clean aluminium oxide or garnet abrasives (Free from any chloride or Iron / Steel contamination). When hand or power tool cleaning is required on S.S., only S.S. wire-brushes (including 410 S.S.) which have not been previously used on C.S. surfaces may be used.



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 87 of 135		

The surface profile of steel surfaces after blasting shall be of preparation grade Sa 2-1/2 of Swedish Standards SIS-05-5900 (Latest Revision) or better according to ISO 8501-1 and shall be measured using the replica tape method or the comparator method.

The roughness (profile) of blast-cleaned surfaces shall be Medium (G) according to ISO 8503-2: 1988 (appendix 1) unless otherwise specified. Medium defines a surface profile with a maximum peak-to-valley height of 60-100 microns, and G indicates that the surface profile is obtained by grit blasting. For the evaluation of surface roughness Comparator G shall be used.

Abrasive blast cleaning shall NOT be performed when the ambient or the substrate temperatures are less than 3° C above the dew point temperature. The relative humidity should preferably be below 50% during cold weather and shall never be higher than 60% in any case.

Abrasive blast cleaning shall be performed with a clean, sharp grade of abrasive. Grain size shall be suitable for producing the specified roughness. Abrasives shall be free from oil, grease, moisture and salts, and shall contain no more than 50ppm chloride. The use of silica sand, copper slag and other potentially silica containing materials shall not be allowed

The blasting compressor shall be capable of maintaining a minimum air pressure of 7 kPa at the nozzle to obtain the acceptable surface cleanliness and profile.

The blast cleaning air compressor shall be equipped with adequately sized and properly maintained oil and water separators. The air supply shall be checked to ensure no oil and water contamination at the beginning of each work shift.

Blast cleaning abrasive shall be stored in a clean, dry environment at all times. Recycling of used abrasive is prohibited.

After blast cleaning, the surfaces shall be cleaned by washing with clean water (Pressure 7kg/Cm<sup>2</sup> using suitable nozzles. During washing broom corn brushes shall be used to remove foreign matter.

Assessment of the blast cleaned surfaces shall be carried out in accordance with reference code.

Blast cleaned surfaces which show evidence of rust bloom or that have been left uncoated overnight shall be re-cleaned to the specified degree of cleanliness prior to coating.

All grit and dust shall be removed after blasting and before coating application. Removal shall be by a combination of blowing clean with compressed air, followed by a thorough vacuum cleaning with an industrial grade, heavy duty vacuum cleaner.



All cleaned surfaces shall have protection from atmospheric corrosion as per IS8629:1977

### 3.1.5 Alternate Methods of Surface Preparation

When open air blasting is not permitted on site, or when space limitations or surface configurations preclude blasting, the alternate cleaning methods listed below may be used with prior approval. Alternate cleaning methods shall consider the degree of surface cleanliness and roughness profile required by the specified coating system.

- Vacuum or suction head abrasive blast-cleaning,
- Wet jet abrasive blast-cleaning,



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 88 of 135		

- Compressed-air wet abrasive blast cleaning,
- Pressurized liquid blast-cleaning,
- Power tool cleaning,
- Hand or power tool cleaning,

Hand and/or power tool cleaning shall only be used for spot repair where abrasive blasting is not permitted or is impractical, and on items which could be damaged by abrasive blasting. Power tool cleaning shall not be carried out with tools which polish the surface, e.g. power wire brushes.

The surfaces of equipments and prefabricated piping etc. which are received at site Primerised or with finish paints, depending upon their conditions, shall be touched up and painted at site. For these surfaces sand blasting is not envisaged and these surfaces shall be prepared using power brushes, buffing or scraping, so as to achieve a surface finish to St-3 as per SIS-05-5900 . After wash-up the area to be touched up shall be jointly marked, measured and recorded for payment purposes. The type of system & nos. of coat (primer and/or finish paint) to be applied after touch up, which shall be decided by OWNER/CONSULTANT in writing before taking up the job.

When paint is to be applied on damaged painted surfaces of equipments all loose and flaking paint work should be removed to a firm feathered edge. Rusted spots should be cleaned by one of the methods specified in the clauses 4.4.1 & 4.4.2 above. In case the previous paint work is not compatible to the specified one the entire coating must be removed.

It shall be ensured that sand blasted surface/machine cleaned surface is not contaminated with oil and grease. Water shall also not be allowed to come in contact with sand blasted surface.

## 4.0 APPLICATION

### 4.1 General

The final specification of paint systems to be used to suit the exposure conditions of equipment and steelwork, shall be as specified on the scope of work, equipment data sheets or the drawings.

All coatings shall be in accordance with Indian / International Standards, the coating manufacturer's product data sheets and application instructions and the requirements contained in this specification.



#### 4.1.1 General Requirements for Shop Application

All work areas which facilitates shop paint application shall be surface prepared for painting and have the paint system applied before installation.

Equipments assembled at site shall only receive primer coat in the shop and finish coatings will be applied at site.

In all cases, where surfaces will be inaccessible after shop assembly, they shall be prepared and have the paint system applied before assembly is carried out. Drying times between successive coats shall be at least those recommended by the manufacturer.

All known field weld areas shall be given the specified abrasive blast surface preparation but left uncoated for a distance of 50mm from the weld line. Such areas shall be given the appropriate touch-up treatment after installation.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 89 of 135		

The manufacturer's directions for preparation and application of coatings shall be followed to ensure that the durability of the coating system is not impaired.

The Contractor shall submit the full details of the proposed surface preparation and paint systems prior to the commencement of any surface preparation.

#### 4.1.2 General Requirements for Site Application

Paint shall be stored only in accordance with the manufacturer's instructions.

All materials used for the specific system being applied shall be products supplied by one manufacturer and details of such product shall be submitted for approval before commencement of work.

The contents of cans shall be thoroughly stirred before being poured into paint pots and shall be thinned only in the specified proportions in accordance with the manufacturer's instructions.

Finish coats may be applied by spraying except where any over spray is likely to affect finished surfaces or where spraying constitutes a health hazard to workmen in the other areas. Brush and roller application will require multiple coats to achieve the specified dry film thickness.

Brush application may be used only with the approval of the company.

Roller application shall only be used on relatively large surface areas ( i.e. > 50m<sup>2</sup>) and only if spraying is not an option.

The Contractor shall complete the application of any one type of paint or each coat thereof, before beginning the next coat on that section.

In cases nominated as critical, the application of each coat shall be approved before application of the next coat can proceed, in accordance with 'hold' points nominated in the Inspection and Test Plans (ITPs)



All fittings within any given area are to be painted with the same system as the area unless otherwise specified.

Where 2 coat of finish paint are indicated they shall be applied in two different shades to ensure that two coat are applied.

Paint shall not be applied in rain, snow, fog or mist or when the relative humidity is such as to cause condensation on metal surface.

The CONTRACTOR must ensure the availability of a specialist from the paint manufacturer, at SITE during pendency of CONTRACT within his quoted rates to ensure the quality of painting & procedure. Addition of drying agents, pigments or other substances is not allowed unless specifically prescribed or approved by paint manufacturer's specialist.

Name plates/tags attached to the equipments/machineries shall not be painted or removed during painting job. Failing to comply with above, the CONTRACTOR may be required to replace name plates/tags at his cost.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 90 of 135		

#### 4.1.3 Qualifications and Materials

All surface preparation, coatings application and inspection, shall be carried out by personnel experienced in that particular field. Contractors shall submit the names of subcontractors to be employed for the specific work together with the brand names of coating materials for approval prior to commencement of application.

#### 4.1.4 Handling and Transport

All pipe work, steelwork and equipment that have been finish coated shall be handled with care to preserve the coating in the best practical condition.

Painted materials shall not be handled until the coating has completely cured and dried hard. Supports in contact with coated steel during transport and storage shall be covered with a soft material to prevent damage to the coating. Appropriate materials shall be used during transportation between coated steelwork and holding down chains to prevent damage to the coating.

### 4.2 Application of Coatings

#### 4.2.1 General

The application method and type of equipment to be used shall be suitable for the paint specified and the surface being painted.

Paints and thinners shall be brought to the point of usage in unopened original containers bearing the manufacturer's brand name and colour designation and ready-mixed unless otherwise specified. Two-pack systems shall be mixed at the site of application to the paint manufacturer's recommendations. The mixed amount prepared shall be no more than the amount that can be applied during the stated pot life.

Paint shall be applied so that an even film of uniform thickness, tint and consistency covers the entire surface and is free of pin holes, runs, sags or excessive brush marks. Film finish shall be equal to that of first class brushwork.

Unless it is practical to do so colour shades for primer, intermediate coat and finish coat must be different to identify each coat without any ambiguity.



Paint ingredients shall be kept properly mixed during paint application.

Equipment shall be kept clean to ensure dirt, dried paint and other foreign materials are not deposited in the paint film. Any cleaning solvents left in the equipment shall be completely removed before painting.

To ensure the required film thickness is achieved on angles, welds, sharp external edges, nuts and bolts, a coat shall be applied to such items/locations immediately prior to the application of each coating to the whole area.

Care shall be taken to ensure paint application into all joints and crevices.

The contact surfaces between steelwork to be fastened by means of friction grip bolting shall be abrasive blast cleaned and prime coated only, prior to erection.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 91 of 135		

#### 4.2.2 Atmospheric conditions

Surface preparation and coating shall not be carried out in inclement weather and shall be carried out such that the surface being coated is free of moisture, wind-borne or blast cleaning dust.

Coatings shall not be applied if:

- The relative humidity exceeds 85%.
- The ambient temperature is less than 5<sup>0</sup>C (depending on local condition)
- The metal temperature is less than 3<sup>0</sup>C above the dew point.
- There is likely hood of an unfavourable change in weather conditions within two hours after painting.

As a general rule, sufficient ventilation, dehumidification and heating capacity to cope with local climatic conditions must be secured before any coating – related work is started.

In any case, humidity, ambient and surface temperature conditions at the time of paint application, and curing and drying time before application of the next coat, shall be in accordance with the paint manufacturer's recommendations. These conditions shall be recorded in the Inspection Test Record (ITR) by the Contractor and be available for review.

#### 4.2.3 Conventional or Airless Spray

Spray equipment shall be equipped with accurate pressure regulators and gauges. Spray gun nozzles and needles shall be those recommended by the paint manufacturer.

Air from the spray gun shall be clean and dry with no traces of oil or moisture.

Coatings shall be wet on contacting the painted surface. Areas of dry spray shall be removed and the correct system re-applied.

#### 4.2.4 Brush Application

The method of "laying-off" shall be suited to the paint specified and shall ensure minimum brush marking.



#### 4.2.5 Roller Application

A uniform method of application shall be adopted when painting large areas. The rolling direction shall minimise paint joint build up. Edges and areas subject to possible roller damage shall be brush-painted prior to rolling.

#### 4.2.6 Thickness of Coatings

The maximum thickness DFT in any one application shall not exceed that specified in Technical specifications/ recommended by the paint manufacturer.

Wet film thickness gauges shall be used to make frequent checks on the applied wet film. The Contractor shall maintain at the site of painting operations, a dry film thickness tester of an approved type with a valid current calibration.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 92 of 135		

Coating thickness checks in accordance with reference code shall be performed, and the Contractor shall undertake remedial action if the measured thickness is less than specified.

Build up of each material to required thickness shall be made prior to the application of the subsequent coat; final film build shall be the minimum specified.

#### 4.2.7 Multiple Coat Applications (Except Wet-On-Wet)

Before successive paint coats are applied, intermediate coats shall be inspected for surface contamination. The presence of any grease or oil, shall be removed by a suitable solvent, and any salt and dirt adhering to the surface shall be removed by scrubbing with a solution of non-toxic detergent (except those prescribed by the manufacturer as "wet-on-wet"). Removal of contaminants shall only be performed after an intermediate coat has had sufficient time to cure.

The surface shall then be pressure hosed or dusted down by brush to disturb and remove deposits not apparent on visual inspection.

Coatings shall be applied only under the following conditions:

- The surface has been cleaned and is dry;
- The manufacturer's stated minimum time for re-coat has elapsed;
- The manufacturer's stated maximum time for re-coat has not elapsed. If the maximum time has elapsed then pre-treatment shall be in accordance with the paint manufacturer's recommendations; and  
Damaged areas in preceding coat have been made good in accordance with this Specification.

When multiple coat of finish paint are indicated, they shall be applied in different shades to ensure that multiple coats have been applied.

#### 4.2.8 Protective Coatings for Fasteners

Black and galvanised erection bolts/nuts and galvanised holding down bolts/nuts shall be prepared and painted in accordance with Section 4.4 of this Specification.

Black high tensile bolts/nuts shall be painted after erection to the same paint system specification as the surrounding structural steel.



### 4.3 Hot Dip Galvanising

All galvanising shall be carried out by the hot dipping process and conform to the requirements of IS-2629:1985 and uniformity of coating shall conform to IS 2633:1986.

All welding slag shall be removed by chipping, wire brushing, flame cleaning or abrasive blast cleaning where necessary prior to galvanising

For temporary identification, either water-soluble marking paints or detachable metal labels shall be used. For permanent identification, figures/labels shall be heavily punched or embossed by the fabricator.

For galvanised items after pickling, the work shall be inspected and any defects that render the work unsuitable for galvanising shall be repaired. After such repairs, the work shall again be cleaned by pickling.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 93 of 135		

The coating mass of zinc shall be as specified on equipment data sheets and the Drawings. Galvanised coatings shall be tested by the methods described in referred code.

After galvanising all material shall be cooled to air temperature in such a manner that no embrittlement occurs.

Galvanised coatings shall be smooth, uniform, adherent and free from stains, surface imperfections and inclusions.

All gratings and fixtures including nuts, bolts and washers that are required to be galvanised, shall be hot dipped galvanised and all nut threads shall be re-tapped after galvanising and a lubricant applied on Cold working of galvanised steelwork shall be avoided.

#### 4.4 Damaged or Inaccessible Surfaces

##### 4.4.1 Damaged Paint Surface

Repair of damaged painted surfaces, as well as painting of galvanised and black bolts, and galvanised holding down bolts after erection shall comply with this Clause. The treatment shall be:

- Pre-clean the damaged or unpainted areas in accordance with Section 4.2.1 of this Specification;
  - Disc or hand sand to clean bright metal;
- Inorganic zinc primers subject to mechanical damage or weld etc shall be power tool cleaned
- Feather backs by sandpapering or whip blasting the original coatings surrounding the damaged area over a 50mm distance. A rough surface shall be obtained on epoxy coatings;
  - Clean surface to remove all dust;
- Conduct surface contaminant test in accordance with Section 4.2.2 of this document; and
 

Build up a new paint system over the affected area with paints equal to those originally used and having the same dry film thickness for each coat. As an exception, damaged inorganic zinc primers shall be repaired with epoxy organic zinc rich paint and shall be applied within four hours of blast cleaning.

The new coatings shall overlap the original coating over the 50mm prepared distance and shall be colour matched to the specified colour of the original coating.

##### 4.4.2 Damaged Galvanised Surfaces

Damaged areas caused by oxy-cutting, welding or physical impact shall be treated as follows:



- Prepare the surface by removing any weld slag followed by vigorous power wire brushing of the coating surrounding the damaged area over a 50mm distance;
  - Clean surface to remove all dust; and
- Apply two coats of organic zinc-rich primer to a minimum DFT of 100 microns.

The area to be reinstated shall be colour matched to the surrounding finish colour with 40 microns of aluminium paint to the manufacturer's **written instructions**.

##### 4.4.3 Inaccessible Surfaces

Surfaces that will be inaccessible after erection of other elements of the structure, shall be fully painted prior to the installation of the obstructing item.



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 94 of 135		

#### 4.5 Surfaces Not To Be Coated

The following surfaces shall not be blasted or coated unless specifically directed:

Machined surfaces, bearings, seals, grease fittings, adjusting screws and name plates, and identification tags.

- Valve stems;
  - Raised faces on pipe and equipment flanges;
  - Electrical cabling;
  - Instrumentation, gauges and sight glasses;
  - Titanium, stainless steel and non-metallic surfaces; and
- Field weld margins, 50mm either side of weld, on tankage and piping, prior welding.

The rear face of piping flanges shall be shop prime coated only. Flange holes for fasteners shall be fully coated.

#### 4.6 Wash-Up

All surface of equipments/prefabricated piping etc. Primerised / painted at Vendor shop and received at site if required shall be washed up as follow:

- a) Washing with clean water (Pressure 7 Kg/cm<sup>2</sup>) using suitable nozzles. During washing, broomcorn brushes shall be used to remove foreign matter.
- b) Solvent washing, if required, to remove traces of wash up as per above procedure of all surfaces of equipment, piping, structure etc. completely painted at contractor's shop shall be included in the quoted rates of oil, grease etc. Wash up as per above procedure of all surfaces of equipment, piping, structure etc. completely painted at contractor's shop shall be included in the quoted rates.

#### 4.7 Touch-Up Painting

Prior to the application of any coat, all damage to the previous coat(s) shall be touched-up. Damage to finished work shall be thoroughly cleaned and re-coated.



Surface preparation shall be done as per clause no. 3.0.....

Items supplied with the manufacturer's standard coating system shall be touched-up with the same generic coating system or recoated.

#### 4.8 Paint Storage

The following must be ensured:

- a) All paints and painting material shall be stored only in such rooms assigned for the purpose. All necessary precaution shall be taken to prevent fire. The Storage building

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 95 of 135		

shall preferably be separate from adjacent buildings. A sign-board bearing the Words "PAINT STORAGE- NO NAKED LIGHT" shall be clearly displayed outside. The building shall be properly ventilated and shall be adequately protected with fire fighting equipment.

- b) Storage shall be far away from heated surface open flames, sparks & well protected from sun rays.
- c) Ambient temperature at which paints are stored shall be intimated to paint manufacturer & their advice sought regarding precautions to be taken if any, regarding flammability, explosiveness & toxicity.
- d) Maximum allowed storage time for various paint materials shall be clearly indicated on individual containers. Materials which have passed expiry date shall not be used.
- e) Paints in non-original containers and/or in containers without seals, shall not be used.

## 5.0 COATING SYSTEM SELECTION



### Coating Systems for Structures Piping and Equipment

The following Table 1 shall be used as a general guide for the selection of a paint system suitable for a particular plant area application. Paint systems specified on equipment data sheets and the Drawings shall take precedence over the general paint system area applications listed in Table 1.



**TABLE - 1**

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks	
01	Structural Steel work with operating temp. Up to 90 <sup>o</sup> C (Steel structures, Piping support, uninsulated CS piping, flanges, valves, stairways, walkways etc. except grating).	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1  F1 : One coat of two packs. Polyamide Cured Epoxy.  F5 : One coat of two pack aliphatic acrylic polyurethane	P2 : 60 microns  F1 : 120 – 200 microns  F5 : 60 microns	Total dry film thickness of paint system: 240 microns as per C4 – High durability	Total dry film thickness of paint system: 320 microns as per C5 – High durability
02	Uninsulated CS piping, flanges, valves with operating temp. From Above 90 <sup>o</sup> C to 200 <sup>o</sup> C.	Blast cleaning to near white metal grade Sa-2½, of Swedish Standards SIS-05-5900 (Latest)	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1  F3 : Two coats of single pack special Oleo resinous based heat resistant ready mixed Aluminium Paint.	P1 : 75 microns  F3 : 2 x 25 microns for each coat Total - 125 microns.	Total dry film thickness of paint system: 125 microns.	





	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>		PNCN/ PC288/E/001/PART-II-SEC - 7.0  Document No.  Sheet 96 of 135	P  Rev 	



Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks	
03	Uninsulated CS piping, flanges, valves with operating temp. Over 200° C.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1  F4 : Two coats of Heat Resisting Silicon Aluminium Paint.	P1 : 75 microns  F4 : 2 x 25 microns for each coat Total - 50 microns.	Total dry film thickness of paint system: 125 microns.	
04	Insulated CS piping flanges, valves with operating temp up to 90° C	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F8 : One coat of high temperature epoxy phenolic	F8 : 2 x 125 microns	Total dry film thickness of paint system: 250 microns.	
05	Insulated CS piping, flanges, valves with operating temp. From 90° C to 200° C.	Blast cleaning to near white metal grade Sa-2½, of Swedish Standards SIS-05-5900	F8 : Two coats of high temperature epoxy phenolic (novolac)	F8 : 2 x 125 microns	Total dry film thickness of paint system: 250 microns	
06	Insulated CS piping, flanges, valves with operating temp. Over 200° C.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F9 : Two coats of Inorganic Co-polymer based coating With an Inert Multipolymer Matrix.	F9 : 2 x 150 microns	Total dry film thickness of paint system: 300 microns.	
07	Uninsulated CS equipment with operating temp. Up to 90° C, to be treated at Manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1  F1 : One coat of two packs. Polyamide Cured Epoxy.  F5 : One coat of two pack aliphatic acrylic polyurethane	P2 : 60 microns  F1 : 120 – 200 microns  F5 : 60 microns	Total dry film thickness of paint system: 240 microns as per C4 – High Durability	Total dry film thickness of paint system: 320 microns as per C5 – High Durability
08	Uninsulated CS equipment with operating temp. From 91° C to 200° C, to be	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1	P1 : 75 microns  F3 : 2 x 25 microns	Total dry film thickness of paint system: 125 microns.	

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>		PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
			Document No.	Rev	
			Sheet 97 of 135		



Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks
	treated at Manufacturer's shop.	05-5900 (Latest).	F3 : Two coats of single pack special Oleouresinous based heat resistant ready mixed Aluminium Paint.	for each coat	
09	Uninsulated CS equipment with operating temp. Over 200°C, to be treated at Manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F4 : Two coats of Heat Resisting Silicon Aluminium Paint.	P1 : 75 microns  F4 : 2 x 25 microns for each coat Total - 50 microns.	Total dry film thickness of paint system: 125 microns.
10	Insulated CS equipment with operating temp. Up to 90°C, to be treated at Manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F8 : Two coats of high temperature epoxy phenolic (novolac)	F8 : 2 x 125 microns	Total dry film thickness of paint system: 250 microns
11	Insulated CS equipment with operating temp. From 91°C to 200°C, to be treated at Manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F8 : Two coats of high temperature epoxy phenolic (novolac)	F8 : 2 x 125 microns	Total dry film thickness of paint system: 250 microns
12	Insulated CS equipment with operating temp. Over 200°C, to be treated at Manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F9 : Two coats of Inorganic Co-polymer based coating With an Inert Multipolymer Matrix.	F9 : 2 x 150 microns	Total dry film thickness of paint system: 300 microns.
13	Surface of structural steel for furnaces, external surface of furnaces, external surface of flue duct,	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1  F3 : Two coats of	P1 : 75 microns  F3 : 2 x 25 microns for each coat	Total dry film thickness of paint system: 125 microns.

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>		PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
			Document No.	Rev	
			Sheet 98 of 135		



Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks	
	metal stacks and similar with operating temp. Up to 200°C. (With exclusion of stair ways, walk ways etc.).		single pack special Oleo resinous based heat resistant ready mixed Aluminium Paint.			
14	For external surfaces of flue ducts, metal stacks, and similar with operating temp. Above 200°C.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1  F4 : Two coats of Heat Resisting Silicon Aluminium Paint.	P1 : 75 microns  F4 : 2 x 25 microns for each coat Total - 50 microns.	Total dry film thickness of paint system: 125 microns.	
15	For surfaces of air cooler heads not galvanized with operating temperature up to 90° C, treated at manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1  F1 : One coat of two packs. Polyamide Cured Epoxy.  F5 : One coat of two pack aliphatic acrylic polyurethane	P2 : 60 microns  F1 : 120 – 200 microns  F5 : 60 microns	Total dry film thickness of paint system: 240 microns as per C4 – High Durability	Total dry film thickness of paint system: 320 microns as per C5 – High Durability
		NOTE: All surfaces shall be galvanized at manufacturer's shop with exception of the end header of air cooled heat exchangers that shall be treated as described above at Manufacturer's shop. In case the same surfaces shall not be treated at shop, they shall be treated at site according to environmental and operating conditions.				
16	For surfaces of air cooler heads not galvanized with operating temperature up to 91° C TO 200°C, treated at manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F3 : Two coats of single pack special Oleouresinous based heat resistant ready mixed Aluminium Paint.	P1 : 75 microns  F3 : 2 x 25 microns for each coat	Total dry film thickness of paint system: 125 microns.	

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>		PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
			Document No.	Rev	
			Sheet 99 of 135		

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks	
		NOTE: All surfaces shall be galvanized at manufacturer's shop with exception of the end header of air cooled heat exchangers that shall be treated as described above at Manufacturer's shop. In case the same surfaces shall not be treated at shop, they shall be treated at site according to environmental and operating conditions.				
18	STORAGE TANKS					
a)	Acid / Alkali CS Storage Tank (External Surface including all stair ways)	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1  F1 : One coat of two packs. Polyamide Cured Epoxy.  F5 : One coat of two pack aliphatic acrylic polyurethane	P2 : 60 microns  F1 : 120 – 200 microns  F5 : 60 microns	Total dry film thickness of paint system: 240 microns as per C4 – High Durability	Total dry film thickness of paint system: 320 microns as per C5 – High Durability
b)	CS Storage Tanks, Excluding indicated in Sl. No. (a)	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1  F1 : One coat of two pack Polyamide Cured Epoxy.  F5 : Two-pack aliphatic Isocyanate cured acrylic finish paint	P1 : 60 microns  F1 : 120 - 200 microns  F5 : 60 microns	Total dry film thickness of paint system: 240 microns as per C4 – High Durability	Total dry film thickness of paint system: 320 microns as per C5 – High Durability
19	Cold Insulated Carbon Steel and low alloy Steel (1-¼ Cr through 9 Cr) Piping and Equipment. (Upto 60 Deg. C)	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F7 : Two coats of Tar Free Epoxy paint suitably pigmented	F7 : 2 x 125 microns	Total dry film thickness of paint system: 250 microns.	
20	Cold Insulated high alloy Steel piping and Equipment (Upto 200 Deg. C)	Lightly Blast cleaned as per Sa 1.0 Swedish Standards SIS-05-5900	F8 : Two coats of high temperature epoxy phenolic (novolac)	F8 : 2 x 125 microns	Total dry film thickness of paint system:250 microns	



	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>		PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
			Document No.	Rev	
			Sheet 100 of 135		

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks	
		(Latest).				
21	DELETED					
22	Surface (CS) with Equipment with temp. Indicating paint from 220°C to 240°C treated at Manufacturer's shop	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F6 : Temperature indicating paint	P1 : 75 microns  F6 : 2 x 25 microns for each coat Total - 50 microns.	Total dry film thickness of paint system: 125 microns.	
23	PACKAGE:					
a)	Surface(CS) with operating temperature upto 90°C treated at Manufacturer's shop	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1  F1 : One coat of two packs. Polyamide Cured Epoxy.  F5 : One coat of two pack aliphatic acrylic polyurethane	P2 : 60 microns  F1 : 120 – 200 microns  F5 : 60 microns	Total dry film thickness of paint system: 240 microns as per C4 – High Durability	Total dry film thickness of paint system: 320 microns as per C5 – High Durability
b)	Surfaces (CS) with operating temperature upto 91 <sup>0</sup> C TO 200 <sup>0</sup> C, treated at manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F3 : Two coats of single pack special Oleouresinous based heat resistant ready mixed Aluminium Paint.	P1 : 75 microns  F3 : 2 x 25 microns for each coat	Total dry film thickness of paint system: 125 microns.	
c)	Surface (CS) with operating temp. Over 200°C, treated at manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F4 : Two coats of Heat Resisting Silicon Aluminium Paint.	P1 : 75 microns  F4 : 2 x 25 microns for each coat Total - 50 microns.	Total dry film thickness of paint system: 125 microns.	
d)	Package in	Blast cleaning	F7 : Two coats of Tar	F7 : 2 x	Total dry film	

	<b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
	Sheet 101 of 135			

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks
	Carbon Steel and low Alloy Steel (1- <sup>1</sup> / <sub>4</sub> Cr through 9 Cr) with cold insulated surface treated at manufacturer's shop (Upto 60 Deg. C)	to near white metal grade 2 <sup>1</sup> / <sub>2</sub> , of Swedish Standards SIS-05-5900 (Latest).	Free Epoxy paint suitably pigmented	125 microns	thickness of paint system: 250 microns.
e)	Package in Cold Insulated high alloy Steel. (Upto 200 Deg. C)	Lightly Blast cleaned as per Sa 1.0 Swedish Standards SIS-05-5900 (Latest).	F8 : Two coats of high temperature epoxy phenolic (novolac)	F8 : 2 x 125 microns	Total dry film thickness of paint system: 250 microns
f)	DELETED				
24	For internal surface of shell, roof of CS tanks, with operating temp. Upto 110°C	Blast cleaning to near white metal grade 2 <sup>1</sup> / <sub>2</sub> , of Swedish Standards SIS-05-5900 (Latest).	F2 : Two coats of two pack amine adduct cured Phenolic (Novolac) epoxy (immersion grade)	F2 : 2 x 150 microns for each coat	Total dry film thickness of paint system: 300 microns.
25	For underside (soil side) of the tank bottom (CS) below only of the fixed tanks, bottom & shell shall be treated as follows:	Blast cleaning to near white metal grade 2 <sup>1</sup> / <sub>2</sub> , of Swedish Standards SIS-05-5900 (Latest).	F7 : Two coats of Tar Free Epoxy paint suitably pigmented  OR  F8 : Two coats of high temperature epoxy phenolic (novolac)	F7 : 2 x 200 microns  OR  F8 : 2 x 150 microns	Total dry film thickness of paint system: 400 microns.  OR  Total dry film thickness of paint system: 300 microns.
26	CS Equipment and associated piping subject to cyclic, intermittent or regeneration operating condition (e.g. Molecular Sieve Driers) subjected to very severe corrosion with	Blast cleaning to near white metal grade 3, of Swedish Standards SIS-05-5900 (Latest).	Primer: One coat of Thermal spray Aluminium paint and sealed with a Silicon Aluminium seal Finish Coat: One coat of Thermal spray Aluminium paint and sealed with a Silicon Aluminium seal.	Primer: 125 microns  Finish: 125 microns	Total dry film thickness of paint system 250 microns.



	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 102 of 135		

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks
	wide operating temperature range.				

## NOTES:

### Primers

#### **ZINC ETHYL SILICATE PRIMER – P1**

The zinc ethyl silicate consists of two packs. One pack contains the ethyl silicate binder with suitable solvents. The other pack contains zinc dust (NOT Paste). Zinc dust shall be ASTM D 520 Type II. They have to be mixed in suitable proportions before application as recommended by manufacturer.



<b>Volume solids</b>	:	Min.64% ±2
<b>DFT Range</b>	:	50 – 75 microns
<b>Theoretical Spreading Rate</b>	:	12.8 – 8.53 sqm/litre
<b>Colour</b>	:	Grey
<b>Application</b>	:	Spray (airless/air)
<b>Drying time ( dry to handle )</b>	:	< 45 mins. @ 30 Deg. C and 65% RH
<b>Curing</b>	:	<16 hrs @ 30 Deg. C and 65% RH
<b>% of total metallic zinc in dry film (As per the ASTM D520 – Spherical size)</b>	:	<b>(SSPC SP 20 Level 1) &gt;85% by wt.</b>
<b>Specific Gravity</b>	:	<b>2.5 Kg/Litre min.</b>
<b>Storage life</b>	:	6 months under sealed conditions

Zinc silicate Material curing shall be checked using ASTM D 4752, minimum Acceptable value is 4.

#### **ZINC RICH EPOXY PRIMER – P2**

The zinc rich epoxy consists of two packs. One pack contains the epoxy binder with suitable solvents. The other pack contains zinc dust as per ASTM D520 Type II. They have to be mixed in suitable proportions before application as recommended by manufacturer.

<b>Volume solids</b>	:	65% min. ±2
<b>DFT</b>	:	50 – 100 microns
<b>Theoretical Spreading Rate</b>	:	13 – 6.5 sqm/litre
<b>Colour</b>	:	Grey
<b>Application</b>	:	Airless spray/air spray/brush
<b>Drying time ( dry to handle )</b>	:	<10 min. @ 30 Deg C
<b>Hared Dry</b>	:	< 1.5 hrs @ 30 Deg C
<b>% of total metallic zinc in dry film (As per the ASTM D520 – Spherical size)</b>	:	<b>(SSPC SP 20 Level 2) 81% by wt. min.</b>
<b>Specific Gravity</b>	:	<b>2.3 Kg/Litre min.</b>
<b>Storage life</b>	:	12 months under sealed conditions

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 103 of 135		

## Finish Paints

### HIGH BUILD EPOXY FINISH – F1

This finish paint is fast drying, high build, Two-pack polyamide cured epoxy resin

<b>Volume solids</b>	:	85% min. ±2
<b>DFT Range</b>	:	100 – 200 microns
<b>Theoretical Spreading Rate</b>	:	7.6 – 3.8 sqm/litre
<b>Colour</b>	:	As per Manufacturer List
<b>Binder</b>	:	Polyamide cured epoxy resin, Lead & Chrome Free
<b>Application</b>	:	Brush or spray
<b>Drying time</b>	:	< 2 hrs @ 30 Deg C
<b>Over coating time</b>	:	< 2 hrs @ 30 Deg C
<b>Storage life</b>	:	24 months under sealed conditions

### HIGH BUILD EPOXY FINISH (Immersion Grade) – F2

This finish paint is high build, Two-pack phenolic (novolac) epoxy



<b>Volume solids</b>	:	68% min. ±2
<b>DFT Range</b>	:	100 – 150 microns
<b>Theoretical Spreading Rate</b>	:	6.8 – 4.5 sqm/litre
<b>Colour</b>	:	As per Manufacturer List
<b>Binder</b>	:	Amine adduct cured epoxy resin
<b>Application</b>	:	Brush or spray
<b>Drying time</b>	:	< 1.5 hrs @ 30 Deg C
<b>Over coating time</b>	:	< 6.5 hrs @ 30 Deg C
<b>Storage life</b>	:	24 months under sealed conditions

### HEAT RESISTANT ALUMINIUM FINISH PAINT : F3

It is a single pack system based on oleo resinous general purpose aluminium paint with good heat resistance upto 250 Deg. C. and light reflection.

<b>Volume solids</b>	:	25% min. ±2
<b>DFT Range</b>	:	25 microns
<b>Theoretical Spreading Rate</b>	:	10 sqm/litre
<b>Main pigment</b>	:	Aluminium (ASTM 962), Lead & Chrome Free
<b>Colour</b>	:	Metallic Aluminium
<b>Pigment Volume Concentration</b>	:	15 – 20%
<b>Application</b>	:	Brush or spray



	<b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
	Sheet 104 of 135			

<b>Drying time</b>	:	Surface dry <1hr. @ 30 Deg. C
		Hard dry < 3 hrs. @ 30 Deg. C
<b>Storage life</b>	:	24 months under sealed conditions

#### **HEAT RESISTANT SILICON ALUMINIUM FINISH PAINT : F4**



It is a single pack system based on ambient curing silicone aluminium pigmented polysiloxane paint with maximum heat resistance of upto 600 Deg. C.

<b>Volume solids</b>	:	25% min. ±2
<b>DFT Range</b>	:	25 microns
<b>Theoretical Spreading Rate</b>	:	10 sqm/litre
<b>Main pigment</b>	:	Aluminium (ASTM 962), Lead & Chrome Free
<b>Colour</b>	:	Metallic Aluminium
<b>Pigment Volume Concentration</b>	:	15 – 20%
<b>Application</b>	:	Brush or spray
<b>Drying time</b>	:	Surface dry < 1hr. at 30 Deg. C
		Hard dry < 3 hrs. at 30 Deg. C
<b>Storage life</b>	:	12 months under sealed conditions

#### **TWO PACK ALIPHATIC ACRYLIC POLYURETHANE FINISH PAINT – F5**

It Consists of Acrylic Resin in Part A. Part B consists of an aliphatic poly-isocyanate with appropriate solvents and additives.

<b>Volume solids</b>	:	51% min. ±2
<b>DFT range</b>	:	50 – 100 microns
<b>Theoretical Spreading Rate</b>	:	10.2 – 5.1 sqm/litre
<b>Main pigment</b>	:	Suitable pigments to get the desired colour, <b>Lead &amp; Chrome Free</b>
<b>Colour</b>	:	Metallic Aluminium
<b>Binder</b>	:	Shall not contain any binder other than

	<b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
	Sheet 105 of 135			

	:	acrylic resin; should not contain any <b>alkyd / acrylate alkyds / esters.</b>
<b>Application</b>	:	Brush or spray
<b>Drying time</b>	:	Surface dry < 1hr. @ 30 Deg. C
	:	Hard dry < 8 hrs. @ 30 Deg. C
<b>ISO 11507/ASTM G 154, QUV A - Accelerated weathering</b>	:	<b>Gloss retention: approx. 80 % and colour change approx. DE 1.2 after 3000 hours exposure</b>
<b>Storage life</b>	:	24 months under sealed conditions

#### **TEMPERATURE INDICATING PAINT : F6**



It is a single pack temperature indicating system based on silicone binder. Pigments change colour by heating. The colour change of the coating is permanent. At approximately 200°C, the colour changes from green to blue, above 310°C, the colour changes from blue to greyish white. Maximum service temperature is 400°C.

<b>Volume solids</b>	:	40% min.
<b>DFT</b>	:	25 microns
<b>Theoretical Spreading Rate</b>	:	16 sqm/litre
<b>Main pigment</b>	:	As per shade requirement, Lead & Chrome free
<b>Colour</b>	:	As per manufacturer
<b>Binder</b>	:	Based in silicone Resins
<b>Application</b>	:	Brush or spray
<b>Drying time</b>	:	Surface dry < 1hr. @ 30 Deg. C
	:	Hard dry < 4 hrs. @ 30 Deg. C
<b>Storage life</b>	:	12 months under sealed conditions

#### **TAR FREE EPOXY – F7 (Coal Tar is Banned Globally being Carcenogenic)**

A high build two component abrasion resistant, pure epoxy with anti-corrosive properties meant for excellent performance.

<b>Volume solids</b>	:	Minimum 72%
<b>DFT Range</b>	:	150 – 200
<b>Theoretical Spreading Rate</b>	:	4.8 – 3.6 sqm/litre
<b>Application</b>	:	By brush or airless spray

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 106 of 135		

<b>Drying time</b>	:	Touch Dry within 4 hrs. @ 30 Deg C
		Hard dry < 9 hours @ 30 Deg. C
<b>Storage life</b>	:	12 months under sealed conditions

### **EPOXY PHENOLIC (NOVOLAC) – F8**

Two Pack epoxy-phenolic (novolac) cured with amine adduct used as an External coating for the protection of insulated (CUI) equipment.

<b>Volume solids</b>	:	68% min.
<b>DFT Range</b>	:	100 – 150 microns
<b>Theoretical Spreading Rate</b>	:	6.8 – 4.5 sqm/litre
<b>Binder</b>	:	Epoxy phenolic (novolac)
<b>Dry Temp. Service</b>	:	Min. -196 to max. 205 Deg. C.
<b>Application</b>	:	Airless Spray / Brush Touch up
<b>Drying Time</b>	:	Surface dry < 1.5hr. @ 30 Deg. C
		Hard dry < 6 hours @ 30 Deg. C
<b>Storage life</b>	:	12 months under sealed conditions

### **INORGANIC CO-POLYMER COATING – F9**

MIO pigmented single component inorganic copolymer coating which cures to form an in polymer matrix able to resist temperatures up to 650°C/1202°F and thermal shock/cycling dry or dry/wet service.

<b>Volume solids</b>	:	74% min.
<b>DFT Range</b>	:	150 microns
<b>Theoretical Spreading Rate</b>	:	5 sqm/litre
<b>Binder</b>	:	Inorganic copolymer coating
<b>Dry Temp. Service</b>	:	Min. -196 to max. 650 Deg. C.
<b>Application</b>	:	Airless Spray / Brush Touch up
<b>Drying Time</b>	:	Surface dry < 0.5hr. @ 30 Deg. C
		Hard dry < 1.5 hours @ 30 Deg. C
<b>Storage life</b>	:	12 months under sealed conditions



## **6.0 MACHINERY, ELECTRICAL AND INSTRUMENT EQUIPMENT:**

### **6.1 Machinery**

Steel surfaces shall be treated with complete paint system at Manufacturer's shop. The paint system shall be according to Manufacturer's Std. However, suitable for operating condition and the environmental condition where the machinery will operate. Where necessary machinery shall be restored at site by Contractor with suitable finish.

### **6.2 Electrical and Instrument Equipment**

Steel surfaces shall be treated with complete paint system at Manufacturer's shop. The paint system shall be according to Manufacturer's Std., however suitable for operating condition and the environmental condition where the electrical and instrument equipment will operate. Where



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 107 of 135		

necessary Electrical and Instrument Equipment shall be restored at site by Contractor with suitable finish.

## 7.0 COLOURS:

These shall be as required by specification and in particular for:

Description	Colour	Ra1	Correspond. Asian Paint colors to be defined – See Note-2
- Piping with temperature less than 90°C	GREY	7035	
- Piping, hot surface, flue gas ducts and stacks with temperature above 90°C	SMOOTH	ALUMINIUM	“
- Cooling Water Piping	SEA GREEN		“
- Fire fighting Piping	Red	3002	“
- Structures upto 2 MT	BLACK	9005	“
- Structures above 2 MT	GREY	7010	“
- Stair cases – ladders	BLACK	9005	“
- Walkways	GREY	7010	“
- Handrails assemblies	YELLOW	1004	“
- Equipment	GREY	7035	“
- Hot equipment	SMOOTH	ALUMINIUM	“
- Fire fighting equipment	RED	3002	“
- Valves in general	GREY	7035	“
- Hot valves	SMOOTH	ALUMINIUM	“
- Safety and Fire fighting valves	RED	3002	“
- Valves handwheels	BLACK	9005	
- Electric Rotary Machines	SKY BLUE	5012	
- Electric Static Machines	GREY	7035	
- Machinery (compressors & pumps) with operating temperature less than 90°C	GREY	7035	“
- Machinery (compressors & pumps) with operating temperature above 90°C	SMOOTH	ALUMINIUM	“
<b>FURNACES</b>			
- Casing and connected steel works	SMOOTH	ALUMINIUM	“
- Steel work not connected to casing	SMOOTH	ALUMINIUM	“
<b>AIR COOLER</b>			
- High Temperature Surfaces (Temp. > 90°C)	SMOOTH	ALUMINIUM	

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 108 of 135		

Description	Colour	Ra1	Correspond. Asian Paint colors to be defined – See Note-2
- Low Temperature surface (Temp. $\leq$ 90°C)	GREY	7035	“
- Flare $\leq$ 90°C	GREY	7035	“
- Flare $\geq$ 90°C)	SMOOTH	ALUMINIUM	“
<b>TANKS</b>			
- Shell of fixed roof	WHITE	9010	“
- Roof of fixed roof tank	WHITE	9010	

NOTE-1: The colours shall be according to IS2379:1990/International STD. RAL or BS, proposed by Contractor or Manufacturer

## 8.0 PARTICULAR DESCRIPTION

The abrasive Grit Blasting shall be used for surface preparation. **Sand blasting is prohibited due to environmental regulations.**

Primerized surface shall be faultless and shall not have mud-cracking, dripping over thickness and dry sprays.

Blast cleaning and painting shall not be carried out on wet surfaces.

Blast cleaning shall not be done when surfaces temperatures are less than 3°C above dew point, or temperature is below 5°C.

No acid washes or other cleaning solutions or solvents shall be used on metal surfaces after they have been blasted.

The surface preparation of all steel surfaces to be coated shall be free of all mill scale, rust corrosion product, oxides, paint, oil or other foreign matter



Only dry abrasive blasting procedures will be allowed. The compressed air supply used for blasting shall be free of detrimental amounts of water and oil. Adequate separator and traps shall be provided and these shall be kept emptied of water and oil. Any blast cleaning set up without functioning moisture separators shall be removed from blast cleaning areas.

All welded areas and appurtenances shall be given special attention for removal of welding flux in crevices. Welding splatter, slivers, laminations and underlying mill scale exposed during sand blasting shall be removed or repaired.

The blast-cleaned or power brushing surfaces shall be coated with primer within four hours of surface preparation.

No primer or intermediate or finishing coating shall be applied without prior notification to the Company.

The application of the products shall be carried out in strict compliance with the paint manufacturer's recommendation.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 109 of 135		

The Contractor shall provide suitable protection for all adjacent plants or equipment from airborne during spraying and sand blasting.

## 9.0 INSPECTION AND TESTING

The inspection and testing requirements outlined in this section shall be performed for shop and site applied coating systems.

Preference shall be given to manufacturers and applicators that are quality certified to ISO 9001: 2000.

Documentation of coating material manufacturers and applicators shall include daily inspection reports, equipment reports, and shall clearly identify and trace materials supply and testing performed on coated items and areas.

Inspection and Test Plans (ITPs), and quality control procedures used for application of coating systems shall form part of the Method Statement and shall be submitted for approval by the Principal prior to commencement of work.

The applicator shall appoint a certified inspector of coatings for inspection and testing of coating systems.

Tests of coated areas and items shall form part of the ITPs.



- Surface Preparation in accordance to Swedish Standard SIS-05-5900 (Latest).
- Blast cleaning profile shall be checked using a suitable profile meter – Acceptable profile shall be 40 - 60 microns.
- Check of time of top coating and drying in accordance with the direction of the paint manufacturer.
- Check of dry film thickness by suitable non-destructive Instrument such as “MIKROTEST”, “DIAMETER” or equivalent.
- Before any coating work is performed on the site, the contractor shall ensure that any works applied by others is acceptable.

Any defect that are discovered, are to be notified in writing to the owner before proceeding with the contract work. To ensure the good execution of painting work following test shall be performed:

- Surface Preparation
- Surface contaminant tests
- Surface profile tests
- Coating thickness tests
- Tests for cure of coatings
- Adhesion tests
- Continuity testing
- Iron contamination
- Chloride contamination
- Dust Contamination

All Inspection and Test Records (ITRs) shall be submitted with the Manufacturer's Data Report (MDR) at the conclusion of the job.

Defective coated areas shall be suitably marked for rectification work to be performed in compliance with this specification.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 110 of 135		

Access shall be granted for inspection of all paint work, and witnessing of test work. This shall not however relieve the Contractor of their own QA/QC responsibilities.

## 10.0 ADHESION TEST RESULTS

For all type of primer the Contractor shall guarantee the Classification of Adhesion Test Results as per ASTM D3359. The acceptable Rate Adhesion Test Results shall be for sandblasted and primerized surfaces shall be minimum 3A (or Higher)

For primer plus finishing coat(s) the Contractor shall guarantee the Classification of Adhesion Test Results as per ASTM D 3359. The acceptable Rate Adhesion Test Results shall be for blast cleaned and painted surfaces shall be minimum 3A ( or higher).

After test, the surface must be repaired according to the system applied.

## 11.0 SUBMISSION OF DATA

Contractor shall submit in phase of bid the original technical data sheet and system for all material supplied by him to apply for the permanent works and test report for the paint in compliance to IS101. This material shall be subject to Owner's approval.

The test certificates of zinc silicate shall provide the specific gravity of mixed paint.

## 12.0 LETTER AND NUMBER INSCRIPTION

Inscriptions letters, as herebelow indicated, shall be made on equipments, piping, storage tanks, machinery etc.

### 12.1 Geometric forms and dimensions

Letters and numbers dimensions shall be orientatively fixed according to following:

(A – Dimension of side of unitary elements of grid)

- Storage Tanks A – 60 mm
- Equipments and piping with O.D. above 600 mm A– 40 mm and
- Equipments and pipings with O.D. from 300 to 600 mm and for machinery of great dimensions A – 20 mm
- Equipments and pipings with O.D. less than 300 mm and for machinery with small dimensions A – 10 mm

### 12.2 Inscription's Colours

Inscriptions shall be Black ENI 901 (RAL 9005) on light base

Inscriptions shall be White ENI 101 (RAL 9010) on dark base

### 12.3 Spaces and Interspaces



Spaces between words and assemblage of numbers shall have dimensions equal to 2A

Interspaces between letters or numbers shall have dimensions equal to A.

## 13.0 Colour Band for piping ;-

As a rule minimum width of colour band shall confirm to the following Table:-



	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 111 of 135		

Nominal pipe Size	Width L (mm)
3" & below	25
4" NB-6" NB	50
8" NB-12"NB	75
14" OD & above	100

#### 14.0 LIST OF MANUFACTURERS :

1. M/s Berger Paints
2. M/s Jensions & Nickolson
- 3.M/s Jotun Paints
4. M/s Asian Paints
5. M/s Grauer & Weil (India) Limited
6. M/s Shalimar paints
7. M/s Garware Paints
8. M/s Goodlass Nerolac Paints Ltd
9. M/s.HEMPEL Paints
10. M/s International Paints (Akzo Nobel Brand)
11. M/s Carboline (India) Pvt. Ltd.
- 12.M/s Mohan Paints

**15.0** The contractor shall obtain prior approval from Engineer-In-Charge for the brands of paint material proposed to be used. The contractor shall submit the following details of paint material either at the time of bidding or soon after award of work for approval of paints.

- a. Technical data sheet
- b. Material safety data sheet
- c. Finger printing of paint products as per ISO 20340



**16.0** Owner reserves the right to take random samples and get it tested through reputed labs. In case the supplied paint material do not meet the specified performance requirements then suitable action shall be taken against the paint supplier. The decision of Engineer-In Charge shall be final and binding on the Contractor in such cases

#### 17.0 WARRANTY:

Contractor along with Paint Manufacturer jointly shall develop the paint schemes following the system specification.

They shall jointly provide a performance guarantee for a period 5 years as stipulated below,



	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 112 of 135		

After 1 years – Corrosion in 3% of total painted area accepted



After 2 years – Corrosion in 6% of total painted area accepted

After 3 years – Corrosion in 9% of total painted area accepted

After 4 years – Corrosion in 12% of total painted area accepted

After 5 years – Corrosion in 15% of total painted area accepted

where spontaneous visible corrosion has broken down the paint film to a degree exceeding “Ri 3” (as defined in ISO 4628/3-2003).

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 113 of 135		

### **ANNEXURE- 7 - 3**

#### **QUALITY CONTROL PROCEDURE AND INSPECTION REQUIREMENTS**

##### **1.0 LSTK CONTRACTOR'S QUALITY CONTROL**



- 1.1 LSTK CONTRACTOR shall provide a quality control program manual include specific WORK methods and inspections, which assure quality.

This quality control program manual must be submitted to OWNER for Approval before starting the construction activities.



All installation WORK must be in strict accordance with this approved manual.

- 1.2 The quality control program shall include as a minimum the following:

- Methods use to control drawings; specifications and CONTRACT correspondence to assure that only the latest revisions are being used in the field.
- Inspection personal name, organization.
- Inspection methods and documentation of inspection (or tests) for shop fabrication, if required, and installation.
- Material control procedures from SITE receiving point, through "over, short and damage inspection" through storage and through installation.
- Positive material identification Procedures for:
  - Electrical cable pulling and testing.
  - Asphalt placement inspection.
  - Handling and storage methods to prevent damage.
- Inspection and testing procedures and reports for civil, structural, piping, electrical, instrument, equipment and all installation WORK.
- Repair.
- Scrap and reject.
- Grouting.
- Welding.
- Welder qualification.
- Receiving all permanent plant material & equipment.
- Rigging.
- Welder's tests.
- Nondestructive examinations to be used.
- Positive material identification. etc.
- Identification of LSTK CONTRACTORS and ensuring their compliance with the manual and WORK required.
- Material certification verification methods.
- Calibration procedures for measurements and test equipment.
- Marking and identification of components in process and complete assemblies.



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 114 of 135		

- 2.0 Shop fabrication and field installation inspection OWNER'S REPRESENTATIVE to ensure specifications. in the following areas will be performed by full adherence to Receiving and inspection.
- Calibration of test inspection equipment.
  - Preventive maintenance and storage protection.
  - Internal cleanliness.
  - Proper material use and control.
  - Nondestructive testing and its results.
  - Workmanship.
- 3.0 OWNER'S REPRESENTATIVE or others as authorized by OWNER are to be permitted access to LSTK CONTRACTOR'S work areas for the purpose of inspection of material, equipment, documentation and other areas as required in LSTK CONTRACTOR'S quality assurance / quality control program.
- 4.0 No concrete will be placed by LSTK CONTRACTOR without an OWNER "Pour Release Form".
- 5.0 OWNER'S construction inspections will not relieve. LSTK CONTRACTOR of inspection or other responsibilities.
- 6.0 For piping all welders test pieces shall be supplied by LSTK CONTRACTOR and fully prepared for welding by LSTK CONTRACTOR.
- 7.0 LSTK CONTRACTOR shall evidence its familiarity and experience with the execution of the installation of WORK to the requirements of the applicable codes and shall perform its WORK in accordance to these requirements and to instructions issued by OWNER'S REPRESENTATIVE in this regard.
- 8.0 **CHECK ON QUALITY OF WORK**
- 8.1 OWNER'S REPRESENTATIVE'S inspector shall have free access to the place where the WORK is performed at all times, in order to check the quality of WORK
- 8.2 If during inspection / check reveals unsatisfactory WORK, LSTK CONTRACTOR shall immediately at LSTK CONTRACTOR'S expense. take such corrective measures as deemed required.
- 9.0 **CONTROL SYSTEMS**
- LSTK CONTRACTOR shall initiate and maintain the following control systems
- 9.1 **Backfilling**
- Compaction tests.
- 9.2 **Concrete**
- Design mix and approval record(s).
  - Batch plant inspection record.
  - Slump test record.
  - Compressive test record.
  - Pour release record.
  - Grouting release record.
  - Placement inspection records.
  - Concrete curing records.
- 9.3 **Asphalt**
- Design mix and approval records.
  - Batch plan inspection records. Placement inspection records.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 115 of 135		

- 9.4 **Piping**
- Weld x-ray file.
  - Pipe and fitting certificate file.
  - Isometric weld control sheet. Hydrostatic test records.
- 9.5 **Grounding**  
Earth resistance test records.
- 9.6 **Electrical Cable and Instrument cable**
- Insulation resistance test records.
  - Continuity test records.
- 9.7 **Material certification files**
- 9.8 **Equipment**
- Weld x-ray file.
  - Material certificate files.
  - Equipment installation records.
  - Equipment maintenance record.
  - Hydrostatic test records.
  - Grouting release records.
  - Alignment records.
  - Vibration records.
10. **Requirements for Certification of Materials**
- 10.1 Mill certification of materials will be required based on the material type, the use and the codes and requirements.
- 10.2 LSTK CONTRACTOR shall provide:
- Type A certification of compliance, for all but not limited to the following materials which LSTK CONTRACTOR is responsible to supply:
- Imported backfill materials.
  - Ready mix concrete.
  - Asphalt paving materials
  - Prefab concrete items, including pre-cast manholes, catch basins, pits, sumps and sleepers.
  - Paving stones and tiles.
  - Inserted and embedded items, other than rebar, wire mesh and anchor bolts.
  - Masonry blocks.
  - Steel sliding plates.
  - Special grouting materials, i.e. non-shrink type.
  - Grouting materials, including grounding loop and branch wire which they are LSTK CONTRACTOR'S supply.
- Type "B "certificate, for all but not limited to the following materials, which LSTK CONTRACTOR is responsible to supply:
- Materials to be considered structural or structural grade.
  - Reinforcing grade.
  - Wires mesh reinforcement fabric.
  - Anchor bolts.
- 10.3 **Definition of Type of Certificates**  
**Type A (certificate of Compliance):**

This is a certificate of compliance, issued by the manufacturing or processing works and

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 116 of 135		

signed by the quality department or persons to carry the responsibility for quality and conformity, stating that the materials supplied correspond (5) with what was agreed in the purchase order.



Type B (mill Certificate) :

This is a certificate on which the manufacturer's head of quality department confirms that the product supplied corresponds with what has been agreed in the purchase order. Certification shall be on the basis of tests carried out on the material of the product itself, as per purchase order specification. The testing and certification are to be carried out by a testing center which is independent of the production section of the manufacturing works and which has the code-approved facilities. Independence of such testing center should be warranted by LSTK CONTRACTOR.

- 10.4 LSTK CONTRACTOR will maintain a systematic filing system of all certificates and reports for all tests and inspections carried out by it under the applicable specifications, standards and codes of practice quoted therein.

LSTK CONTRACTOR may use its own format for records but this must be submitted to OWNER'S REPRESENTATIVE for his approval prior to use.

LSTK CONTRACTOR can expect to be audited on a continuous basis. Originals of all documents to be sent to OWNER'S REPRESENTATIVE.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 117 of 135		

## **ANNEXURE- 7 – 4**

### **SCHEDULE, PROGRESS EVALUATION AND PROGRESS REPORTING**

#### **1.0 GENERAL**

- 1.1 WORK shall start and be completed in the field as indicated on the approved project construction schedule.

LSTK CONTRACTOR shall follow the sequence of construction in executing the WORK as shown in the schedule or as modified by OWNER.

The detailed scheduling of WORK will be supplied by the LSTK CONTRACTOR. WORK shall be conducted in such a manner that other construction activities are not affected.

Once detailed schedule, established and approved by OWNER, LSTK CONTRACTOR commits itself to follow the schedule in detail.

#### **2.0 DETAILED & SCHEDULE**

- 2.1 Detailed construction schedule must cover all construction work, from lowest level up to highest level.
- 2.2 Activities shown by means of a bar chart must include as a minimum the activities listed in 4.

#### **3.0 PROGRESS REPORTING**

LSTK CONTRACTOR shall issue a reporting procedure and a representative sample of all progress reports.

Following schedules and reports must be issued by LSTK CONTRACTOR to OWNER:



Construction schedule. ( preliminary and detailed)  
Monthly status report.  
Weekly progress report.  
Monthly construction guide schedule.  
Daily manpower reports.

All except detailed construction schedule based on approved project construction schedule.

#### **4.0 CONSTRUCTION SCHEDULE**

Within **Two** months after Effective Date, LSTK CONTRACTOR will issue separate graphical "S" curves for the following work activities of total CONTRACT.

Installation of :

	<b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 118 of 135		

- Concrete foundations, pits. manholes. catch basins, trenches and concrete structures.
- Prefabricated concrete items
- Concrete paving and elevated slabs
- Other paving and final surfacing
- Grouting.
- Final road paving.
- Underground piping.
- Underground cable trenches and cables.
- Building erection.
- Structural steel erection.
- Engineering and design of small bore carbon steel piping systems.
- Prefabrication of piping.
- Electrical installation.
- Instrument installation.
- Equipment assembly and elect
- Erection of piping.
- Flushing and cleaning
- Hydro-testing
- Painting
- Insulation.

## 5.0 INTRODUCTION

The introduction to the monthly status report shall include LSTK CONTRACTOR'S comments on the overall construction schedule with a status update line as attachment, and shall consist of the following items:

- Goals achieved last month.
- Goals for next month.
- Reason for delay, if any. Reason for deviation of original schedule.
- Average manpower by craft, including management and indirect staff.
- LSTK CONTRACTOR'S comments to general situation.



## 6.0 CONSTRUCTION ACTIVITIES STATUS

This section consists of scheduled versus actual progress curves.

The progress curves are to be commented upon by LSTK CONTRACTOR.

The basis for reporting shall be the construction schedule:

The monthly status shall be reported as a percentage of the total WORK per type of WORK.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b>  <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 119 of 135		

## 7.0 MANPOWER AVAILABILITY / REQUIREMENTS FOR THE MONTH COMING

LSTK CONTRACTOR shall submit its manpower availability requirements for the next month. This section consists also of the scheduled versus the actual manpower curves.

These manpower curves are accompanied by LSTK CONTRACTOR'S comments hereon.

## 8.0 MAIN CONSTRUCTION EQUIPMENT AVAILABILITY / REQUIREMENTS FOR THE MONTH COMING

LSTK CONTRACTOR shall submit its main construction equipment availability / requirements for the next month. This section consists also of the scheduled versus actual construction equipment requirement curves. These by LSTK CONTRACTOR'S comments hereon.

## 9.0 WEEKLY PROGRESS REPORT

Progress reporting will be done on a weekly basis by the actually completed work based on details of work such as quantities or piece of equipment as a percentage of the total anticipated work per work activities as defined in item 4.

9.1 Progress will only be reported on the basis of completed activities as per the percentage breakdown of the major steps as follows:

### Progress Measurement Parameters

Actual physical progress in the field shall be measured based upon standard percentage of completion of progress stages, that, they are to be prepared by LSTK CONTRACTOR and Approved by OWNER to calculate actual physical progress of the WORK, the exact weight value of each activity from lowest level up to highest level in each category of the WORK shall be specified by LSTK CONTRACTOR and supplied to OWNER.

After OWNER'S Approval this weight value can be used for calculation of actual progress of the WORK

## 10.0 WEEKLY PROGRESS MEETING

### 10.1 Weekly Work List



In the weekly progress review meeting LSTK CONTRACTOR shall forecast the WORK it plans to perform during the week by means of a weekly WORK list including its manpower resource allocation as per the activities listed in 4 and 6.

This weekly program shall be in accordance with the construction guide schedules.

### 10.2 Work Front

LSTK CONTRACTOR shall submit monthly and weekly a total recapitulation Of the total work



	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 120 of 135		

front available with estimated manpower requirements, materials and equipment which shall be supplied by LSTK CONTRACTOR.

## 11.0 MONTHLY CONSTRUCTION GUIDE SCHEDULE

Based on approved overall construction schedule, LSTK CONTRACTOR must issue a monthly construction guide schedule covering a two (2) months period, for each individual activity.



Progress updating of construction guide schedules must be weekly and presented in the weekly progress review meeting at site.

The updated issue will show for each individual activity:

- Percent complete.
- Weight factor complete.

## 12.0 DAILY MANPOWER REPORTS

LSTK CONTRACTOR shall be furnished daily manpower report as per agreed format.

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 121 of 135		

## ANNEXURE- 7 – 5

### EXECUTION PLAN

#### **1.0 BIDDER ORGANISATION**

##### **1.1 Company Organisation**

Bid shall include a description of the organization, its management structure and organization chart of Bidder's company with particular reference to the means whereby the execution of this project will be related to the overall company organization.

The Bidder shall also furnish the name(s) of their partners, associated/ subsidiary companies & their activities, and whether any such associated/ subsidiary company will be involved in the execution of WORK, and if so, their scope thereof.

##### **1.2 Project Organization**

Bidder shall give charts of organization, which he intends to use in the execution of the work. Such charts must show lines of authority and communication of senior personals who will be assigned to this work in Bidder's home - office and other offices where WORK shall be performed (if any) and the lines connecting such Project Organization to the Bidder's internal overall organization including partners (if any). The chart shall be supported by a narrative, which shall explain how the proposed organisation will operate and in particular will provide

The name of the location of the office(s) in which the Basic and Detail Engineering Design Packages of the plant shall be carried out.

If any parts of the Basic and Detail Engineering Design Packages are to be carried out in more than one office, then details of the distribution of the jobs between offices and coordination procedure shall also be presented.

A description of the facilities offered to the OWNER'S resident engineers.

#### **2.0 Estimated project and Engineering man-hours**

Bidder shall give an estimate of the engineering man-hours and its break down for all activities

#### **3.0 Methods and procedures**

Bidder shall summarise the methods and procedures that BIDDER intends to implement during the performance of the WORK. It shall include the proposed procedures such as Engineering, Procurement, construction strategy, WORK Progress Measurement, Pre-commissioning, Commissioning and Performance Test Run of the PLANT, and Training.



BIDDER shall also furnish proposed procedures for the Project management, communication and method and frequency of reporting the progress of the WORK.

The final form for reports, which will be subject to OWNER's Approval, shall include as a minimum the following :

- a) Planning and Scheduling
- b) Work Progress
- c) Safety and Security

#### **NOTES:**

- a) Sample reporting forms and other key standard forms shall be included.
- b) Bidder shall state the extent to which he will be using computerized drafting, etc.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 122 of 135		

#### 4.0 Job descriptions and personnel resumes

Bidder shall include job descriptions and personnel resumes of his staff nominated to the key positions, including (where applicable) at least the followings, or Bidder's equivalent:



Project director  
 Process engineering co-ordinator  
 Construction manager  
 Process engineer  
 Project engineering co-ordinator  
 Senior pre-commissioning engineer  
 Senior commissioning engineer  
 Training co-ordinator and instructor.  
 Construction Engineering Coordinator  
 Construction Quality Control Engineer  
 Construction Project Control Engineer  
 Welding Specialists  
 Heavy Lift Rigging Specialist  
 Senior Specialist Engineers  
 Senior Planning Engineers  
 Materials Coordinators  
 Senior Construction Engineers  
 Senior Pre-commissioning Engineers  
 Warehousing Officer  
 Material Planning Engineers

Resumes shall give at least the name, age, nationality, education, professional exception/deviation and previous experience of each assigned personnel. Additionally, one alternative shall be offered for each position. **Bidder shall ensure that personnel to be deployed meet the minimum criteria specified in Annexure-7-6**

Bidder shall confirm that these key personnel will be made available to WORK on the Project as required by the schedule on full time basis.

Bidder shall furnish Summary of its Deployment Schedule Personnel as per **Annexure-7-7**.

Bidder understands that the said proposal represents the minimum deployment and the Bidder acknowledges that the said deployment may have to be augmented with additional number and/or categories, if required, if directed by Engineer-in-Charge in order to complete the work within the completion schedule and quoted lump sum price.

	<b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
	Sheet 123 of 135			

## 5.0 Construction equipment and machinery

The BIDDER shall furnish details of construction equipment & machinery, testing equipment, tools/tackles, etc., which will be made available by the Bidder at the Site. Bidder shall furnish Summary of such details as per **Annexure-7-8, Annexure-7-9**.

Such list shall, in no way limit the CONTRACTOR's responsibility to arrange & provide any additional construction equipment, tools, tackle, etc., which might be required to execute and complete the WORK as per contractual schedule.

BIDDER shall furnish the procedures and his tools for erection of the Heavy Lift Equipments including tall columns):

## 6.0 Heavy lifts

BIDDER shall furnish his proposed, site transportation, lifting, along with preliminary rigging schemes and erection procedure for the heavy lifts. Such plans / schemes shall be furnished along with detailed write -up on heavy cranes proposed to be deployed by CONTRACTOR, duly supported by relevant technical literature.

## 7.0 BIDDER experience & exception/deviation to perform the work

The BIDDER should have experience in the construction of similar Plants. The BIDDER should have successfully executed and completed construction of at least one similar Plant with his own project management and with complete responsibility of construction / erection and pre-commissioning.

The BIDDER shall furnish, as a part of his Tender Documents establishing the BIDDER'S experience and exception/deviation to perform the CONTRACT. Such documentary evidence shall also establish to OWNER's satisfaction that the BIDDER has the necessary financial, technical, project management capabilities and the requisite resources to execute the Work.

Such documentary evidence shall also be furnished for BIDDER'S proposed Subcontractors, if any. The Bidder shall furnish, in a tabular form, a list of jobs of similar type and magnitude executed by them in the past. BIDDER shall also furnish details of their experience in erection of heavy lifts. The Bidder shall furnish documentary evidence, establishing to OWNER satisfaction, that such jobs have been timely and successfully executed by them. The BIDDER shall also furnish the details of their present major commitments.

## 8.0 QA/QC Program

Bidder shall furnish a summary description of their proposed QA/QC program.

Bidder shall furnish any other technical information / details as per the requirements of ITB.



## 9.0 Technical assistance

The extent of the Technical Services and Assistance to be rendered by CONTRACTOR for, commissioning and performance test run, etc., is to be proposed

## 10.0 Training

Bidder shall furnish the following details regarding the Training of OWNER'S personnel:

- a) Bidder's organisation set up for Training program.

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 124 of 135		

b) Training facilities available with the Bidder to train the OWNER'S personnel in

- Theory of process, operation, maintenance and manufacturing of products
- Field (on the job) training in process, operation, maintenance and manufacturing of products, to train the personnel on the job.
- Test procedure and other matters.

c) The courses and their duration, number of attendees in each course and location where such courses will be held that the Bidder would recommend OWNER to consider.

d) Bidder's experience of training the personnel for units similar to the subject PLANT.

11.0 Estimate of the number of personnel required for the safe and satisfactory operation of the Plant.



For and on behalf of .....

Stamp & Signature : .....

Name : .....

Designation : .....



Date : .....

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and Chemicals Limited</u></b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b></p>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 125 of 135		

## ANNEXURE-7-6

### Minimum Qualification & Exp. Of Key Supervisory Construction Personnel

<u>SL. NO.</u>	<u>CATEGORY</u>	<u>QUALIFICATION &amp; EXPERIENCE</u>
1	RESIDENT CONSTRUCTION MANAGER / RESIDENT ENGINEER / SITE-IN-CHARGE	Degree in Engg. With minimum 20 years relevant experience in construction should successfully constructed & commissioned at least one process unit in hydrocarbon / fertilizer sector.
2	LEAD DISCIPLINE ENGINEER	Degree in relevant Engg. discipline with minimum 15 years experience in Construction or Diploma in relevant Engg. Discipline with minimum 20 years experience in Construction.
3	LEAD WELDING / NDT ENGINEER	Degree in Mechanical Engg./Metallurgy with minimum 15 years experience in Welding / NDT (Non-Destructive Testing) plus Level-II in RT (Radiographic Testing) or diploma in Mechanical Engg. / Metallurgy with minimum 20 years experience in Welding / NDT plus Level-II in RT.
4	LEAD QA/QC ENGINEER	Degree in Engg. With 15 years Construction Experience of which 5 years should be as QA Manager.
5	LEAD PLANNING ENGINEER	Degree in Engg. With 15 years experience in Planning & Scheduling.
6	LEAD SAFETY OFFICER	Degree / Diploma in Engg. And Diploma in Industrial Safety with min. 10 years relevant experience in Construction Safety.
7	WAREHOUSE-IN-CHARGE / MATERIALS MANAGER	Graduate in Science or Diploma in Engg. / Materials Management with 15 years experience in Warehousing / Stores Management of similar nature.
8	DISCIPLINE SURVEYORS	Degree in relevant Engineering Discipline with minimum 3 years experience in Construction or diploma in relevant Engineering Discipline with minimum 6 years experience in Construction.
9	QUANTITY SURVEYORS	Degree in relevant Engineering Discipline with minimum 3 years experience or diploma in relevant Engineering Discipline with minimum 6 years experience in quantity estimation, field measurement, rate analysis etc. in construction field.

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 126 of 135		



For and on behalf of .....

Stamp & Signature : .....

Name : .....

Designation : .....

Date : .....

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 127 of 135		

## ANNEXURE-7-7

### Deployment Schedule of Supervisory Personnel

SL. NO.	DESCRITPI ON	DEPLOYMENT SCHDULE																											
		1	2	3	4	5	6	7	8	9	10	.	.	.	..	..	.	.	..	..	.	..	.	.	..	35	36	37	TOTAL
1	PROJECT MANAGEM ENT																												
1.1	PROJECT MANAGER																												
1.2	PLANNING MANAGER																												
1.3	PLANNING ENGINEERS																												
2	RESIDUAL DESIGN AND DETAILED ENGINEERING																												
2.1	PROJECT ENGINEERING MANAGER																												
2.2	ENGINEERING COORDINATOR																												
2.3	ENGG. PERSONNEL FOR VARIOUS DISCIPLINE																												
2.3.1	CIVIL STRUCTURAL																												
(i)	ENGINEERS																												
2.3.2	PRESSURE VESSELS																												
2.3.3	MECHANICAL EQPT/ ROTARY EQPT.																												
2.3.4	PIPING																												
(i)	ENGINEERS																												
2.3.5	ELECTRICAL																												
(i)	ENGINEERS																												













[illegible]

**PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT**  
**OWNER: Bharat Coal Gasification and Chemicals Limited**

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 134 of 135		



For and on behalf of :...

Stamp & Signature : .....

Name : .....

Designation : .....

Date : .....

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP</b>	PNCN/ PC288/E/001/PART-II-SEC - 7.0	P	
		Document No.	Rev	
		Sheet 135 of 135		

**ANNEXURE-7-9**  
**Details Of Equipment Proposed to be used for Tendered Work**

**I / We, shall use the following MAJOR equipments owned by the tenderer for the work, if awarded to me /us :**

Sl. No	Description	Quantity. (Numbers)	Make	Capacity	Owner	Approximate date when it will be deployed at site	Period of retention at site

For and on behalf of .....

Stamp & Signature : .....

Name : .....

Designation : .....

Date : .....



	PROJECTS & DEVELOPMENT INDIA LTD.	PC009/E/001/P-II/ SEC-8.0	P1	
		Document No.	Rev	
		Sheet 1 OF 14		

## PART II: TECHNICAL (2)



### SECTION – 8.0

#### PERFORMANCE & GUARANTEE TESTS

**PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT**

**PROJECT: COAL TO AMMONIUM NITRATE COMPLEX, AT LAKHANPUR, ODISHA (INDIA)**

P1	15/03/2024	15/03/2024	Issued for Client's approval	SR	SK	MN
P	06/03/2024	06/03/2024	Issued for Client's comment	SR	SK	MN
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD



	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC009/E/001P-II/ SEC-8.0	P1	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b> <b><u>PERFORMANCE AND GUARANTEE TEST</u></b>	Document No.	Rev	
	Sheet 2 OF 14			

## **CONTENTS**

Section Number	Description	Sheet Number
1.0	Performance Guarantees	3
2.0	Performance Tests	11

## **LIST OF ATTACHMENTS**

Attachment number	Description	Number of Sheets
1	Overall Raw Material & Utility Balance Diagram	1

	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC009/E/001P-II/ SEC-8.0	P1	
	<b><u>Bharat Coal Gasification and Chemicals Limited PERFORMANCE AND GUARANTEE TEST</u></b>	Document No.	Rev	
	Sheet 3 OF 14			

## 1.0 GUARANTEES

### 1.1 Performance Guarantees

#### 1.1.1 Synthesis Gas Purification Plant:



LSTK Contractor shall guarantee performance of Synthesis Gas Purification Plant as specified in this Clause under the following heads.

1. Capacity
2. Quality of the product
3. Pollution Level
4. Noise Level
5. Life of the Catalyst & Adsorbents

Failure to meet capacity of the plants, quality of the products, pollution levels and noise levels shall be breach of contract requiring corrective action by LSTK contractor irrespective of the cost involved. LSTK Contractor shall specify Guaranteed Performance Parameters for the Purification Plant for generating Ammonia Syn. Gas & Carbon Dioxide Gas to produce Ammonia & Ammonium Nitrate as specified below:

Parameter	Units	Value (LSTK Contractor to indicate)
Ammonia synthesis gas on LSTK basis.	Nm <sup>3</sup> /Hr (Min/Nor/Max.)	* / 105000 /
Carbon-di-oxide gas on LSTK basis.	Nm <sup>3</sup> /Hr (Min/Nor/Max.)	* / 24000+2550 /
Sulphur	% of recovery to be guaranteed	
Utility & Process Nitrogen	To be guaranteed as per Section-2.0 & 4.0 of Part-II Technical	
Material/ Utilities consumption per 1000 NM3 of Ammonia Syn. Gas:		
HP/MP/LP Steam import	MT	
Fuel gas to flare system	Nm <sup>3</sup>	
Net export of HP/MP/LP steam (if generated)	MT	
Power Consumption	KW hr/hr	
Net energy Consumption (NCV based)	Gcal	
Cooling water make-up	m <sup>3</sup>	
DM Water	m <sup>3</sup>	
Treated Condensate export	m <sup>3</sup>	

Note:- \*-Minimum figures for checking turn-down parameters.

	<div><div><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></div><div><b><u>Bharat Coal Gasification and Chemicals Limited</u></b></div><div><b><u>PERFORMANCE AND GUARANTEE TEST</u></b></div></div>	PC009/E/001P-II/ SEC-8.0	P1	
		Document No.	Rev	
		Sheet 4 OF 14		

### 1.1.2 Cooling Towers:

LSTK Contractor shall guarantee **cooling water requirement pertaining to** LSTK-2 Battery Limit.:

Failure to meet above shall be breach of contract requiring corrective action by LSTK Contractor at his own risk and cost within reasonable time in consultation with owner. LSTK Contractor shall specify Guaranteed Performance Parameters for Purification Plant Cooling Towers:



Parameter	Units	Value (LSTK contractor to indicate)
Cooling water requirement	m <sup>3</sup> /hr	
Hot Water Temperature (Return)	deg C	
Cold Water Temperature (Supply)	deg C	36
Pressure drop across supply and return header terminal points.	Kg/cm <sup>2</sup>	

### 1.1.3 Works cost (Consumption of Raw material & Utilities) Guarantee:

LSTK Contractor shall guarantee overall consumption of Power, Process water, De-mineralized water, Methanol consumption and make-up, Cooling water circulation for generating Ammonia Syn. Gas & Carbon-Di-oxide Gas required for production of Ammonia & Ammonium Nitrate at 100% plant capacity.

LSTK Contractor shall furnish all data as per Attachment-1 and shall guarantee the Total Works Costs per day for generating Ammonia Syn. Gas (**105000** NM<sup>3</sup>/hr) & Carbon-di-oxide Gas (**24000+2550** NM<sup>3</sup>/hr) required for production of Ammonia & Ammonium Nitrate meeting the quality and conditions in the following manner.

Sl. No	Raw Materials/ Utilities	Consumption per day (Q)	Cost per day (Q*R) INR
1.	Clean Syngas input	To be filled by LSTK contractor	Q*
2.	MP Nitrogen	To be filled by LSTK contractor	Q*3750
3.	Utility Nitrogen	To be filled by LSTK contractor	Q*3750
4.	De-mineralised water, M <sup>3</sup>	To be filled by LSTK contractor	Q* 53.69
5.	Condensate export (**)	To be filled by LSTK contractor	Q*(-)47.41
6.	Methanol (consumption & make-up) kg	To be filled by LSTK contractor	Q*28
7.	Steam	To be filled by LSTK contractor	Q*800

	<div><div><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></div><div><b><u>Bharat Coal Gasification and Chemicals Limited</u></b> <b><u>PERFORMANCE AND GUARANTEE TEST</u></b></div></div>	PC009/E/001P-II/ SEC-8.0	P1	
		Document No.	Rev	
		Sheet 5 OF 14		

8.	Make-up Water for Cooling Towers Purification Plant, M <sup>3</sup>	To be filled by LSTK contractor	Q* 35.75
9.	Power, KWh	To be filled by LSTK contractor	Q* 4
10.	Instrument air	To be filled by LSTK contractor	Q* 600
11.	Guaranteed Total Works Cost "A"/Day = $\sum(Q \times R) \{Sl.No.1-9\}$		
12.	Production figures (per day): a. Ammonia Syn. Gas (N <sub>2</sub> +3H <sub>2</sub> ) "N" = Nm <sup>3</sup> b. Carbon-Di-oxide Gas = Nm <sup>3</sup>		
	Guaranteed Specific Work Cost/1000 Nm <sup>3</sup> Ammonia Syn. Gas ("S" = A/N x 1000) =		

Note:

- (\*\*) Credits will be given for export condensate suitable for HP Steam generation.
- The guaranteed works cost shall include cost of materials and utilities required and power consumption for building cooling/heating, lighting, ventilations, air conditioning and consequent costs of such materials which are not in the usual operation of the plant.
- For Bid submission purpose, LSTK Contractor shall furnish consumption and generation figures of, Power, Cooling Water Make-up, DM Water, and Condensate export respectively whose actual works cost shall be calculated on the basis of Unit Price mentioned in the above table.
- For the purpose of calculating specific works cost of Ammonia synthesis gas; Demineralised water, condensate export, Make up water for cooling tower, Process Nitrogen, Utility Nitrogen, power and Net HP/MP/LP steam export shall be considered.
- Steam generated inside Purification Plant shall be consumed within the same B.L.
- No meter tolerances are allowed.



## 1.2 Conditions for Guarantees:

For proving the performance guarantees, the following shall be provided by Owner to the LSTK Contractor.

**1.2.1** Raw materials and utilities in sufficient quantities conforming to the range of specifications supplied to LSTK Contractor by Owner and used as the design basis for Ammonia /Ammonium Nitrate/ Off-sites & Utility Plant.

**1.2.2** Purification Plant and Cooling Water Circulation are to be operated under the direction and supervision of LSTK Contractor/ Process licensor as defined in operating manuals to be supplied by LSTK Contractor/process licensors.

## 1.3 Consumption of Raw Materials & Utilities:

	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC009/E/001P-II/ SEC-8.0	P1	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b> <b><u>PERFORMANCE AND GUARANTEE TEST</u></b>	Document No.	Rev	
	Sheet 6 OF 14			

Consumption of raw materials and utilities shall be measured and calculated as per figures indicated by various calibrated instruments. **No instrument tolerance is acceptable during guarantee test and / or different operational phases.** All measuring instruments shall be part of the system/ plant installed by the LSTK Contractor and no special instrumentation for the purpose of guarantee tests shall be required. Contractor shall furnish overall raw material and utilities balance as per Attachment 1

#### 1.4 **Basis of Works Cost:**

- i) Costs mentioned in the clause 1.1.3 are indicative and may change at a later date. Revision, if any, will be intimated to LSTK Contractor before 15 days of price bid opening and the same shall be used for evaluation of the bids.
- ii) The guaranteed works cost shall include cost of materials and utilities required, for building cooling/heating, lighting, ventilations, air conditioning and consequent costs of such materials which are not in the usual operation of the plant.

#### 1.5 **Sustained Load Test Run Guarantee:**



The LSTK Contractor guarantees that the Sustained Load test described in this clause will be successfully completed. During the Sustained Load Test the contractor will demonstrate that the Purification Plant and Associated Cooling Towers operate for a minimum of 45 days at an aggregate output of min. 70% of the rated capacity (110% of normal capacity). If the contractor fails to achieve any of the requirements of this test, contractor shall remedy the Works to achieve the above guarantee, in a reasonable time frame, in consultation with Owner.

#### 1.6 **Capacity Guarantees:**

The LSTK Contractor shall guarantee the Purification Plant for capacities indicated as per this table.

Parameter	Units	Value (Bidder to indicate)
Ammonia synthesis gas on LSTK basis.	Nm <sup>3</sup> /Hr (Min/Nor/Max.)	* / 105000 /
Coarbon-di-oxide gas on LSTK basis.	Nm <sup>3</sup> /Hr (Min/Nor/Max.)	* / 24000+2550 /

Note: - \*- Minimum figures for checking turn-down parameters (minimum turn down ratio should not be less than 50% of design capacity).

	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC009/E/001P-II/ SEC-8.0	P1	
	<b><u>Bharat Coal Gasification and Chemicals Limited PERFORMANCE AND GUARANTEE TEST</u></b>	Document No.	Rev	
	Sheet 7 OF 14			

## 1.7 Quality Guarantees:

### 1.7.1 Product Ammonia Syn. Gas Quality:



Hydrogen (H <sub>2</sub> )	Vol %	~75
Nitrogen (N <sub>2</sub> )	Vol %	~25
Argon (Ar)	PPMV	30 (Max.)
Methane (CH <sub>4</sub> )	Vol %	Non Traceable
CO + CO <sub>2</sub> + other Oxygen bearing components	PPMV	5 (Max.)
Pressure	Kg/Cm2abs	18 (Min.)(hold)
Temperature	°C	30 (Max.) (hold)
Quantity	NM <sup>3</sup> /NM3 of feed clean syngas	(To be specified by LSTK CONTRACTOR)

### 1.7.2 Product Carbon-Di-oxide Gas Quality:

Sl. No.	Components	Composition	
1.0	Carbon dioxide (CO <sub>2</sub> ), Vol % (min).	98.5 (min., dry)	
2.0	Hydrogen (H <sub>2</sub> ), Vol % (max)	0.1 (dry)	
3.0	Nitrogen (N <sub>2</sub> ), Vol % (max)	1.0 (dry)	
4.0	Argon (Ar) Vol % (max)	0.01 (dry)	
5.0	Carbon Mono-Oxide (CO) Vol % (max)	0.15 (dry)	
6.0	Moisture Vol %	Saturated	
7.0	HCN PPM by Vol	1	
8.0	Methanol PPM by Vol	100 (max, dry)	
9.0	Sulphur (COS+H <sub>2</sub> S) PPM by Vol	5 (max)	
10.0	Pressure @ B.L of Coal Gasification Plant, kg/cm <sup>2</sup> g (Min.)	32	57
11.0	Temperature, °C	<100	270

### 1.7.3 By-Product Sulphur (solid) Quality:

Sulphur (S)	Wt. %(min, dry)	99.9
Hydrogen Sulphide (H <sub>2</sub> S)	Wt.ppm(max, dry)	10
Ash	Wt.ppm (max)	200
Pressure	Kg/Cm2abs	Atmospheric

	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC009/E/001P-II/ SEC-8.0	P1	
	<b><u>Bharat Coal Gasification and Chemicals Limited PERFORMANCE AND GUARANTEE TEST</u></b>	Document No.	Rev	
	Sheet 8 OF 14			

Temperature	°C	Ambient
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#### 1.7.5 Utility & Process Nitrogen Quality:

Parameter	Unit	Utility Value	Process Value
Nitrogen (N <sub>2</sub> )	Vol. %, Min.	99.99%	99.99%
Oxygen (O <sub>2</sub> )	Vol. PPM	< 10	< 10
Pressure (Min/Nor/Max.)	Kg/Cm <sup>2</sup> abs	7.0/9.0/10.0	36
Temperature	°C	Ambient	Ambient

#### 1.7.6 Effluent from Purification Plant:

Plant should be designed for zero liquid discharge (ZLD).

The failure to meet above guarantees shall be breach of contract requiring corrective action by LSTK contractor irrespective of the cost involved.

#### 1.7.7 Quality of HP/MP/LP Steam (if generated) Exported at B.L.:



The quality of Steam produced in Purification Plant shall be according to the Clause No-3.1, 3.2, 3.3 of Section 2.0 of Part-II Technical.

#### 1.8 Pollution Level:

LSTK Contractor shall guarantee the limits of pre-treated liquid effluents at the Battery Limit, gaseous emission to the atmosphere and noise levels (as specified) as per the relevant existing and latest norms of CPCB, PESO and other applicable stringent environmental norms of CPCB/ state pollution control board. The determination of the ability of Purification Plant to meet these guarantees will be made during the thirty days' guarantee test or at any other time under similar conditions prior to the Preliminary Acceptance of the Process Plant/ Units. In the event guaranteed pollution level are not fulfilled during the 30days' guarantee test it shall be breach of contract, requiring corrective action by LSTK contractor irrespective of the cost involved. The treated liquid effluents discharged from the ISBL Plants shall meet the following limits.

S. No.	Parameter	Unit	Norms. (Max.)
1	Odour & Colour	-	Odourless & Colourless
2	pH Value	-	6.5 to 8.0
3	Suspended solids	ppm	100
4	Oil and grease	ppm	10.0



	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC009/E/001P-II/ SEC-8.0	P1	
	<b><u>Bharat Coal Gasification and Chemicals Limited PERFORMANCE AND GUARANTEE TEST</u></b>	Document No.	Rev	
	Sheet 9 OF 14			

S. No.	Parameter	Unit	Norms. (Max.)
5	Total residual chlorine	ppm	1.0
6	Total Ammonical Nitrogen as "N"	ppm	50
7	Total Kjeldahl Nitrogen as "N"	ppm	100
8	Free ammonia (as NH <sub>3</sub> )	ppm	5.0
9	BOD as O (3 days at 27 <sup>0</sup> C)	ppm	30
10	COD as O	ppm	250
11	Lead (as Pb)	ppm	0.10
12	Copper (as Cu)	ppm	3.0
13	Zinc (as Zn)	ppm	5.0
14	Nickel (as Ni)	ppm	3.0
15	Fluoride (as F)	ppm	2.0
16	Dissolved Phosphates (as P)	ppm	5.0
17	Sulphide (as S)	ppm	2.0
18	Iron (as Fe)	ppm	3.0
19	Vanadium (as V)	ppm	0.20
20	Nitrate Nitrogen as "N"	ppm	10
21	Chromium (Cr)	ppm	2
22	Hexavalent Cr (Cr <sup>6+</sup> )	ppm	0.1
23	Mercury (as Hg)	ppm	0.01
24	Arsenic (As)	ppm	0.2

### 1.8.1 Gaseous Emission:


#### Stack gas Emission Limits:

S. No.	Source	Suspended Particulate Matter (mg/Nm <sup>3</sup> )	SO <sub>x</sub> (mg/Nm <sup>3</sup> )	NO <sub>x</sub> (mg/Nm <sup>3</sup> )	CO (mg/Nm <sup>3</sup> )
1.	Gas Purification section	≤ 5	<50	<250	<100

Note: Bidder to refer applicable latest statutory norms of stringent CPCB/state pollution control board.

The failure to meet above guarantees shall be breach of contract requiring corrective action by LSTK contractor irrespective of the cost involved.

### 1.8.2 Ground Level Concentration:

	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC009/E/001P-II/ SEC-8.0	P1	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b> <b><u>PERFORMANCE AND GUARANTEE TEST</u></b>	Document No.	Rev	
	Sheet 10 OF 14			

The LSTK Contractor shall guarantee the ground level concentration in the atmospheric air of LSTK plant area 5m inside boundary and shall not exceed the limits given below:

TLV (for 8 hrs working) – LSTK Plant Area

Parameter	Value
Ammonia	< 25 mg/Nm <sup>3</sup>
Hydrocarbons (Methane)	100 ppm
Carbon monoxide	2 ppm
Vanadium as V <sub>2</sub> O <sub>5</sub>	50 µg/Nm <sup>3</sup>

### 1.9 **Noise Level:**

LSTK Contractor shall guarantee the noise level within the ISBL Plant premises. Noise nuisance from machinery is normally specified as sound pressure level which for standard design shall not exceed, in work areas, 85dB (a) at 1m distance from each source. .

### 1.10 **Catalyst and Adsorbents Life Guarantees:**



The Catalysts in the Purification Plant shall retain their full abilities and performance for the following periods which commence from the date of Preliminary Acceptance of the Plant.

Sl. No	Service	Guaranteed Life (in years)
1.0	HT/LT (if applicable) shift converter catalyst	5
2.0	Adsorbents	3

Contractor guarantees that if any catalyst or adsorbent does not meet the guaranteed EOR conditions before the expiry of its guaranteed life as specified in table above, from the date of preliminary acceptance of plant, contractor shall replace as follows:

If the catalyst /adsorbent fail to fulfil the guarantee, contractor shall deliver full replacement of catalyst volume free of charge for the 1<sup>st</sup> year. For the 2<sup>nd</sup> & 3<sup>rd</sup> year replacement would be on pro-rata basis. Pro-rata catalyst volume shall be calculated by multiplying full charge of loaded catalyst volume with the ratio between un-expired portion of the 2<sup>nd</sup> & 3<sup>rd</sup> year (in days calculated from the date of failure) and 730 days.

Contractor shall pass on to Owner the residual catalyst/adsorbent life as guaranteed by the catalyst manufacturers to Contractor, if any, beyond the guaranteed life of catalyst under contract.

	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC009/E/001P-II/ SEC-8.0	P1	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b> <b><u>PERFORMANCE AND GUARANTEE TEST</u></b>	Document No.	Rev	
	Sheet 11 OF 14			

## 2.0 PERFORMANCE TESTS



### 2.1 General:

LSTK Contractor shall prove the performance guarantees during tests of the composite plant as specified in this clause under the following headlines:

- ❖ Sustained Load Test
- ❖ Notice of Guarantee Test
- ❖ Guarantee Test
- ❖ Measurements during Guarantee Test
- ❖ Inconsistent Measurements
- ❖ Deviations from Specifications
- ❖ Guarantee Test Results

#### 2.1.1 Sustained Load Test:

After Mechanical Completion has occurred, the LSTK Contractor shall commence the Commissioning operations of Purification along with Associated Cooling water requirement leading to generating Ammonia Syn. Gas & Carbon Dioxide Gas for Ammonia & Ammonium Nitrate production. After Purification Plant has commissioned and at least near rated daily capacity has been achieved, LSTK Contractor's authorised representative shall give notice in writing to Owner that Plant is ready for a sustained load test. On receipt of this notice, but not later than 15 days after the notice, Owner shall conduct the sustained load test under the direct supervision of LSTK Contractor for a consecutive period of 45 days or less at the discretion of the Owner. The sustained load test of the composite plant shall be deemed to have been completed if Plant produces an average of not less than 70% of the daily rated capacity (110% of normal capacity). If, during the sustained load test, there are interruptions due to reasons not attributable to the obligations and responsibilities of LSTK Contractor, periods of such interruptions shall be included and regarded as days of operation at min. 95% of daily rated capacity or actual load prior to interruptions whichever is lower. The cumulative period of such interruptions shall be limited to a maximum of **7** (seven) days. Owner shall have the option to reduce the period of sustained load test of 45 days. During the sustained load test, LSTK Contractor shall use their best efforts to ensure that pollution level and noise level are within the limits specified in the Contract. LSTK Contractor shall endeavour to complete the sustained load test within a reasonable period after Mechanical completion, but shall complete the same in any case within 90 days from Mechanical completion. If, during the sustained load test, corrective measures are

	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC009/E/001P-II/ SEC-8.0	P1	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b> <b><u>PERFORMANCE AND GUARANTEE TEST</u></b>	Document No.	Rev	
	Sheet 12 OF 14			

required and involve procurement of new items of Equipment or modification of items of Equipment which require longer period for delivery than covered by the 180 days period, the period shall be suitably adjusted as agreed with Owner. However, design engineering and placement of orders shall be completed within 90 days from Mechanical completion. On satisfactory completion of the sustained load test, the results achieved shall be tabulated and jointly signed by LSTK Contractor's and Owner's representatives within ten days of completing the sustained load test. During the sustained load test, no standby items of Equipment shall be used in parallel for completing the test.




### **2.1.2 Notice of Guarantee Test:**

On successful completion of the sustained load test, LSTK Contractor shall give notice in writing for commencing the guarantee test. On receipt of the notice, but not later than 15 days after the notice, Owner shall conduct the guarantee test run under the direction and supervision of LSTK Contractor. During the guarantee test, no stand by items of Equipment shall be used in parallel for proving the guarantee. The range of operating conditions shall be within the design conditions.

### **2.1.3 Guarantee Test:**

The guarantee test shall be carried out for 7 (Seven) consecutive days. In determining the ability of the composite plant to meet the guarantees all feed rates, product rates and quality, and utility consumption shall be averaged over a period consisting of best continuous 72 hours selected out of the 7 (Seven) days test period. The 72 consecutive hours period shall exclude periods during the test when the operating conditions are other than those recommended or approved by LSTK Contractor or periods of non-operation due to failure of Equipment, lack of sufficient feed or utilities, or any other cause beyond the control of LSTK Contractor including the period required to bring Ammonia Syn. gas generation Unit back to operation at the rate of production achieved prior to the upset. For the purpose of computing the average performance, LSTK Contractor shall select any best continuous 3 days out of the 7 days test period so long as this includes a continuous and uninterrupted run of 72 (Seventy two) hours and the aggregate total hours of interruptions do not exceed 96 hours.

In case of failure (beyond acceptable limits/parameters where Mutually Agreed Damages' are levied) of 1<sup>st</sup> Guarantee test, the LSTK Contractor shall within 30 days from the beginning of the 1<sup>st</sup> guarantee test shall give a full and detailed statement in writing to OWNER. The statement shall contain the detailed description and corrective measures which LSTK Contractor intends to take and the time required for the same to be completed and a repeat guarantee test to be made.

	<div><div><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b></div><div><b><u>Bharat Coal Gasification and Chemicals Limited</u></b> <b><u>PERFORMANCE AND GUARANTEE TEST</u></b></div></div>	PC009/E/001P-II/ SEC-8.0	P1	 
		Document No.	Rev	
		Sheet 13 OF 14		

LSTK contractor shall wherever possible shall carry out such corrective measures and repeat the guarantee test within the shortest possible time, but not later than 90 days from the beginning of the first guarantee test unless otherwise agreed with Owner.

If the guarantee test has not been conducted within a period of 12 (twelve) months from Mechanical completion for reasons not attributable to LSTK Contractor, then LSTK Contractor and Owner shall consult and agree on conducting a guarantee test for plants.

During the Guarantee Test Run, the Production capacity of Purification Plant for generating Ammonia Syn. Gas & Carbon Dioxide Gas for Ammonia & Ammonium Nitrate production shall be guaranteed as follows:

Parameter	Units	Value (Bidder to indicate)
Ammonia synthesis gas on LSTK basis.	Nm <sup>3</sup> /Hr (Min/Nor/Max.)	- / 105000 / -
Coarbon-di-oxide gas on LSTK basis.	Nm <sup>3</sup> /Hr (Min/Nor/Max.)	- / 24000+2550 / -



This guarantee for the Purification Plant capacity shall be substantially proved when 105000 Nm<sup>3</sup>/Hr of Ammonia Syn. gas is going to Ammonia Plant to produce Ammonia. The product quality as specified shall also be met during the Guarantee Test Run. Also LSTK Contractor shall demonstrate that the ISBL Plant is capable of producing 1.1 × 105000 Nm<sup>3</sup>/Hr Ammonia Syn. Gas and 1.1 × 24000+2550 Nm<sup>3</sup>/Hr Carbon-di-oxide Gas for (12+12) continuous hours or as mutually agreed by LSTK Contractor/ Owner/ PMC.

LSTK Contractor shall demonstrate that the ISBL Plant is capable of producing 0.5× 105000 Nm<sup>3</sup>/Hr Ammonia Syn. Gas and 0.5× (24000+2550) Nm<sup>3</sup>/Hr Carbon-di-oxide Gas for 12 continuous hours or as mutually agreed by LSTK Contractor/ Owner/ PMC.

Note: - Minimum figures for checking turn-down parameters (minimum turn down ratio should be not less than 50% of design capacity).

#### **2.1.4 Measurements during Guarantee Test:**

For determination of the average performance achieved during the guarantee test, all inputs and outputs shall be measured through appropriate meters specified and installed in plant by LSTK Contractor and jointly calibrated and certified to be correct by LSTK Contractor and Owner. No metering tolerances shall be allowed. LSTK Contractor shall have all measurements and records certified by Owner beforehand.

	<b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b>	PC009/E/001P-II/ SEC-8.0	P1	
	<b><u>Bharat Coal Gasification and Chemicals Limited</u></b> <b><u>PERFORMANCE AND GUARANTEE TEST</u></b>	Document No.	Rev	
	Sheet 14 OF 14			

#### **2.1.5 Inconsistent Measurements:**

If any measurement is demonstrably inconsistent with the bulk of the data, or is otherwise suspected to be incorrect, then meter will be re-calibrated. Inconsistency in metering after the calibration if observed then it has to be rectified or in the worst case, meter to be replaced. However in no case, reading should be adjusted.

#### **2.1.6 Deviations from Specifications:**

In the event that the feed gas, fuel gas, utilities, climatic conditions, or any other conditions is not in accordance with conditions specified or referred to in Contract and are prejudicial to LSTK Contractor or Owner as demonstrated by LSTK Contractor or Owner, Owner and LSTK Contractor shall mutually, reasonably, and in good faith negotiate an adjustment to the performance guarantees. Any such adjustments to the performance guarantees shall be made utilising the same methods of calculation as were used in establishing the original performance guarantees to the extent such methods continue to be applicable in accordance with good engineering principles and practice.

#### **2.1.7 Guarantee Test Results:**

Within a reasonable period of time but not later than 15 working days from the completion of the guarantee test, Contractor shall determine the results thereof and if in LSTK Contractor's judgement, the performance guarantees have been achieved, submits its calculations and report to Owner for Owner's acceptance. The method of calculation for the Guarantee Test Run shall be mutually agreed by LSTK Contractor, Owner and PMC before starting of Guarantee Test Run. All data will be collected jointly in presence of LSTK contractor, Owner and PMC. Owner will review the report, calculations and the supporting data and accept the same in writing, if the results are in accordance with the provisions of this Section. In case, Owner does not accept the performance guarantee results, Owner shall indicate in writing to LSTK Contractor in what respect the performance guarantees have not been met, within 15 working days of receipt of the report by Owner from the LSTK Contractor. In the event of rejection of Guarantee test results by Owner, LSTK Contractor shall take immediate actions to set right as per the provisions of the contract and repeat guarantee test to the satisfaction of Owner.

 <b>पी डी आई एल</b> <b>PDIL</b>	<b>PROJECTS &amp; DEVELOPMENT INDIA LIMITED</b>	PC-288/E001/Sec-9	P	 
		Document No.	Rev	
		Sheet 1 of 24		



## SECTION : - 9.0

### DRAWINGS AND DOCUMENTS

**PLANT : SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE.**

**PROJECT : SETTING UP OF HIGH ASH COAL-TO-AMMONIUM NITRATE PLANT IN MAHANADI COALFIELDS LIMITED (MCL).**



**CLIENT : Bharat Coal Gasification and Chemicals Limited (BCGCL).**

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER:</b> <u>Bharat Coal Gasification and Chemicals Limited</u> <b>DRAWINGS AND DOCUMENTS</b></div>	PC-288/E/Sec-9	P	<div> बी एच ई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 2 of 24		



## PROCESS

S. No	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
1.0	Basis of Design	Y	Y		Y
2.0	Process Description	Y	Y		Y
3.0	Process Flow Diagram	Y	Y		Y
4.0	Utility flow diagram	Y	Y		Y
5.0	Material Selection diagram	Y	Y		Y
6.0	P&I Diagrams	Y	Y		Y
7.0	Utility/Chemical Requirements	Y	Y		Y
8.0	Data sheet of all equipment and machinery	N	Y		Y
9.0	Process Specifications of catalysts, chemicals, compressors, and reformer	Y	Y		Y
10.0	Logic diagrams	N	Y		Y
11.0	Safety valve Specifications	N	Y		Y
12.0	Instrumentation Control philosophy	Y	Y		Y
13.0	HAZOP Study and Compliance report	N	Y		Y
14.0	Flare Load Summary	Y	Y		Y
15.0	Plot Plan (Preliminary)	Y	Y		Y
16.0	Operating Manuals and maintenance manuals (Preparation for startup, Normal startup, operation, shutdown and emergency shutdown guidelines)	N	Y		Y
17.0	Analytical Manual / MSDS	N	Y		Y





<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></div> <div><b>OWNER:</b> <u>Bharat Coal Gasification and Chemicals Limited</u></div> <div><b>DRAWINGS AND DOCUMENTS</b></div>	PC-288/E/Sec-9	P	<div><div>बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 3 of 24		

S. No	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approve d/ As-built
	<b>ELECTRICAL</b>				
1.0	Load List indicating rated and absorbed power of loads and duty type (Continuous / Standby / Intermittent) at different voltages including emergency loads.	N	-	Y	Y
2.0	Load Data indicating normal, peak, starting and construction power requirement at various voltage levels.	N	-	Y	Y
3.0	Single line distribution diagram (power, lighting, DC supply and UPS supply) including protection and metering details giving rating of each equipment.	N	Y	-	Y
4.0	Specification Sheets and Technical Particulars of Electrical Equipment	N	Y	-	Y
5.0	General arrangement and foundation drawings of all equipment.	N	-	Y	Y
6.0	Equipment layout in Sub Station, MCC room, and plant area showing location of all electrical equipment.	N	Y	-	Y
7.0	Cable schedule.	N	--	Y	Y
8.0	Cable rack / trench / pipe layout.	N	Y	-	Y
9.0	Power Layout.	N	-	Y	Y
10.0	Schematic diagram for all control panel & switch boards.	N	-	Y	Y
11.0	Feeder Details of all switch boards	N	Y	-	Y
12.0	Interconnection & Terminal connection diagram	N	-	Y	Y
13.0	List of controls, interlocks, indication & metering at various locations for all drives.	N	-	Y	Y
14.0	Characteristic curves for motor/ relays etc.	N	-	Y	Y
15.0	Sizing Calculations for Electrical System and Equipment.	N	Y	-	Y
16.0	Design calculations (for system design and equipment sizing,	N	Y	-	Y



<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER:</b> <u>Bharat Coal Gasification and Chemicals Limited</u> <b>DRAWINGS AND DOCUMENTS</b></div>	PC-288/E/Sec-9	P	<div></div>
		Document No.	Rev	
		Sheet 4 of 24		

	earthing, lighting, cables, bus ducts etc.)				
17.0	Earthing and lightning protection layout	N	Y	-	Y
18.0	Lighting layout and Distribution diagram	N	Y	-	Y
19.0	Drawings and documents asked for each equipment as per respective Technical Specifications	N	Y	-	Y
20.0	Control & operation write up/Block logic diagrams.	N	-	Y	Y
21.0	Catalogues for all bought out items	N	-	Y	Y
22.0	Bill of Materials covering all electrical equipment and installation materials	N	-	Y	Y
23.0	Installation operation and maintenance(Manual)	N	-	-	Y
24.0	System study Report	N	-	Y	Y
25.0	Spare Parts list	N	-	Y	Y
26.0	Test Certificates	N	-	Y	Y
27.0	Guarantee Certificates	N	-	Y	Y
28.0	Quality Assurance Plan & Formats	N	Y	-	Y
29.0	Hazardous area Classification Drawing	Y	Y	-	Y
30.0	Erection Drawings & Details	N	Y	-	Y
31.0	Construction & Commissioning specification and procedure for all equipment.	N	-	Y	Y
32.0	Any other drawings & data as required for satisfactory installation, operation & maintenance.	N	Y	Y	Y
<b>MECHANICAL PIPING</b>					
1.1	Equipment layout drawing.	Y	Y	-	Y
1.2	Piping Layout drawing.	N	Y	-	Y
1.3	Quality control procedure & plan for piping system.	Y	Y	-	Y
1.4	Service Index	Y	Y	-	Y



	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>	PC-288/E/Sec-9	P	
		Document No.	Rev	
		Sheet 5 of 24		
<b>DRAWINGS AND DOCUMENTS</b>				

1.5	Design data and layout.				
1.6	Design basis	Y	Y	-	Y
1.7	Criteria for Flexibility Analysis	Y	Y	-	Y
1.8	Piping material specification	N		Y	Y
1.9	Issued for construction (IFC) Drawing.				
1.9.1	Piping GA DRGS.	N	-	Y	Y
1.9.2	Isometrics	N	-	Y	Y
1.9.3	Piping supports, operating platforms drawing.	N	-	Y	Y
<p>Legends:</p> <p>Y : Yes</p> <p>N : No</p> <p>Note :</p> <p>1. 6 copies of drawings shall be supplied with Bid and 8 copies of Final documentations shall be supplied in hard copies as well as 2 soft copies in CD formats. Applicable software are MS Office 2013 &amp; Above , Word, Access, Excel, Autocad.</p> <p>2. Package vendor shall prepare all the instrument specifications and detail instrument engineering documents in the INTOOLS software package.</p> <p>3. Document marked as (**) are to be approved by authorised Third Party Inspection Agency and Statutory Authorities as applicable.</p>					



MECHANICAL ROTATING EQUIPMENTS					
A.	Pumps				
1.0	List of drawings / documents including drawing number, revision number, description and approval status	N	Y	-	Y
2.0	Detailed manufacturing programme (Time bar chart )	N	Y	-	Y
3.0	Certified dimensional outline drawing	Y	Y	-	Y
4.0	Cross sectional drawing and bill of material	N		Y	Y
5.0	Shaft seal drawing and bill of material	N	Y	-	Y
6.0	Shaft coupling assembly drawing and bill of materials including allowable misalignment clearances, shaft bores & key ways dimensions with tolerances and the style of coupling guard	N	Y	-	Y
7.0	Primary & auxiliary sealing schematic and bill of materials including seal fluid, fluid flows, pressure pipe and valve sizes, instrumentation, orifice sizes, and piping arrangement drawings	N	Y	-	Y
8.0	Cooling or heating schematic and bill of materials including cooling & heating media, fluid flows, pressure, pipe and valve sizes, instrumentation, orifice sizes and piping arrangement drawings	N	Y	-	Y
9.0	Lube oil schematic and bill of materials	N	Y	-	Y
10.0	Lube oil system arrangement drawing including sizes, rating and location of all customer connections	N	Y	-	Y
11.0	Lube oil component drawings data	N	Y	-	Y
12.0	Electrical and instrumentation schematics, wiring diagrams and bill of materials	N	Y	-	Y
13.0	Electrical and instrumentation arrangement drawing and list of	N	Y	-	Y

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER:</b> <u>Bharat Coal Gasification and Chemicals Limited</u> <b>DRAWINGS AND DOCUMENTS</b></div>	PC-288/E/Sec-9	P	<div><div>बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 7 of 24		

	components				
14.0	Performance curves	N		Y	Y
15.0	Pump specification sheet with complete details in Performa enclosed with enquiry / order	N	Y	-	Y
16.0	Certified foundation assembly drawing of pump with driver & all accessories mounted on base plate with load diagram for foundation design (In case of motor being procured by purchaser, motor frame details will be supplied to vendor within 4 weeks.)	N	Y	-	Y
17.0	Engineering flow diagram showing: - Lubrication & sealing lines - Flushing / washing lines - Cooling / steam lines	N	Y	-	Y
18.0	Reference list for pumps supplied in past for similar duty conditions. Reference list shall contain complete address of user, user's purchase order number, brief specifications and date of commissioning , if owner desires		Y	-	
19.0	Lube oil schedule	N	-	-	Y
20.0	Automatic recirculation valve assembly drawing, sectional drawing with bill of material	N	Y	-	Y
21.0	Quality Assurance Plan / Inspection test plan	N	Y	-	-
22.0	Material test certificates and Inspection & performance test report along with dispatch clearance certificates from inspector	N	-	-	Y
23.0	Instruction manuals describing installation, operation and maintenance procedures	N	-	-	Y
24.0	Spare parts list		Y	-	Y
25.0	Parts catalogue complete with reference drawing nos. and sketches etc.	N	-	-	Y
<b>B.</b>	<b>COMPRESSORS</b>				
1.0	List of drawings / documents	N	Y	-	Y

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER:</b> <u>Bharat Coal Gasification and Chemicals Limited</u> <b>DRAWINGS AND DOCUMENTS</b></div>	PC-288/E/Sec-9	P	<div><div>बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 8 of 24		




	including drawing number, revision number, description and approval status				
2.0	Detailed manufacturing programme (Time bar chart )	N	Y	-	Y
3.0	Specification sheet complete filled in PDIL Performa enclosed with enquiry/order.	N	Y	-	Y
4.0	Equipment layout with main overall dimensions including those required for foundations and piping design for compressor and auxiliaries. (This layout shall include the driven equipment and its auxiliaries).	Y	Y	-	Y
5.0	Performance curves for Centrifugal compressor :	N		Y	Y
	i) For turbine driven compressor, Discharge pressure, Brake horse power, Polytropic head and Efficiency Vs Inlet capacity (from surge point to 115 % of rated capacity) of the compressor at specified inlet pressure, temp. and mol. wt. of the gas and at 80, 90, 100 and 105 % speed for each stage and for overall compressor				
	ii) For constant speed motor driven compressors Discharge pressure , Brake horse power , Polytropic head and Efficiency Vs Inlet capacity ( from surge point to 115 % of rated capacity ) of the compressor at specified inlet pressure, temp. and mol. wt of the gas for each stage and for overall compressor				
	iii) Torque Vs Speed curve for the compressors.		-		
6.0	Performance Curve	N		Y	Y
7.0	i) Calculation of the lateral critical speeds of the compressors. ii) Calculation of the torsional critical speeds. Analytical report for torsional vibration of whole set. iii) Thrust loading curves for each casing / barrel for various operating conditions.	N	-	Y	Y

<div><div></div><div>पी डी आई एल <b>PDIL</b></div></div>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>		PC-288/E/Sec-9	P	<div><div></div><div>बी एच ई एल <b>BHEL</b></div></div>
	<b>OWNER: <u>Bharat Coal Gasification and Chemicals Limited</u></b>		Document No.	Rev	
	<b>DRAWINGS AND DOCUMENTS</b>		Sheet 9 of 24		



	iv) Response curve of deflection Vs RPM for varying amount of imbalance. v) Torsional critical response curve				
8.0	Overall dimensional drawing with all main dimensions, size and location of piping connections for compressors and its auxiliaries.	N	Y	-	Y
9.0	Cross sectional drgs. Of the compressor showing details of construction including sealing details, bearing etc. With part no., description and material of construction.	N		Y	Y
10.0	Coupling drawings	N	-	Y	Y
11.0	Seal assembly drawings & Bill of material	N	-	Y	Y
12.0	Lube oil Pumps				
	a) Specification sheet	N	Y		Y
	b) Performance curve	N	Y		Y
	c) Cross Sectional drawing	N			Y
13.0	Certified foundation scope drawing of the compressor with driver and all accessories resting on the foundation and control panel. In the event of motor not in the scope of supply of vendor the motor frame dimensions shall be supplied by the purchaser later). Direction and magnitude of all unbalanced forces, couples and centre of gravity along with direction of rotation shall also be mentioned	N	Y	-	Y
14.0	a) Engineering flow diagram indicating all instruments, valves, etc. marked with battery limit of supply of :  - Process Gas lines - Cooling Water lines - Lubricating Oil lines - Condensate drain and vent lines  The above drawings shall identify all components by size, pressure rating and material	Y	Y	-	Y

	b) Material balance for gas, lube & seal oil.				
15.0	Piping layout plan and elevation drawings for gas, cooling water and utility lines, lube and seal oil lines etc.	N	Y	-	Y
16.0	Driver : Selection details a) Speed - torque diagram b) GD2 of the rotating masses of the compressor referred to the motor speed	N	-	Y	Y
17.0	a) Piping isometrics for gas pipes DN>20, piping manifold and all oil lines. b) Flexibility analysis for gas lines.	N	-	-	Y
18.0	Piping support location drgs. With forces, moments and movements for gas pipes and with weights for all lines.	N	Y	-	Y
19.0	Certified allowable forces, moments, movements, stresses for compressor nozzles.	N	Y	-	Y
20.0	Bill of Material for Piping and supports.	N	Y	-	Y
21.0	Bill of Material for insulation for Piping.	N	Y	-	Y
22.0	Bill of quantity for Painting for piping, equipments and auxiliaries.	N	Y	-	Y
23.0	Thermal calculation for heat exchangers, Mechanical calculation and fabrication drawings for heat exchangers and Pressure vessels.	N	Y	-	Y
24.0	Inspection and Test Procedure.	N	-	-	Y
25.0	Quality Assurance Plan / Inspection test plan	N	Y	-	-
26.0	Inspection and test reports, material test certificates, radiographic reports duly approved by specified inspecting authority, certificates for compressors, heat exchangers, pressure vessels, pipings, valves, instruments and other auxiliaries.	N	-	-	Y





	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>		PC-288/E/Sec-9		P
	<b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>		Document No.		Rev
	<b>DRAWINGS AND DOCUMENTS</b>		Sheet 11 of 24		 



27.0	Lubrication schedule	N	-	-	Y
28.0	Reference list supplied in past for similar duty conditions. Reference list shall contain complete address of user, user's purchase order number, brief specifications and date of commissioning , if owner desires		Y		
29.0	Instruction manual for erection, installation, operation and maintenance of compressor and its accessories (important clearances to be maintained should be clearly specified.).	N	-	-	Y
30.0	Spare parts list		Y	-	Y
31.0	List of special tools	Y	-	Y	Y
32.0	Installation list of similar machines shall also include the following : a) Client, location and year of installation b) Drive c) Model No. and type of compressor d) Duty condition of the compressor e) Speed and KW rating	N	-	-	-
<b>C.</b>	<b>TURBINE</b>				
1.0	List of drawings / documents including drawing number, revision number, description and approval status	N	Y	-	Y
2.0	Detailed manufacturing programme (Time bar chart )	N	Y	-	Y
3.0	Specification sheet with complete details in proforma enclosed with enquiry/order	N	Y	-	Y
4.0	Equipment layout with main overall dimensions including those required for foundations and piping design for Turbine and auxiliaries.	Y	Y	-	Y
5.0	Performance curves for steam turbine : a) steam consumption versus KW ( for various extraction rate in case of extraction	N		Y	Y

<div><div>पी डी आई एल PDIL</div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></div> <div><b>OWNER: <u>Bharat Coal Gasification and Chemicals Limited</u></b></div> <div><b>DRAWINGS AND DOCUMENTS</b></div>	PC-288/E/Sec-9	P	<div><div>बी एच आई एल BHEL</div></div>
		Document No.	Rev	
		Sheet 12 of 24		



	turbine) b) overall efficiency vs. load curve c) steam consumption correction curves d) curve showing variation of exhaust temperature with inlet flow (i.e. under various loads) : - for change in live steam pressure - for change in live steam temperature - for change in speed from governor set point speed to max. continuous speed - for change in cooling water inlet temperature from 25°C to 35°C				
6.0	Thrust loading curves of each casing / barrel for various operating conditions	N	-	Y	Y
7.0	Overall dimensional drawing with all main dimensions, size and location of piping connections for turbine and its auxiliaries.	N	Y	-	Y
8.0	Cross sectional drawings of the turbine showing details of construction including governor, inlet trip and control valves sealing details, bearing details etc. With part no., description and material of construction.	N		Y	Y
9.0	Description of governing system	N	-	Y	Y
10.0	Blading plan for turbine	N	-	Y	Y
11.0	Coupling drawings	N	-	Y	Y
12.0	a) Engineering Flow diagram indicating all the Instruments with limit of supply of steam and condensate lines, lube and control oil lines, Flushing and washing line and cooling water lines.	N	Y	-	Y

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER:</b> <u>Bharat Coal Gasification and Chemicals Limited</u> <b>DRAWINGS AND DOCUMENTS</b></div>	PC-288/E/Sec-9	P	<div><div>बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 13 of 24		



	b) Material balance for steam condensate, lube & control oil.				
13.0	Certified civil scope drawings for foundation of steam turbine and all auxiliaries.	N	Y	-	Y
14.0	Piping layout plan, elevation and support drawings for steam and condensate lines, lube and control oil lines, gland sealing steam lines, flushing and washing lines.	N	Y	-	Y
15.0	a) Piping isometrics for steam pipes for DN>20, piping manifold and all oil lines b) Flexibility analysis for steam lines	N	Y	-	Y
16.0	Piping support location drgs. With forces, moments and movements for steam and condensate pipes and with weights for all lines	N	Y	-	Y
17.0	Certified allowable forces, moments, movements, stresses for turbine nozzles.	N	-	Y	Y
18.0	Calculation of the lateral critical speeds of the turbines, Campbell diagram and Goodman diagram.	N	-	Y	Y
19.0	Bill of materials for piping and supports.	N	Y	-	Y
20.0	Bill of materials for insulation for piping.	N	Y	-	Y
21.0	Bill of quantity for painting for piping, equipments and auxiliaries.	N	Y	-	Y
22.0	Thermal calculation for heat exchangers, Mechanical calculation and fabrication drawings for heat exchangers and pressure vessels.	N	Y	-	Y
23.0	Instruction and Maintenance manual for erection & maintenance of turbine and its accessories (important clearances to be maintained should be clearly specified.).	N	-	-	Y
24.0	Cross sectional drawings of the Barring gear.	N	-	Y	Y

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></div> <div><b>OWNER:</b> <u>Bharat Coal Gasification and Chemicals Limited</u></div> <div><b>DRAWINGS AND DOCUMENTS</b></div>	PC-288/E/Sec-9	P	<div><div>बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 14 of 24		



25.0	Lubrication schedule	N	-	-	Y
26.0	Inspection and Test Procedure.	N	-	-	Y
27.0	Quality Assurance Plan / Inspection test plan	N	Y	-	Y
28.0	Inspection and test reports, material test certificates, radiographic reports duly approved by specified inspecting authority.	N	-	-	Y
29.0	Reference list for Turbines supplied in past for similar duty conditions. Reference list shall contain complete address of user, user's purchase order number, brief specifications and date of commissioning , if owner desires		Y	-	-
30.0	Spare parts list		Y	-	Y
31.0	Parts catalogue complete with reference drawing nos. and sketches etc.	N	-	-	Y
<b>D.</b>	<b>FANS &amp; BLOWERS</b>				
1.0	Specification sheets completely filled in proforma.	N	Y	-	Y
2.0	Characteristic Curves - Performance curves, showing discharge pressure, capacity, and brake horse power at the inlet specified conditions (Pressure, capacity, temperature, molecular weight).	N		Y	Y
3.0	Spare parts list		Y	-	Y
4.0	Details of Lubrication and sealing system	N	-	-	Y
5.0	Data for selection of motor :	N	Y	-	Y
	a) Type				
	b) HP absorbed at duty point				
	c) RPM				
	d) Recommended HP				
	e) Max. starting torque as % NRT				
	f) GD2 figure for rotating mass of the Fan / Blower				

<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER:</b> <u>Bharat Coal Gasification and Chemicals Limited</u> <b>DRAWINGS AND DOCUMENTS</b></div>	PC-288/E/Sec-9	P	<div></div>
		Document No.	Rev	
		Sheet 15 of 24		



	g) Speed vs. Torque for the Fan / Blower				
6.0	General Arrangement Drawing with all main dimensions, size and location of connections for ducting with all horizontal & vertical clearance necessary for installation and disassembly.	N	Y	-	Y
7.0	Cross sectional drawing of fan with parts list	N		Y	Y
8.0	Instruction manual for erection, installation operation and maintenance of fan and its accessories (Important clearances to be maintained should be clearly specified).	N	-	-	Y
9.0	Quality Assurance Plan / Inspection test plan	N	Y	-	Y
10.0	Lubrication schedule	N	-	-	Y
11.0	Reference list indicating duty condition, location, year of installation, name of client, if owner desires		Y	-	-
12.0	GA drawing with all details & dims. Including fan, drive, motor	Y	Y	-	Y
13.0	Description of capacity control with details	Y	-	-	Y
E.	AGITATORS				
1.0	Specification sheets completely filled in PDIL proforma.	N	Y		Y
2.0	General Arrangement Drawing with all main dimensions, size and location of connections for installation and disassembly.	N	Y		Y
3.0	Spare parts list		Y		Y
4.0	Details of Lubrication and sealing system	N	-	-	Y
5.0	Instruction manual for erection, installation operation and maintenance of fan and its accessories (Important clearances to be maintained should be clearly specified).	N	-	-	Y

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b>		PC-288/E/Sec-9		P
	<b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>		Document No.		Rev
	<b>DRAWINGS AND DOCUMENTS</b>		Sheet 16 of 24		

6.0	Quality Assurance Plan / Inspection test plan		Y		Y
7.0	Reference list indicating duty condition, location, year of installation, name of client , if owner desires		Y	-	
F.	<b>EOT</b>				
1.0	Data sheets – completely filled		Y		Y
2.0	General arrangement Drg.showing various details & all principal dimensions of the assembled unit, horizontals and vertical clearances and approaches		Y		Y
3.0	Spare parts list		Y		Y
4.0	Quality Assurance Plan / Inspection test plan		Y		Y
5.0	Reference list indicating, location, year of installation, name of client , if owner desires		Y		
G.	<b>HVAC System</b>				
1.0	List of drawings / documents including drawing number, revision number and Description & approval status		Y		Y
2.0	Specification sheets -Completely filled in agreed proforma.		Y		Y
3.0	General Assembly drawings with main overall dimensions including those required for accessories and auxiliaries and all horizontal & vertical clearances for dismantling, direction of rotation etc		Y		Y
4.0	Quality Assurance Plan / Inspection test plan		Y		Y
5.0	Spare part list		Y		Y
6.0	Cross-Sectional drawing of AC Plant and auxiliaries alongwith Bill of Materials.			Y	Y
7.0	Reference list for similar types of AC Plant supplied in past for similar duty conditions. Reference list shall contain complete address of user, user's purchase order number, brief specifications and date of commissioning along with operating conditions , if owner desires		Y		
<b>MECHANICAL STATIC EQUIPMENT</b>					
<b>A. STORAGE TANK</b>					



<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER:</b> <u>Bharat Coal Gasification and Chemicals Limited</u> <b>DRAWINGS AND DOCUMENTS</b></div>	PC-288/E/Sec-9	P	<div><div>बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 17 of 24		

1.1	Contractor document index with schedule of submission	-	-	Y	-
1.2	Mechanical Engineering Datasheet	-	-	Y	Y
1.3	General arrangement drawings of tank indicating design data , fabricated equipment weight, general notes, nozzle schedule, details of shell, supporting arrangement , main weld seams ,nozzle orientation plan etc.	N	Y	-	Y
1.4	Bottom And Annular Ring Layout & Weld Detail	N	Y		Y
1.5	Detail of sump for drain nozzles	N		Y	Y
1.6	Shell plate layout (showing location of nozzles and manhole)	N		Y	Y
1.7	Mechanical design calculations complying with the specifications and codes.	N	Y	-	Y
1.8	Detail of wind girder	N	Y	-	Y
1.9	Stairways, intermediate & top plate form	N	-	Y	Y
1.10	Roof plate layout & weld detail	N	Y	-	Y
1.11	Detail of nozzles on shell & roof	N	-	Y	Y
1.12	Details of internals like guide rollers, roof stoppers, still wells, dip pipe, heating coil e.t.c	N	-	Y	Y
1.13	Materials test certificates duly stamped by inspecting authority ( ** )	N	-	-	Y
5.14	QAP & inspection and test plan ( ** )	N	Y	-	Y
1.15	Welding procedure and qualification test reports ( ** )	N	-	Y	Y
1.16	Destructive and non destructive procedure & test reports ( ** )	N	-	Y	Y
1.17	Heat treatment, Hydro test procedure and time temperature charts ( ** )	N	-	Y	Y
1.18	Records of vacuum box test, spark test for rubber lining, plumpness, roundness, peaking, banding etc. ( ** )	N	-	Y	Y
1.19	Radiographic examination reports ( ** )	N	-	-	Y
1.20	Certified 'as built' drawings Incorporating actual dimensions And material used, duly certified by the inspector	N	-	Y	Y
1.21	Completion certificates (including inspection certificates, hydrostatic test certificate , local code	N	-	Y	Y



<div><div>पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER:</b> <u>Bharat Coal Gasification and Chemicals Limited</u> <b>DRAWINGS AND DOCUMENTS</b></div>	PC-288/E/Sec-9	P	<div><div>बी एच ई एल <b>BHEL</b></div></div>
		Document No.	Rev	
		Sheet 18 of 24		

	requirements) ( ** )				
1.22	Vendor's quality assurance Practice ( ** )		-	-	Y
1.22	1. Final civil load data including details of foundation/anchor bolts 2. Foundation settlement check record ( ** )	N	-	Y	Y
1.23	List of spare parts and details ( ** )	N	Y	-	Y
1.24	Information on all bought out Components i.e vendors, size, model No., catalogues, installation & Operating manual, drawings and Calculations as applicable	-	-	Y	Y
Document marked as ( ** ) are to be approved by authorized Third Party Inspection Agency and Statutory Authorities as applicable.					
<b>B. PRESSURE VESSEL/ FILTER/COLUMN/ REACTOR e.t.c</b>					
1.1	<b>Mechanical Engineering Datasheet</b>	-	-	Y	Y
1.2	General arrangement drawings indicating design data , fabricated equipment weight, general notes, nozzle schedule, details of shell, heads supporting arrangement , main weld seams ,nozzle orientation plan etc	N	Y	-	Y
1.3	Detail of nozzles, manholes, accessories etc.	N	-	Y	Y
1.4	Detail of internals such as tray, tray support ring, bolting bars etc.	N	-	Y	Y
1.5	Detail of demister	N	Y	-	Y
1.6	Mechanical & Structural Design calculations, Hydrodynamic calculation for Internals including fabrication drgs. of main equipment & Internals complying with the specifications and codes.	N	Y	-	Y
1.7	Detail of packing support, demister support, grating & grating support	N	Y	-	Y
1.8	Detail of internal distributor	N	Y	-	Y
1.9	Detail of external clips such as ladder, platform, pipe support	N	-	Y	Y
1.10	Detail of insulation ,fireproofing	N	-	Y	Y
1.11	Detail of pipe davit	N	-	Y	Y
1.12	Detail of lifting lug, tailing lug & trunion etc. including design calculation	N	-	Y	Y
1.13	Shell development drawings incorporating all attachments and weld seams	N	-	Y	Y
1.14	Name plate drawing detail along	N	Y	-	Y





<div><div>पी डी आई एल PDIL</div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></div> <div><b>OWNER:</b> <u>Bharat Coal Gasification and Chemicals Limited</u></div> <div><b>DRAWINGS AND DOCUMENTS</b></div>		PC-288/E/Sec-9	P	<div><div>बी एच आई एल BHEL</div></div>
			Document No.	Rev	
			Sheet 19 of 24		

	with name plate bracket				
1.15	Template Drawing For Anchor Chair Of Equipment	N	-	Y	Y
1.16	Mechanical design calculation (strength calculation)	N	Y	-	Y
1.17	Approved certificate & approved Documents from statutory Authority (if applicable)	N	-	Y	Y
1.18	Certified 'as built' drawings Incorporating actual dimensions And material used, duly certified by the inspector	N	-	Y	Y
1.19	Data folder as per specification	N	-	Y	Y
1.20	Materials test certificates duly stamped by inspecting authority ( ** )	N	-	-	Y
1.21	QAP & inspection and test plan ( ** )	N	Y	-	Y
1.22	Welding procedure and qualification test reports ( ** )	N	-	Y	Y
1.23	Destructive and non destructive procedure & test reports ( ** )	N	-	-	Y
1.24	Heat treatment, Hydro test procedure and time temperature charts ( ** )	N	-	Y	Y
1.25	Radiographic examination reports ( ** )	N	-	-	Y
1.26	Records/ drawings, charts duly approved, signed and stamped by Statutory Authorities ( ** )	N	-	-	Y
1.27	<b>Completion certificates</b> (including Inspection certificate, hydrostatic Test certificate, local code requirements, rubbing of code Stamp and name plate etc.) ( ** )	N	-	-	Y
1.28	Packing and forwarding instruction ( ** )	N	-	-	Y
1.29	Transportation drawing showing overall dimension, C.G. weight and handling instructions duly approved by appropriate authority	N	-	Y	Y
1.30	Erection scheme drawings Including weights, C.G., slinging Facilities, guideline & instructions	N	-	Y	Y
1.31	Assembly & Installation Detail ( ** )	N	-	Y	Y
1.32	Final civil load data including details of foundation/anchor bolts	N	-	Y	Y
1.33	List of spare parts and details ( ** )	N	Y	-	Y
1.34	Material & Purchase Requisition of equipment	N	-	Y	Y
<b>Document marked as ( ** ) are to be approved by authorized Third Party Inspection Agency and Statutory Authorities as applicable.</b>					
<b>C. HEAT EXCHANGERS</b>					

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		Document No.	Rev	
		Sheet 20 of 24		

1.1	<b>Mechanical Engineering Datasheet</b>	N	Y	-	Y
1.2	General arrangement drawings indicating design data , fabricated equipment weight, general notes, nozzle schedule, details of shell, heads supporting arrangement , main weld seams ,nozzle orientation plan etc.	N	Y	-	Y
1.3	Tube bundle details & tube layout. Detail drawings	N	-	Y	Y
1.4	Details of nozzles and exchanger support	N	-	Y	Y
1.5	Details of gaskets	N	Y	-	Y
1.6	Heat exchanger detailed drawings and parts list	N	-	Y	Y
1.7	Mechanical design calculations complying with the specifications and codes.	N	Y	-	Y
1.8	For expansion bellow : Expansion bellow mechanical Design calculation along with detailed Drawings indicating design data, Component details, material Details, fabrication procedure, NDT Proposed, heat treatment Procedure e.t.c	N	-	Y	Y
1.9	List of spare parts with details, special accessories, tools & tackles, etc.	N	Y	-	Y
1.10	Name plate drawing detail along With name plate bracket	N	-	Y	Y
1.11	Approved certificate & approved Documents from statutory Authority (if applicable)	N	-	Y	Y
1.12	Manufacturer's Data Report	N	-	Y	Y
1.13	Final civil load data including details of foundation/anchor bolts	N	-	Y	Y
1.14	Welding procedure and qualification test reports ( ** )	N	-	Y	Y
1.15	Transportation drawing showing overall dimension, C.G. weight and handling instructions duly approved by appropriate authority (**)	N	-	Y	Y
1.16	Destructive and non destructive procedure & test reports (**)	N	-	Y	Y
1.17	Heat treatment, Hydro test procedure and time temperature charts ( ** )	N	-	Y	Y
1.18	Procedure for repair of damaged tubes (**)	N	-	Y	Y
1.19	QAP & inspection and test plan ( ** )	N	Y	-	Y

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>	PC-288/E/Sec-9	P	
		Document No.	Rev	
		Sheet 21 of 24		
<b>DRAWINGS AND DOCUMENTS</b>				



1.20	Records of NDT tests e.g. radiography, ultrasonic testing(UT), magnetic particle / Penetrant testing ( MP/PT), hardness etc. ( ** )	N	-	-	Y
1.21	Materials test certificates duly stamped by inspecting authority ( ** )	N	-	Y	Y
1.22	PWHT charts ( ** )	N	-	Y	Y
1.23	Test on production test coupons ( ** )	N	-	-	Y
1.24	Hydraulic/pneumatic test reports ( ** )		-	-	Y
1.25	Mock-up test for tube to tube sheet joint ( ** )		-	-	Y
1.26	Certified 'as built' drawings Incorporating actual dimensions And material used, duly certified by the inspector	N	-	-	Y
1.27	Radiographic examination reports ( ** )	N	-	-	Y
1.28	Completion certificates (including Inspection certificate, hydrostatic Test certificate, local code requirements, rubbing of code Stamp and name plate etc.) ( ** )	N	-	-	Y
1.29	Mechanical guarantee certificate	N	-	-	Y
1.30	Inspector's final certificate ( ** )	N	-	-	Y
1.31	Packing and forwarding instruction ( ** )	N	-	-	Y
1.32	Instruction for erection and Installation, bolt tensioner device Catalogue (if BTD applicable), etc ( ** )	N	-	Y	Y
1.33	Site Preservation Procedure	N	-	Y	Y
1.34	Material & Purchase Requisition of equipment	N	-	Y	Y

**Document marked as ( \*\* ) are to be approved by authorized Third Party Inspection Agency and Statutory Authorities as applicable.**

**LEGEND: Y – Yes, N – No**

Notes :

- Final documentations shall be supplied in hard copies as well as soft copies in Pen drive, CD Formats. Applicable Software are MS Office 2000, Word, Access, and Excel.
- Document marked as ( \*\* ) are to be approved by authorized Third Party Inspection Agency and Statutory Authorities as applicable.
- Final documentation shall be supplied in hard copies (6 prints) and soft (2 pen drive, CDs ) in addition to Submission through email.
- All drawing & documents shall be submitted in A2/A3 or A4 paper size .Documents in higher paper size shall be submitted in exceptional circumstances or as indicated in MR/Tender.



 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER:</b> <u>Bharat Coal Gasification and Chemicals Limited</u>  <b>DRAWINGS AND DOCUMENTS</b>	PC-288/E/Sec-9	P	 <b>बी एच ई सी एल</b> <b>BHEL</b>
		Document No.	Rev	
		Sheet 22 of 24		

5. Bill of material (showing part no. MOC, Size, quantity, weight of each part) shall form part of the respective drawing.
6. Each vendor Drawing/Data (listed under Review & information) shall have been reviewed by the LSTK Contractor for ensuring strict compliance to the NIT Specification requirements and shall carry the Reviewers signature /seal of the Contractor, prior to submission for PMCs Review/Record and as Final Documentation. Drawings submitted without Contractors review shall be returned. Any Deviation to Purchase Specifications shall be clearly brought out through Deviation Waivers Permits for PMCs Approval.
7. The Purchase Requisition shall be submitted only for Record purpose and same shall not be reviewed by PMC/Owner. The onus of complying tender requirement lies with the Contractor. Any comment on vendor document during detail engineering to meet tender requirement shall be complied by the contractor without any cost or schedule implication to Owner/PMC.
8. For proprietary equipment (supplied by Process Licensor), In that case LSTK contractor to submit Licensor specifications, GA drawing, design calculation, civil foundation load detail , detail drawing (except proprietary detail) of Licensor e.t.c for PMC/Owner Information as minimum documentation during execution.
9. Mechanical Design of equipments shall be done on internationally reputed software such as PV-Elite etc. No hand calculations are acceptable.

Strength calculation shall be performed in latest version of PV-elite software. LSTK contractor/ Vendor shall send soft copy of PV-elite (.pvd file) along with equipment document submission during detail engineering to PMC/Owner.

## Instrumentation



Sl.No	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approve d/ As-built
1	Drawing & document schedule	N	Y	-	Y
2	Instrument Index	Y	-	Y	Y
3	Instrument sizing calculations (control vales, safety valves & flow elements)	N	Y	-	Y
4	Utility requirements	Y	Y	-	Y
5	Level sketches	N	-	Y	-
6	Material Requisition	N	Y	-	Y
7	Purchase Requisition	N	-	Y	-
8	Vendor Drawings	N	Y	Y	Y
9	Functional Schematic	N	-	Y	-
10	Logic Diagrams as per ISA 75.2	N	-	Y	-
11	Instrument loop drawings	N	-	Y	-

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER:</b> <u>Bharat Coal Gasification and Chemicals Limited</u> <b>DRAWINGS AND DOCUMENTS</b></div>	PC-288/E/Sec-9	P	<div> बी एच ई एल <b>BHEL</b></div>
		Document No.	Rev	
		Sheet 23 of 24		

12	Control room layout	Y	Y	-	Y
13	Layout of equipment inside control room	N	Y	-	Y
14	Power supply distribution	N	Y	-	Y
15	Wiring diagram for panels	N	-	Y	-
16	Configuration diagram	Y	Y	-	Y
17	I/O assignment	N	Y	-	Y
18	DCS graphics, report/log formats & other DCS docs.	N	Y	-	Y
19	Instrument duct / tray layout	N	-	Y	-
20	Instrument cable schedule	N	-	Y	-
21	Instrument location plans	N	-	Y	-
22	Instrument installation drawings	N	-	Y	-
23	Bill of material for installation items	N	-	Y	-
24	Spare part list for :				
	a. Mandatory Spares	Y	-	Y	-
	b. Start up & commissioning	Y	-	Y	-
25	Inspection & test procedures	N	-	Y	-
26	Complete catalogues with part list for all vendor supplied instruments, control etc.	N	-	Y	-
27	Installation, operation & maintenance manuals	N	-	Y	-
28	As Built Drawings	N	-	Y	Y

Note: \* Indicates number of sets shall be as mentioned in the main NIT.

- Above list is indicative and minimum requirement. PMC/Client may ask any document / drawing post order which shall be absolutely essential to review/approval the instrumentation scope of work as per NIT / process requirements.

<div><div>पी डी आई एल PDIL</div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></div> <div><b>OWNER: <u>Bharat Coal Gasification and Chemicals Limited</u></b></div> <div><b>DRAWINGS AND DOCUMENTS</b></div>	PC-288/E/Sec-9	P	<div><div>बी एच आई एल BHEL</div></div>
		Document No.	Rev	
		Sheet 24 of 24		

<div> पी डी आई एल PDIL</div>	PROJECTS & DEVELOPMENT INDIA LIMITED	PC-288/E001/Sec-10	0	<div></div>
		Document No.	Rev	
		Sheet 1 of 32		

## SECTION: 10.0

### SPARE PARTS

**PLANT : SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE.**

**PROJECT : SETTING UP OF HIGH ASH COAL-TO-AMMONIUM NITRATE PLANT IN MAHANADI COALFIELDS LIMITED (MCL).**

**CLIENT : BHARAT COAL GASIFICATION AND CHEMICALS LIMITED (BCGCL).**

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		Document No.	Rev	
		Sheet 2 of 32		

## CONTENTS

Section Number	Description	Sheet Number
1.0	Spare parts for Commissioning	
2.0	Mandatory spare parts	
2.1	Process Items	
2.2	Mechanical Rotating Items	
2.3	Static Equipments Items	
2.4	Piping & Fire Fighting Items	
2.5	Electrical Items	
2.6	Instrumentation Items	
3.0	Vendor recommended spare parts	

### 1.0 SPARE PARTS FOR COMMISSIONING

LSTK Contractor shall supply free of cost (Include in the scope) spare parts and Consumables required during Pre-commissioning & Commissioning of the plants until the plant is handed over to the Owner after Performance Guarantee / final acceptance of the plant Test as per mutual understanding of Contractor, Owner and PMC.




However, LSTK Contractor shall provide Pre-Commissioning and Commissioning Spare List along with their Bid.

### 2.0 MANDATORY / INSURANCE SPARE PARTS

LSTK Contractor shall supply mandatory spare parts of the plant as detailed below.

- 2.1) Process Items
- 2.2) Mechanical Rotating Items
- 2.3) Static Equipments
- 2.4) Piping & Fire Fighting items
- 2.5) Electrical items
- 2.6) Instrumentation items
- 2.7) Material Handling items



<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>SPARE LIST</b></div>	PC-288/E001/Sec-10	0	<div></div>
		Document No.	Rev	
		Sheet 3 of 32		

## 2.1 Process Items

S. No.	DESCRIPTION	QUANTITY
1.	Catalysts, Adsorbents	10% of full charge
2.	Tower Packings	10% of full charge

**Note:** Catalyst life shall be as per the guaranteed performance criteria in Technical ITB Section 8.0

## 2.2 Mechanical Rotating Items

LSTK Contractor shall supply mandatory spare parts as per list of spares as detailed below:




- i) Centrifugal / Axial / Rotary Compressor
- ii) Reciprocating Compressor
- iii) Screw Compressor
- iv) Centrifugal Fan
- v) Steam Turbine
- vi) Centrifugal Pump
- vii) Reciprocating Pump
- viii) Metering Pump
- ix) Agitator
- x) HVAC

### i) Centrifugal/ Axial/ Rotary Compressor:

The mandatory spares to be supplied for each working train /unit shall be as under.

Sl. No.	DESCRIPTION	QUANTITY
<b>1.0</b>	<b>Compressor</b>	
1.1	Completely assembled dynamically balanced spare rotor including clearance check and mechanical run test	1 set
1.2	Complete spare coupling including distance piece and set of coupling bolts & nuts	1 set
1.3	Stator blade carrier with stator blades completely assembled ( for axial compressor)	1 set
1.4	Complete set of radial bearing ( Both suction & discharge side )	1 set
1.5	Complete set of Pads for radial bearing with built-in temperature elements ( Both suction & discharge side )	1 set
1.6	Complete set of thrust bearings ( Both active & inactive sides )	1 set
1.7	Complete set of Pads for thrust bearings with built-in temperature elements ( Both active & inactive sides )	1 set
1.8	Complete set of labyrinth seals for each casing including labyrinths for balance piston , oil scraper rings etc.	1 set
1.9	Complete set of Dry Gas Seals & assembly (if applicable)	1Set






<div><div> पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>SPARE LIST</b></div>	PC-288/E001/Sec-10	0	<div><div></div></div>
		Document No.	Rev	
		Sheet 5 of 32		

1.10	Oil slinger ring	1 set
1.11	Liner for each stage	1 set
1.12	Complete inlet valves assembly with internals for each cylinder	1 set
1.13	Complete discharge valves assembly with internals for each cylinder	1 Set
1.14	Complete Set of all Gasket and O-Ring .	2 sets
<b>2.0</b>	<b>Gas Coolers</b>	
2.1	Tubes for gas cooler	1 set
2.2	Tubes for oil cooler (when tube are easily replaceable)	5 % for each cooler
2.3	Complete set of Gaskets for coolers & pressure Vessels	2 sets
<b>3.0</b>	<b>Lube Oil System</b>	
3.1	Spares for lube oil pump :	
	a) gears with Shaft	1 set
	b) complete set of bearings	1 set
	c) complete set of seal	2 sets
3.2	Lube oil filter cartridges	4 sets
3.3	Cylinder lubrication system :	
	a) Complete set of Lubricator bearings	1 set
	b) Pumping unit assembly	1set
	c) Check valves of each size	1 set of each size
	d) Sight glass	1 set
<b>4.0</b>	<b>Accessories</b>	1 set
4.1	Set of spares for all valves ( Isolation, control, safety, non return etc.) in gas lines consisting of spindle, seat , disc, flap, packing , fasteners etc.	1 set
<b>5.0</b>	<b>Instrumentation</b>	
	As per Instrumentation specification enclosed with enquiry / order specification.	
<b>6.0</b>	<b>Electrical</b>	
	As per Electrical specification enclosed with enquiry / order specification.	

iii) **Screw Compressor :**

The mandatory spares to be supplied for each working train /unit shall be as under.

Sl. No.	DESCRIPTION	QUANTITY
<b>1.0</b>	<b>Compressor</b>	
1.1	Completely assembled dynamically balanced spare rotor including clearance check and mechanical run test	1 set
1.2	Complete spare coupling including distance piece and set of coupling bolts & nuts	1 set
1.3	Complete Set of radial bearings (Both suction & discharge side)	1 set
1.4	Complete Set of Pads for radial bearings (Both suction & discharge side)	1 set
1.5	Complete Set of thrust bearings (both active & inactive sides), if applicable.	1 set
1.6	Complete Set of Pads for thrust bearings (both active & inactive sides), if applicable.	1 set

<div><div></div><div>पी डी आई एल</div><div><b>PDIL</b></div></div>	<div><div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></div><div><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></div><div><b>SPARE LIST</b></div></div>	PC-288/E001/Sec-10	0	<div><div></div><div></div></div>
		Document No.	Rev	
		Sheet 6 of 32		




1.7	Complete Set of Mechanical seal	1 set
1.8	Complete Set of oil seals	2 sets
1.9	Complete Set of 'O' rings, gaskets, sealing rings. for compressor	4 sets
<b>2.0</b>	<b>Oil System</b>	
2.1	Spare for oil pump	
	- Complete rotating assembly	1 set
	- Bearings	1 set
	- Oil seal	1 set
	- Gaskets & 'O' rings	2 sets
2.2	Cartridge for oil filter	4 sets
2.3	Gaskets for Oil cooler	2 sets
<b>3.0</b>	<b>Gear Box</b>	
3.1	Set of bearings for gear box including drive end, intermediate stages & driven end	2 sets
3.2	Set of spare wheels & shaft	1 set
3.3	Complete Set Oil seals	2 sets
<b>4.0</b>	<b>Accessories</b>	
4.1	Set of spares for all valves ( Isolation, control, safety, non return etc.) in gas lines consisting of spindle, seat , disc, flap, packing , fasteners etc.	1 set
4.2	Spare elements for permanent filters in gas line	1 set
<b>5.0</b>	<b>Instrumentation</b>	
	As per Instrumentation specification	
<b>6.0</b>	<b>Electrical</b>	
	As per Electrical specification enclosed with enquiry / order specification.	

iv) **Centrifugal Fan:**

The mandatory spares to be supplied for each working train /unit shall be as under.




Sl. No.	DESCRIPTION	QUANTITY
1.0	Completely dynamically balanced rotor assembly including impeller, wheel, key etc.	1 Set
2.0	Shaft sleeve	1 Set
3.0	Complete set of all Bearings	1 Set
4.0	Stuffing box packing rings	1 Set
5.0	Complete set of all Gasket & 'O' rings	1 Set
6.0	Complete mechanical seal , if applicable	1 Set
7.0	Coupling bushes	1 Set
8.0	Complete set of coupling with elements	1 Set.
<b>9.0</b>	<b>Instrumentation</b>	
	As per Instrumentation specification	
<b>10.0</b>	<b>Electrical</b>	
	As per Electrical specification enclosed with enquiry / order specification.	

v) **Steam Turbine :**

<div><div></div><div>पी डी आई एल</div><div><b>PDIL</b></div></div>	<div><div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></div><div><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></div><div><b>SPARE LIST</b></div></div>	PC-288/E001/Sec-10	0	<div><div></div></div>
		Document No.	Rev	
		Sheet 7 of 32		

The mandatory spares to be supplied for each working train /unit shall be as under




Sl. No.	Description	Quantity
<b>1.0</b>	<b>Turbine</b>	
1.1	Completely assembled dynamically balanced rotor	1 set
1.2	Inlet nozzles complete set	1 set
1.3	Complete set of Journal bearing with internals	1 set
1.4	Complete set of Journal bearing Pads	1 set
1.5	Complete set of Thrust bearing with internals	1 set
1.6	Complete set of Thrust bearing Pads	1 set
1.7	Shaft seal carbon labyrinth	2 sets
1.8	Labyrinth seal	2 sets
1.9	Complete Set coupling with all internals/element for turbine & gear box	1 set
1.10	Governor assembly	1 set
1.11	Control valve & servo spares	1 set
1.12	Complete spares for HP/LP servomotor piston kit	2 sets
1.13	Emergency stop valve spare / pilot valve spare	1 set
1.14	Over speed trip spare	1 set
1.15	Thrust collar assembly	1 set
1.16	Sealing compound for parting plane	2 sets
1.17	Shaft driven Lube oil pump complete set	1 set
1.18	Complete Set of Oil seals & gaskets	1 set
<b>2.0</b>	<b>Gear Box Spares</b>	
2.1	Pinion & gears	1 set
2.2	Bearings complete set	1 set
2.3	Shaft seal complete set	2 sets
2.4	Complete set of 'O' ring, gaskets , Oil seals	2 sets
<b>3.0</b>	<b>Lube Oil System</b>	
3.1	Pump complete	1 set
3.2	All bearings	1 set
3.3	Internal gear / screw	1 set
3.4	Mech. seal complete	1 set
3.5	Pump Shaft	1 set
3.6	Set of Coupling , bolts, nuts & washer	1 set
3.7	Relief valve complete assembly with internal	1 set
3.8	Plug & seat for relief valve	1 set
3.9	Spring & stem for relief valve	1 set
3.10	Set of gaskets for each cooler	2 sets
3.11	Lube oil filter cartridges	3 sets
<b>4.0</b>	<b>Instrumentation</b>	
	As per Instrumentation specification	
<b>5.0</b>	<b>Electrical</b>	
	As per Electrical specification enclosed with enquiry / order specification.	

<div><div> पी डी आई एल <b>PDIL</b></div></div>	<div><div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></div><div><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></div><div><b>SPARE LIST</b></div></div>	PC-288/E001/Sec-10	0	<div><div></div></div>
		Document No.	Rev	
		Sheet 8 of 32		

vi) **Centrifugal Pump:**




Sl. No.	Description	Quantity			
		No. of Pumps working			
		1	2	3	4
1.1	Impeller	1 set	1 set	1 set	1 set
1.2	Impeller locking nut	2 sets	2 sets	2 sets	2 sets
1.3	Wear Rings complete set	1 set	2 sets	3 sets	4 sets
1.4	Shaft with keys	1 No.	1 No.	1 No.	1 No.
1.5	Shaft Sleeve	1 set	2 sets	3 sets	4 sets
1.6	Interstage sleeves	1 set	2 sets	3 sets	4 sets
1.7	Interstage Bushes	1 set	2 sets	3 sets	4 sets
1.8	Complete Set of Mech. Seal where applicable	1 set	1 set	2 sets	2 sets
1.9	Constant level Oiler	2 sets	2 sets	2 sets	2 sets
1.10	Deflectors	2 sets	2 sets	3 sets	3 sets
1.11	Complete set of coupling with element and fasteners	1 set	1 set	2 sets	2 sets
1.12	Complete set of all Bearings	1 set	2 sets	2 sets	2 sets
1.13	Complete set of Gaskets & 'O' Rings	2 sets	3 sets	4 sets	6 sets
1.14	Labyrinths	2 sets	3 sets	4 sets	5 sets
1.15	Throat Bushing	1 No.	2 Nos.	3 Nos.	4 Nos.
1.16	Throttle Bushing	1 No.	2 Nos.	3 Nos.	4 Nos.
1.17	Complete set of Oil Seals	2 sets	3 sets	4 sets	6 sets
1.18	Balancing drum & sleeves, as applicable.	1 set	1 set	2 sets	2 sets
1.19	Leak-off valve-gaskets, 'O' Rings and springs	2 sets	3 sets	4 sets	5 sets
1.20	Spares for gear box ( complete set of bearings, all gears wheels with shaft and seals)	1 set	1 set	1 set	1 set
<b>2.0</b>	<b>Instrumentation</b>				
	As per Instrumentation specification				
<b>3.0</b>	<b>Electrical</b>				
	As per Electrical specification enclosed with enquiry / order specification.				

vii) **Reciprocating Pump:**

<div><div> पी डी आई एल <b>PDIL</b></div></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>SPARE LIST</b></div>	PC-288/E001/Sec-10	0	<div><div></div></div>
		Document No.	Rev	
		Sheet 9 of 32		

SI No.	Description	Quantity			
		No. of Pumps working			
		1	2	3	4
<b>A</b>	<b>Main Frame</b>				
1.	Main Bearings	1 set	1 set	1 set	1 set
2.	Big End Bearings	1 set	1 set	1 set	1 set
3.	Thrust Bearings	1 set	1 set	2 sets	2 sets
4.	Crosshead shoes	1 set	1 set	1 set	1 set
5.	Crosshead bushes	1 set	1 set	1 set	1 set
6.	Connecting rod with complete Fasteners for all size	2 sets.	2 sets	4 sets	4 sets
7.	Crank shaft	1 No.	1 No.	1 No.	1 No.
8.	Lube oil pump	1 No.	1 No.	1 No.	1 No.
9.	Spare parts for lube oil pump (set of gears, bushes, gaskets etc.)	1 set	1 set	2 sets	2 sets
10.	Cartridge for oil filter.	2 Nos.	2 Nos.	4 Nos.	4 Nos.
11.	Special gaskets, oil seals, 'O' rings, special bolts etc.	2 sets	2 sets	4 sets	4 sets
<b>B</b>	<b>Fluid End</b>				
1.	Cylinders	1 No.	1 No.	2 Nos.	2 Nos.
2.	Plungers / piston & piston rod assembly, piston rings (if applicable)	1 set	1 set	1 set	1 set
3.	Stuffing box Packings	2 sets	2 sets	4 sets	4 sets
4.	Plunger Packings	2 sets	2 sets	4 sets	4 sets
5.	Complete set of Suction valve & seat	1 set	2 sets	3 sets	4 sets
6.	Complete set of Discharge valve & seat	1 set	2 sets	3 sets	4 sets
7.	Flushing pump (if applicable)	1 No.	1 No.	1 No.	1 No.
8.	Spares for flushing pump.	1 set	1 set	2 sets	2 sets
	- Plunger - Plunger Packings - Valves - Gaskets				
9.	Special gaskets, springs, 'O' rings, and ring nuts for stuffing box packing, cylinder bolts.	2 sets	2 sets	4 sets	4 sets
<b>C</b>	<b>Gear Reducer (If Applicable)</b>				
	Spares for gear box ( complete set of bearings, all gears wheels with shaft and seals)	1 set	1 set	2 sets	2 sets
<b>D</b>	<b>Lube Oil Coolers (If Applicable)</b>				
1.	Special gaskets, if any	2 sets	2 sets	4 sets	4 sets
2.	Spare tubes.	10 %	10 %	10 %	10 %
<b>E.</b>	<b>Instrumentation</b>				
	As per Instrumentation specification				
<b>F.</b>	<b>Electrical</b>				
	As per Electrical specification enclosed with enquiry / order specification.				



<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>SPARE LIST</b></div>	PC-288/E001/Sec-10	0	<div></div>
		Document No.	Rev	
		Sheet 10 of 32		




viii) **Metering Pump:**

Sl. No.	Description	Quantity			
		No. of Pumps working			
		1	2	3	4
<b>A</b>	<b>POWER END</b>				
1.	Main Bearings	1 set	1 set	1 set	1 set
2.	Big End Bearings	1 set	1 set	1 set	1 set
3.	Crosshead shoes	1 set	1 set	1 set	1 set
4.	Crosshead bushes	1 set	1 set	1 set	1 set
5.	Connecting rod with complete Fasteners for all size	2 sets.	2 sets	4 sets	4 sets
6.	Special gaskets, oil seals, 'O' rings , special bolts etc.	2 sets	2 sets	4 sets	4 sets
<b>B</b>	<b>FLUID END</b>				
1.	Cylinders	1 No.	1 No.	2 Nos.	2 Nos.
2.	Plungers	1 set	1 set	1 set	1 set
3.	Diaphragm	1 set	2 sets	3 sets	4 sets
4.	Stuffing box Packings	2 sets	2 sets	4 sets	4 sets
5.	Complete set of Suction valve & seat	1 set	2 sets	3 sets	4 sets
6.	Complete set of Discharge valve & seat	1 set	2 sets	3 sets	4 sets
7.	Special gaskets , springs , 'O' rings , ring nuts for stuffing box packing , cylinder bolts	2 sets	2 sets	4 sets	4 sets
<b>C.</b>	<b>Instrumentation</b>				
	As per Instrumentation specification				
<b>D.</b>	<b>Electrical</b>				
	As per Electrical specification enclosed with enquiry / order specification.				

ix) **Agitator:**

Sl. No.	Description	Quantity			
		No. of Agitator working			
		1	2	3	4
1.1	Complete set of all Bearings	1 set	1 set	1 set	1 set
1.2	Complete set of High speed flexible coupling with bushes /	1 set	1 set	1 set	1 set



<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>SPARE LIST</b></div>	PC-288/E001/Sec-10	0	<div></div>
		Document No.	Rev	
		Sheet 11 of 32		




	elements.				
1.3	High speed Coupling bushes	3 sets	3 sets	4 Sets	4 Sets
1.4	Complete set of Low speed flexible coupling with bushes / elements.	1 set	1 set	1 set	1 set
1.5	Low speed Coupling bushes	3 sets	3 sets	4 Sets	4 Sets
1.6	Complete set of all Oil seal for gear box	1 set	1 set	1 set	1 set
1.7	Complete set of all Oil seal for bearing housing	4 set	4 set	6 set	6 set
1.8	Complete set of Seal packing.	2 sets	2 sets	4 sets	4 sets
<b>2.0</b>	<b>Instrumentation</b>				
	As per Instrumentation specification				
<b>3.0</b>	<b>Electrical</b>				
	As per Electrical specification enclosed with enquiry / order specification.				

**x) HVAC**

Sl. No.	Description	Quantity
1.	Consumable	1set/type
2.	v-belt	2set/each unit
3.	Filter	1set/each unit
4.	All rotary equipment i.e. Pump, blower etc	Clause no-2 (Spare parts of rotary equipment)

**Notes:**

1. 'Set' means complete replacement of particular part in one machine.
2. Item wise price against each item shall be furnished in the Performa enclosed with the enquiry
3. The quotation should contain sectional drawing showing location & part no. (For exact Identification) & material specification
4. Unless otherwise mentioned, Spares are to be considered dedicated for each individual machine On respective tag number basis. For similar (same model no./ capacity) machine, if repeatedly Comes elsewhere in the plant shall have its own dedicated spares as per the list furnished above.




<div><div> पी डी आई एल <b>PDIL</b></div></div>	<div><div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b></div><div><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></div><div><b>SPARE LIST</b></div></div>	PC-288/E001/Sec-10	0	<div><div></div></div>
		Document No.	Rev	
		Sheet 12 of 32		

## 2.3) Static Equipments Items

S.no	Spare Items	Quantities
<b>1.0</b>	<b>Pressure Vessel /Filter /Column/Reactor e.t.c</b>	
1.1	Gaskets for each nozzle with blind flange	200 %
1.2	Bolting for each nozzle with blind flange	10 % (Minimum 2 numbers)
1.3	Gaskets for each girth flange.	200 %
1.4	Bolting for each Girth flange	10 % (Minimum 2 numbers)
1.5	Bolting for internal flange	10 % (Minimum 2 numbers)
1.6	Gasket for internal flange	200 %
1.7	Spare for internals Clamps Washer Stud & bolt	2 % excess, min. 5 piece 20 % excess, min. 3 piece 10%(Minimum 2 numbers)
1.8	Sight/light glass assembly complete with bolting and gasket	300% of each installed glass
1.9	Filter Cartridge/Elements	200%
<b>2.0</b>	<b>Storage Tanks (including ammonia storage tank)</b>	
2.1	Gaskets for each nozzle with blind flange	200 %
2.2	Bolting for each nozzle with blind flange	10 % (Minimum 2 numbers)
<b>3.0</b>	<b>Heat Exchangers – Shell &amp; Tube type</b>	
3.1	Bolting for each nozzle with blind flange	10 % (Minimum 2 numbers)
3.2	Gaskets for each nozzle with blind flange	200 %
3.3	Gaskets for each girth flange.	200%
3.4	Bolting for each Girth flange	10 % (Minimum 2 numbers)
3.5	Tube Plug	5 % of tube holes
<b>4.0</b>	<b>Plate type Exchanger</b>	
4.1	Plate gasket	10 %
4.2	Flow plate	10 %
4.3	Nozzle gasket	200 %
4.4	Glue (1 kg pot)	1
4.5	Special spanner tool	1 for each size/ type

### Notes:

- 1) Quantities shown are for each equipment.
- 2) Above mentioned spare philosophy is also applicable for each Integral static equipment with in a package item.
- 3) Wherever % age is identified, contractor shall supply next rounded figure.
- 4) All spares supplied by contractor shall be properly wrapped and packed so that spares will be preserved in as new condition under the normal condition of storage envisaged and shall be properly tagged & coded so that at a later stage the same can be identified. Packing list shall be furnished so that parts can be identified without uncrating.
- 5) The parts listed are the principal parts only. Other parts shall be considered for recommendation in quantities consistent with the above table.
- 6) All special tools and tackles required for maintenance for critical items shall be supplied along with equipment.

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>SPARE LIST</b></div>	PC-288/E001/Sec-10	0	<div></div>
		Document No.	Rev	
		Sheet 13 of 32		

- 7) Spare parts shall be identical in all respects to the parts fitted on the main equipment, including dimensions, material of construction, testing & heat treatment.
- 8) The Bidder shall quote for all the mandatory spares as defined above & as applicable to the proposed design of the equipment. In case, any spare which is listed above but not applicable due to specific construction/design of the equipment, the same shall be highlighted as 'Not Applicable' against that spare supported with proper technical explanation.
- 9) This specification does not cover spares for electrical, instrumentation, piping, rotating etc. These shall be as per the respective disciplines specifications attached with the NIT document (as applicable).

## **2.4) Piping & Fire Fighting Items**




### **Piping Items:**

Sl. No.	Part Description	Size Range (NB)	Quantity Required (% of as built)	Remark
1	Pipes & Fittings	≤1.5"	5%	min. qty. 6 mtr. / 1 No.
2	Pipes & Fittings	≥ 2"	2%	min. qty. 6 mtr. /1 No.
3	Flanges	≤1.5"	5%	min. qty. 1 No.
4	Flanges	2" to 6"	5%	min. qty. 1 No.
5	Flanges	8" to 36"	2%	min. qty. 1 No.
6	Valves	≤1.5"	5%	min. qty. 1 No.
7	Valves	2" to 14"	5%	min. qty. 1 No.
8	Valves	≥16" with rating ≥900#		Note-5
9	Bolts, Nuts & Gaskets (For each size, rating, material)		10%	min. qty. 1 No.
10	Traps (For each size, rating, material)		2%	min. qty. 1 No.
11	Expansion Bellow (For each size, rating, material)		10%	min. qty. 1 No.
12	Strainer element (For each size, rating, material)		10%	min. qty. 1 No.
13	Complete Gear Box for gear operated Valves		5%	min. qty. 1 No.
14	Seal ring for the Pressure seal type valves		5%	min. qty. 10 Nos.
15	Hose assembly		50%	min. qty. 10 Nos.
16	Bolt torque wrenches (Manual)		1 set	min. qty. 1 set.
17	Bolt torque wrenches (Hydraulic)		1 set	min. qty. 1 set.
18	Bolt tensioning for equipment		1 set	min. qty. 1 set.

### **NOTES:-**

1. Percent of quantity required as mandatory spares is for each and every item/size/material consumed in as built.
2. No substitution in size, rating and material is allowed.
3. Pipe length in meter and other items in No. or Set shall be supplied.
4. Fractional part of quantity shall be converted into nearest upward whole part.
5. For rating ≥900# and sizes ≥16", minimum one qty. valve spare shall be supplied for each size, rating & material.

### **Fire Fighting Items**




<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>SPARE LIST</b></div>	PC-288/E001/Sec-10	0	<div></div>
		Document No.	Rev	
		Sheet 14 of 32		

S. No.	Description	Quantity (% of total installation qty. or as specified)
1	Hose box, RRL hose with couplings, jet nozzle with branch pipe, hose reel with nozzle, hydrant valve, landing valve	5% per item.
2	Monitor per type & capacity	1 no.
3	Portable fire extinguisher per type & capacity ( up to 10 kg )	1%
4	Wheel mounted fire extinguisher per type & capacity (greater than 10 kg )	1 no.



## **2.5) Electrical Items**

Sr. No.	Item	Quantity
<b>1.0</b>	<b>UPS of Each Rating</b>	
A.	Semiconductor Fuses or HRC Fuse Links of each rating	30%
B.	MCB, MCCB and control switches of each rating	1 Set
C.	SCR, diodes and transistors of each type	50%
D.	Capacitors, resistors and chokes of each type	50%
E.	Signal Lamps of each colour & voltage	30%
F.	Control Cards	1 Set
G.	Semiconductor fuses & HRC fuse links of each type	1 Set
H.	IGBT of each type	1 Set
I.	Software and programming terminal	1 Set
J.	Batteries	5 cells
K.	Isolator switch of each type	1 No.
L.	Ventilation Fan each type	2 Nos.
M.	PCBs of each type	1 No.
N.	Electrolyte	10%
<b>2.0</b>	<b>Power and Distribution Transformer (of each type &amp; rating)</b>	
A.	HV Bushing complete with metal parts for all 3 phases	1 Set





<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>SPARE LIST</b></div>	PC-288/E001/Sec-10	0	<div></div>
		Document No.	Rev	
		Sheet 16 of 32		

Sr. No.	Item	Quantity
B.	Trip bar spring and any other spring used in the circuit breaker mechanism for breaker of each rating	1 No.
C.	Shunt trip coil for breaker of each rating	10%
D.	Closing coil for breaker of each rating	10%
E.	Spring charging motor of each rating	1 No.
F.	Spring charging handle for breaker of each rating	1 No.
G.	Racking out handles for breaker of each rating	1 No.
H.	Secondary Isolating contact blocks for breaker of each rating	1 No.
I.	Micro Switch for Test/ Service Position for breaker of each rating	1 No.
J.	Micro Switch for Spring Charging for breaker of each rating	1 No.
K.	Main contact sets/ Jaw contact, Moving coil, Fixed coil complete for breaker of each rating	1 Set
L.	Trip-Neutral-Close Control Switch	2 Nos.
M.	Local-OFF-Remote Selector Switch	2 Nos.
N.	Ammeter Selector Switch	2 Nos.
O.	Voltmeter Selector Switch	2 Nos.
P.	Push Button Element of each type & rating	20 %
Q.	Push Button Actuator of each type	20 %
R.	Trip Selector Switch	2 Nos.
S.	Panel limit switches & interlocking switches	10% each type

<div><div>पी डी आई एल</div><div>PDIL</div></div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div> <div>OWNER: Bharat Coal Gasification and Chemicals Limited</div> <div>SPARE LIST</div>	PC-288/E001/Sec-10	0	<div><div><div>भारत कोयला</div><div></div><div>Coal India</div></div><div><div>बी एच ई एल</div><div></div></div></div>
		Document No.	Rev	
		Sheet 17 of 32		

T.	Panel operating switches (all types)	1 Set each
U.	Breaker limit switches & interlocking switches	10% each type
V.	Protection Relays for different type of feeders i.e Incoming Feeder, Bus-coupler Feeder, Outgoing feeder, Motor Feeder, Transformer Feeder etc.	1 No. for each type of feeder
W.	Trip relays of each type	2 Nos
X.	Auxiliary Relays of each Type	2 Nos.
Y.	Miniature Circuit Breaker of each type & rating	20 %
Z.	Meters (of each type & rating) i) Ammeter ii) Voltmeter iii) Multifunction Meter iv) Energy Meter	1 No. 1 No. 1 No. 1 No.
AA.	Instrument Transformers of each type & rating i) CT ii) PT	3 Nos. 1 Nos.
BB.	Fuses of each type & rating i) HRC HV for VT ii) HRC LV	20 % 20 %
CC.	Lamp Complete assembly of each colour & voltage	10%
DD.	Current transducers of each rating	20%
EE.	Voltage transducers of each rating	20%
FF.	Power Transducers of each rating	20%
GG.	Bus-Bar Support Insulators	1 Set
HH.	Surge Arrestors	1 No.
II.	Inspection Glass	3 Nos.
JJ.	Sprouts	1 Set
KK.	Panel Space Heaters with Thermostat	2 Nos.
LL.	Alarm Annunciator of each type	1 No.
MM.	Interpanel insulation barriers	20% Minimum 1 No.
NN.	Earthing Trolley	1 No.
OO.	Maintenance Trolley for breaker of all rating	1 No.
PP.	Set of gaskets for all ratings & type	1 Set
QQ.	Panel shutter assembly	2 No.
RR.	Removable bus bar shrouds	1 Set
SS.	Bus bar mounted power fix contacts	1 Set
<b>6.0</b>	<b>Each LT (415V) Switchboard (PMCC/EPMCC/APFC/PCC/MCC/ASDB/ DCDB/UPSDB/LSDB)</b>	
A.	Complete ACB (ready to use) of each rating	1 No.
B.	Trip coils for breaker of each rating	10%
C.	Closing coils for breaker of each rating	10%
D.	Spring charging motors of each rating	1 No.
E.	Secondary Isolating contact blocks for breaker of each rating	1 Set.
F.	Arcing contacts & arcing chutes block for breaker of each rating	1 Set.






<div><div>पी डी आई एल</div><div>PDIL</div></div>	<div>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</div> <div>OWNER: Bharat Coal Gasification and Chemicals Limited</div> <div>SPARE LIST</div>	PC-288/E001/Sec-10	0	<div><div><div>भारत कोयला</div><div></div><div>Coal India</div></div><div><div>बी एच ई एल</div><div></div></div></div>
		Document No.	Rev	
		Sheet 18 of 32		

G.	Main contact sets/ Jaw contact compete for breaker of each rating	1 Sets
H.	Trip-Neutral-Close Control Switch	2 Nos.
I.	Local-OFF-Remote Selector Switch	2 Nos.
J.	Ammeter Selector Switch	2 Nos.
K.	Voltmeter Selector Switch	2 Nos.
L.	Push Button Element of each type & rating	20 %
M.	Push Button Actuator of each type	20 %
N.	Trip Selector Switch	2 Nos.
O.	Panel limit switches & interlocking switches	10% each type
P.	Panel operating switches (all types)	1 Set each
Q.	Breaker limit switches & interlocking switches	10% each type
R.	Protection Relays for different type of feeders i.e Incoming Feeder, Buscoupler Feeder, Outgoing feeder, Motor Feeder etc.	1 No. for each type of feeder
S.	Trip relays of each type	2 Nos
T.	Auxiliary Relays of each Type	2 Nos.
U.	Thermal over Load Relay of each rating	2 Nos.
V.	Contactors of each type & rating	2 Nos.
W.	Coils for Contactors – each type/voltage	2 Nos.
X.	ELCB & RCBO of each type	2 Nos.
Y.	Miniature Circuit Breaker of each type & rating	20 %
Z.	SFU of each rating	20 %
AA.	Meters (of each type & rating) i) Ammeter ii) Voltmeter iii) Multifunction Meter iv) Energy Meter	1 No. 1 No. 1 No. 1 No.
BB.	Instrument Transformers of each type & rating i) CT ii) PT	3 Nos. 1 Nos.
CC.	Fuses of of each type & rating HRC LV	20 %
DD.	Lamp Complete assembly of each colour& voltage	10%
EE.	Current transducers of each rating	20%
FF.	Voltage transducers of each rating	20%
GG.	Power Transducers of each rating	20%
HH.	Bus-Bar Support Insulators	1 Set
II.	Panel Space Heaters with Thermostat	2 Nos.
JJ.	Alarm Annunciator of each type	1 No.
KK.	Interpanel insulation barriers	20% Minimum 1 No
LL.	Maintenance Trolley for breaker of all rating	1 No.
MM.	Set of gaskets for all ratings & type	1 Set
NN.	Panel shutter assembly	2 Nos.







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		Document No.	Rev	
		Sheet 21 of 32		

B.	Auto Manual / Local -Remote switch	20%
C.	Ammeters of different ranges	20%
D.	Terminal block	20%
E.	Indicating Lamps of different type	20%
F.	Push Buttons of different type	20%
G.	Complete LCS of each type	20%
<b>15.0</b>	<b>Junction Box</b>	
A.	Junction Box of each type	10 Sets
<b>16.0</b>	<b>Electricals for Overhead Cranes &amp; Hoists (per crane/hoist)</b>	
A.	Bearings of each type & no.	1 Set
B.	Contactor Coil of various ratings	1 Set
C.	Complete set of contactor of each rating	1 Set
D.	Limit switches of each type	2 Nos.
E.	Push Button Elements	20%
F.	Push Button Actuators	20%
G.	Fuses of various ratings	20%
H.	Fuse fittings of various ratings	20%
I.	Indication lamp fittings of each type	20%
J.	Overload relays of various ranges	1 Set
K.	Brake coils for various brakes	1 Set
L.	Set of carbon brushes in case of S.R. motors	1 Set
M.	Set of resistors for S.R. motors	1 Set
N.	Any special tools and tackles required for maintenance	1 Set
<b>17.0</b>	<b>Variable Frequency Drives</b>	
A.	Set of fuses of all types & sizes used in system	5 Sets
B.	Controller Card of each type	1 Set
C.	Power Devices of each type	2 Sets
D.	Software for parameter setting each type	1 Set
<b>18.0</b>	<b>Fire Alarm &amp; Detection System</b>	
A.	Detectors of each type	20%

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B.	Loop card of each type	10%
C.	Charger card	10%
D.	Interface Units of each type	10%
E.	Power supply unit of each type	10%
F.	PCB of all types	20%
G.	Manual Call Points	10%
H.	Fuses of each type & rating	10%
I.	Control relays of each type	10%
J.	Audible hooter/buzzer	10%
<b>19.0</b>	<b>Capacitor Bank</b>	
A.	Capacitor Unit of each rating	3 Sets.
B.	Fuses (if used) of each rating	3 Sets
C.	Power Contactor of each rating	3 Sets.
D.	PF controller card/unit of each type	1 Set
E.	Limit Switch for Capacitor Bank of each type	3 Sets
<b>20.0</b>	<b>Each ANNUNCIATOR PANEL</b>	
A.	Hooters	1 No.
B.	Push Buttons of each type	3 Sets
C.	Terminals	3 Nos.
D.	Acrylics	1 No.
E.	PCB card of each type	1 No.
F.	LED of each colour & voltage	3 Sets
G.	DIP Switches	3 Nos.
H.	CPU	1 No.
I.	SMPS	1 No.
J.	Relays of each type	20% (Min. 1 No.)

- 1) Set means complete replacement of particular part in one machine.
- 2) The above spares do not includes commissioning spares and shall be purely warehouse spare.
- 3) Wherever "Each Type" is specified, it means "of the Type/make/model/size/rating and exactly replaceable"
- 4) Wherever "% qty." is specified, Bidder to quote in next higher rounded figure
- 5) Out of % age spares and minimum qty specified against each item - higher of the two shall be supplied.

Electrical EQUIPMENT which has not been mentioned in this table and needs spare parts, CONTRACTOR shall consider spare parts for them, the quantities for such spare parts shall then be APPROVED by OWNER/CONSULTANT. If any electrical equipment is not coming in this package, there shall be no spares for that equipment.

## **2.6) Instrumentation Items**

### **1.0 INTRODUCTION**

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>SPARE LIST</b></div>	PC-288/E001/Sec-10	0	<div></div>
		Document No.	Rev	
		Sheet 23 of 32		

Purpose of this Specification is to set forth the mandatory requirements of spare parts for instrumentation. The Supplier shall provide spare parts and consumables according to this specification.

## 2.0 SPARE PARTS FOR COMMISSIONING

The Supplier shall provide spare parts and Consumables for Commissioning. They shall be listed and provided along with their bid according to Vendor experience.

Cost of Spare Parts for commissioning shall be included in the total bid price.

## 3.0 MANDATORY SPARE PARTS




The Supplier shall provide mandatory spare parts and Consumables. They shall be listed and provided along with their bid according to the table as below.

Cost of Mandatory Spare Parts shall be included in the total bid price. The Definition of spare parts rules:

- "Set" means complete replacement of particular part in one device;
- Wherever "Each Type" is specified, it means "of the Type / make / model / size / rating and exactly replaceable";
- Wherever "% qty" is specified, Bidder to quote in next higher rounded figure;
- Out of "% qty" spares and minimum qty specified against each item - higher of the two shall be supplied.
- Any other instruments which are not covered and is applicable for the plant, Spares quantity shall be minimum 10% or 1 number each type
- This spare list shall be applicable for other packages like Compressors, turbines, motor, pumps, GTG/HRSG, EDG ID/FD Fan, Pressure Vessels, Exchangers, Reactors, HVAC, Boilers, Dampers, and Diverters etc.




No	Description	Quantity
<b>1.0</b>	<b>Flow Instruments</b>	
1.1	Mass flow meter	<ul style="list-style-type: none"> <li>- Power fuses: 6 nos per set</li> <li>- Sensor assembly: 10% or min 1 no</li> <li>- Electronic head unit: 10% or min1 no complete</li> <li>- Extension cables / special cables</li> </ul>
1.2	Magnetic Flow meter	<ul style="list-style-type: none"> <li>- Power fuses: 6 nos per set</li> <li>- Sensor assembly: 10% or min 1 no</li> <li>- Electronic head unit: 10% or min1 no complete</li> <li>- Extension cables / special cables</li> </ul>
1.3	Vortex Flow Meter	<ul style="list-style-type: none"> <li>- Sensing probe: 1 no for each type</li> <li>- Gasket and Packing: 1 set for each type</li> <li>- Electronic head unit: 10% or min1 no complete.</li> </ul>
1.4	Ultrasonic Flow meter	<ul style="list-style-type: none"> <li>- Probe: 1 pair for each instrument</li> <li>- Electronic card: 1 no for each type</li> <li>- Fuse: 2 nos for all types</li> </ul>



<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>SPARE LIST</b></div>	PC-288/E001/Sec-10	0	<div></div>
		Document No.	Rev	
		Sheet 25 of 32		




<b>4.0</b>	<b>Temperature Instruments</b>	
4.1	RTD, Thermocouple with Thermowell	- Complete instrument: 10% or min 1 nos for each type and range
4.2	Skin Thermocouple	- Complete instrument: 10% or min 1 nos for each type and range
4.3	Multipoint Thermocouple	- Sensor: 10% or min 1 no for each length
4.4	Temperature Gauge with Thermowell	- Complete instrument: 10% or min 1 nos for each type and range
4.5	Temperature Transmitter	- Complete instrument: 10% or min 1 nos for each type
<b>5</b>	<b>Analysers</b>	
5.1	Gas Chromatograph / Mass Spectrometer	<ul style="list-style-type: none"> <li>- Filters: 1 set</li> <li>- Detector Assembly: 1 set</li> <li>- PCB Assembly Power Supply: 2 nos</li> <li>- PCB Assembly Digital temp control: 2 nos</li> <li>- PCB Assembly: 1 no</li> <li>- Pressure Regulator: 1 no</li> <li>- Thermocouple Assembly: 1 no</li> <li>- Solenoid valve: 1 no</li> <li>- Backplane Assembly: 1 no</li> <li>- Igniter Assembly: 1 no</li> <li>- Pressure Sensor: 1 no</li> <li>- Filament Kit: 2 nos</li> <li>- Set of fuses: 1 no</li> <li>- Set of Fittings: 1 no</li> <li>- Pressure Gauge: 1 no</li> <li>- Temperature Gauge: 1 no</li> <li>- Sample Flow meter: 1 no</li> <li>- Bypass Flow meter: 1 no</li> <li>- Any other instrument item : 1 no</li> </ul>
5.2	Other Gas Analyser including CEMS	<ul style="list-style-type: none"> <li>- Sample Flow meter: 1 no</li> <li>- Bypass Flow meter: 1 no</li> <li>- Solenoid valve: 1 no</li> <li>- Communication Board: 1 no for each type</li> <li>- Display Unit: 1 no for each type</li> <li>- CPU Board: 1 no for each type</li> <li>- Sensor Electronic: 1 no for each type</li> <li>- Modulation Unit: 1 no for each type</li> <li>- Sample Cell: 1 no</li> <li>- Sensor: 1 no for each type</li> <li>- O Ring: 3 sets</li> <li>- Thermal Fuse: 2 sets</li> <li>- Heating Cartridge: 1 set</li> <li>- Thermal Trip: 2 sets</li> <li>- Analogue Module: 1 set for each type</li> <li>- Filter Membrane (pack of 25): 1 set</li> <li>- Fuse: 1 set for each type</li> <li>- Any other instrument item : 1 no</li> </ul>






<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>SPARE LIST</b></div>	PC-288/E001/Sec-10	0	<div></div>
		Document No.	Rev	
		Sheet 26 of 32		

5.3	Sample Conditioning system for all analysers	<ul style="list-style-type: none"> <li>- Complete sample kit for sample pumps inclusive of 'O'rings, Seal ring, Diaphragm: 1 set</li> <li>- Solenoid valve for, more than one stream application: 1 no</li> <li>- Flow switch: 1 no</li> <li>- Vaporization system if required, which includes vaporizer, thermostat, electrical tracing cable and heater: 1 set</li> <li>- Cooling system if required, which includes one cooler, flow conditioning system: 1 set</li> <li>- Sample handling system fitting, valves, pressure gauges, regulators, solenoid valves, flow meters / flow switches and other components, etc: 10% or minimum 1 no. for each type</li> <li>- Consumables like filters, membranes, reagents, cal. Gas, carriers: For 1 year of continuous operation</li> <li>- Any other instrument item : 1 no</li> </ul>
5.4	pH, Conductivity Analyser	<ul style="list-style-type: none"> <li>- Complete Analyser with sensor, cables, transmitters: 1 no for each type</li> </ul>
5.5	Silica Analyser	<ul style="list-style-type: none"> <li>- Sensor board: 1 no</li> <li>- Sensor and Detector: 1 no for each type</li> <li>- Rotameter: 1 no</li> <li>- Pressure Control Valve: 1 no</li> <li>- Fuses: 5 sets</li> <li>- Electronic card: 1 no for each type</li> <li>- Other Aux. Cards: 1 no for each type</li> <li>- Probe: 1 no for each type</li> <li>- Filters, O-rings, Gaskets: 2 sets</li> <li>- Consumable Kit: 2 sets</li> <li>- Any other instrument item : 1 no</li> </ul>
5.6	Any other Liquid & Gas Analyser	<ul style="list-style-type: none"> <li>- Sensor module: 1 No</li> <li>- Electronic module: 1 No</li> <li>- Any other instrument item : 1 no</li> </ul>
<b>7</b>	<b>Control Valves, On-off Valves, MOV PCV, Desuperheater/PRDS</b>	
7.1	Pneumatic Actuator	<ul style="list-style-type: none"> <li>- Actuator diaphragm, actuator seal kit and spring sets: 10% or min 1 no for each type</li> </ul>
7.2	Electric Actuator	<ul style="list-style-type: none"> <li>- Main PCB: 1 no for each type</li> <li>- Local / off / Remote Switch: 1 no for each type</li> <li>- Open / Stop / Close Switch: 1 no for each type</li> </ul>






 पी डी आई एल <b>PDIL</b>	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b>  <b>SPARE LIST</b>	PC-288/E001/Sec-10	0	 
		Document No.	Rev	
		Sheet 27 of 32		

7.3	Trim Set	- Trim set consisting of seat ring / seal ring, plug withstem, cage (if any) for each type
7.4	Complete Actuatorwith Handwheel	- one complete Actuator for each type
7.5	Antisurge ControlValve	- 1 no for each type
7.6	Gland Packing, Orings and Bonnet Gasket, Seat Gasket	- 1 set for each tag
7.7	Limit Switch/ Solenoid valve/ Positioner and all Other Accessories.	- 10% or min 1 nos foreach type
7.8	PRDS / Desuperheater	- Same as those of Control Valves - Gaskets for valve and connections per unit (if such gaskets, are special and supplied by PRDS/De-Super heater vendor
7.9	Self-operatedRegulator Repair kit consisting of orifice, plug, spring, gasket, diaphragm, spring, O-ring	- 20% or min 1 no for each type
7.10	MOVs Main PCB of each type Local / Remote / off Selector Switch each type Open / close / stop Selector Switch each type	- 10% or min. 1 no of each type
8	<b>Control Systems</b> <b>DCS/ESD/FGS/ any other PLC</b>	
8.1	Control SystemHardware	<ul style="list-style-type: none"> <li>- CPU : 10% or min 1 no each type</li> <li>- System DC Power supply: 10% or min 1 no each type</li> <li>- All Communication Module: 10% or min. 2 nos for each type</li> <li>- I/O Module: 20% or min 5 nos for each type</li> <li>- OPC / Modbus interface cards: 1 no each along with Connectors / cables</li> <li>- All type system Pre-fab Cable: 10% or min 5 sets foreach type</li> <li>- All type of communication cable: 10% or min 5 sets foreach type</li> <li>- Backplane Unit: 2 nos for each type</li> <li>- FTA board: 2 nos for each type</li> </ul>
		<ul style="list-style-type: none"> <li>- System Battery: 1 no for each type</li> <li>- Terminator: 1 no for each type</li> <li>- Various system / glass fuse: 100% for each type</li> </ul>
8.2	Cabinet	<ul style="list-style-type: none"> <li>- Filter: 100%</li> <li>- Fan: 5% or min. 2 nos for each type</li> <li>- Light: 5% or min. 2 nos for each type</li> <li>- PDB Voltmeter: 5% or min. 2 nos for</li> </ul>




<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>SPARE LIST</b></div>	PC-288/E001/Sec-10	0	<div></div>
		Document No.	Rev	
		Sheet 28 of 32		

		each type - PDB fuse: 100% for each type - Circuit Breaker: 5 nos for each type - Temperature Monitoring for cabinets: 10% or min 1 sets for each type - Fan Failure Unit (FFU): 10% or min 1 sets for each type -
		- Relay: 10% or min 5 nos for each type - Safety Barrier: 10% or min 5 nos for each type - Isolator, Converter: 10% or min 5 nos for each type - Terminal Block with DIN rail: 100 nos for each type - Cables for marshalling rack wiring: 100 m of each color and size - 24V DC Power supply: 10% or min 1 nos for each type - 24 V DC Bulk Power Supply modules : 10% or min 1 nos for each type - Diode-O ring modules: 10% or minimum 1 no. each type
8.3	Hubs, all Switches, Routers ,Bus units	- 20% or min 1 no for each type
8.4	Hardwire console Pushbuttons, lamps, switches (Including relevant terminal modules / accessories):	- 10% or min 1 nos for each type
8.5	Workstation	- Communication card for operator workstation: 10% or min.1 no. - Communication card for engineering workstation: 10% or min.1 no. - Motherboard for operator workstation: 10% or min.1 no - Motherboard for engineering workstation: 10% or min.1 no. - Switching mode power supply: 10% or min.1 no. - Communication card for SOE workstation: 10% or min.1 no, as applicable -
8.6	HDD unit (including Raid-1, Raid-5 and Normal) with all connectors, plugs	- 10% or min. 2 set for each type
8.7	Keyboard (Including operator keyboard) and Mouse	- 2 nos of keyboard for each type - 5 nos of mouse
8.8	Consumables	- A3 Paper: 10 Rims - A4 Paper: 50 Rims - Laser Cartridge: For 6 month usage, min 2sets for each printer
<b>9</b>	<b>Machine Monitoring System / Vibration Monitoring System</b>	
9.1	Central Rack Monitor	- Power Supply Module: 10% or min 1 nos - Vibration, Axial Displace Module: 20%



<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>SPARE LIST</b></div>	PC-288/E001/Sec-10	0	<div></div>
		Document No.	Rev	
		Sheet 30 of 32		

11.4	Insulation Remover	- 5 nos
11.5	IC puller	- 2 nos for each type
11.6	Logic probe	- 2 nos
11.7	Screw driver kit	- 5 sets
11.8	Allen Key Set (1 mm to 8 mm)	- 5 sets
11.9	Lamp puller	- 3 nos
11.10	Torch	- Handheld LED Torch: 10 nos - Head Torch: 10 nos
11.11	Ferruling machine	- 1 no along with printer ribbon and sleeves size of 5.0mm <sup>2</sup> and 3.5 mm <sup>2</sup> , 100 meter each
11.12	Hand-held communicator	- 1 no.
11.13	Battery charger alongwith 1 set of batteries	- 2 nos of each type
12	Gas Detectors	- Transmitter: 10% or min 1 no for each type - Sensor: 10% or min 1 nos for each type - Smoke Detectors , MCP, Sounders, Hooters: 10% or min 1 nos for each type
13	Flame Scanners	- Electronic unit: 10% or min 1 no for each type - Sensor: As required for 1 year operation or 1 no min
14	Loop powered Indicators	- 10% or min 2 nos
15	CCTV camera, camera station lens with zoom, Pan & Tilt Unit, Receiver Unit, electronic unit, , power supply, Wiper & Washer Unit etc	- 10% or minimum one of each type of module.
16	Pressure Relief Valves/ Thermal Relief Valves/ Vacuum Relief Valves / Low Pressure Relief Valves / Pilot Operated Valves	- 10% or minimum one of each type of module
17	Rupture Disc	- 10% or minimum one of each type of module
18	Panel mounted instruments	- 10% or minimum one of each type of module

<div> पी डी आई एल <b>PDIL</b></div>	<div><b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <u><b>OWNER: Bharat Coal Gasification and Chemicals Limited</b></u> <b>SPARE LIST</b></div>	PC-288/E001/Sec-10	0	<div></div>
		Document No.	Rev	
		Sheet 31 of 32		

19	EPABX Unit, Electronic Card each type	<ul style="list-style-type: none"> <li>- 10% or minimum one of each type of module.</li> <li>- Handsets: 10% or min 1 no for each type/ range/ model</li> </ul>
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### 3.0 VENDOR'S RECOMMENDED SPARE PARTS

Contractor shall provide list of recommended spare parts of all the equipments as recommended by OEM (Original Equipment Manufacturer) with recommended quantities not covered in mandatory spares along with itemized price. Owner will review and decide the recommended spares required for the project. Recommended spares and their quantities shall take into account related factors of equipment reliability, effect of equipment downtime upon production or safety, cost of parts and availability of vendor's service facilities around the proposed location of equipment.

#### General Notes:

- 1) The above spares do not include installed spares / commissioning spares. The above shall be Mandatory spares only.
- 2) Set means complete replacement of particular part in one machine/equipment/Fired heater etc.
- 3) Item wise price against each item shall be furnished.
- 4) Wherever "Each Type" is specified, it means "of the Type/make/model/size/rating and exactly replaceable"
- 5) Wherever "% qty." is specified, LSTK Contractor to quote in next higher rounded figure
- 6) Out of % age spares and minimum qty specified against each item - higher of the two shall be supplied.
- 7) Spares mentioned above to be offered as mandatory spares. However, if these spares are not used in the equipments being offered / supplied, the same need not be supplied. Bidder shall clearly indicate against each such spare that these spares / items are not used in their equipments.
- 8) The above is owner's recommended list of spares. The supplier may add other items as per their recommendations.
- 9) The quotation should contain sectional drawing showing location & part no. (For exact identification) & material specification.
- 10) LSTK Contractor to supply all commissioning spares for all necessary equipment's for smooth & trouble free operation of complete system.

LSTK Contractor to supply all mandatory spares parts as per the list for all necessary equipment's for smooth & trouble free operation of complete system.



 <div>पी डी आई एल PDIL</div>	PROJECTS & DEVELOPMENT INDIA LTD.	PC0288/E-001/P-II/ SEC-11.0	P	 <div>भारतीय वैद्युत मशीन निर्माणा संस्थान BHEL</div>
		Document No.	Rev	
		Sheet 1 OF 4		

## PART II: TECHNICAL



### SECTION – 11.0 (2)

#### OWNER'S ENGINEERS IN LSTK CONTRACTOR'S OFFICE

**PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT**

**PROJECT: COAL TO AMMONIUM NITRATE COMPLEX, AT LAKHANPUR ODISHA (INDIA)**

P	05/03/2024	05/03/2024	Issued for Client's comment	SR	SK	MN
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	<p><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>Bharat Coal Gasification and Chemicals Limited</u></b>  <b><u>OWNER'S ENGINEERS IN LSTK CONTRACTOR'S OFFICE</u></b></p>	PC009/E-001/P-II/ SEC-11.0	P	
		Document No.	Rev	
		Sheet 2 OF 4		



## **CONTENTS**

Section Number	Description	Sheet Number
1.0	Owner's Engineers In LSTK Contractor's Design Office	3
2.0	Owner's Engineers In LSTK Contractor's Detailed Engineering Office	4

## **LIST OF ATTACHMENTS**

Attachment Number	Description	Number of Sheets



	<p><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>Bharat Coal Gasification and Chemicals Limited</u></b>  <b><u>OWNER'S ENGINEERS IN LSTK CONTRACTOR'S OFFICE</u></b></p>	PC009/E-001/P-II/ SEC-11.0	P	
		Document No.	Rev	
		Sheet 3 OF 4		

## 1.0 OWNER'S ENGINEERS IN LSTK CONTRACTOR'S DESIGN OFFICE:

1.1 LSTK Contractor shall provide to Owner's Engineers in LSTK Contractor's Design Office the following facilities and services free of charge:

The basis is .....man months for Purification Plant not exceeding..... Engineers at any time.

1.1.1 Fully furnished offices: one double occupancy office, one single occupancy office for each design office. A conference table shall be provided in the single occupancy office.

1.1.2 Office equipment for exclusive use by Owner's Engineers shall be:

- ❖ 1 Fax machine
- ❖ 1 Scanning machine
- ❖ 1 Speaker-type telephone per office
- ❖ 1 Small desk calculator per office
- ❖ 1 PC with internet per engineer and printing facility
- ❖ 1 Photocopying machine

1.1.3 Office stationery



1.1.4 Local transportation from residence to office and vice versa by means of public transport or car pool transportation.

1.1.5 Telephone and fax services in LSTK Contractor's Design office as follows:

- a) Cost of facsimile transmissions is in LSTK Contractor's fixed price.
- b) Cost of international telephone calls up to maximum of **15(fifteen)** hours per month are in LSTK Contractor's fixed price.
- c) Cost of local and domestic telephone calls is in LSTK Contractor's fixed price.

1.1.6 LSTK Contractor shall fully and on a best effort basis assist Owner's resident Engineers in obtaining required Work permits and Visa on time as necessary and required.

1.1.7 Owner's Engineers offices should be near LSTK Contractor's project team (as far as possible) and can access to LSTK Contractor's general computer services of the non confidential nature, computer network and the Engineers shall be authorized to use Internet and e-mail for inter office and other countries and use the video teleconference.

	<p><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>Bharat Coal Gasification and Chemicals Limited</u></b>  <b><u>OWNER'S ENGINEERS IN LSTK CONTRACTOR'S OFFICE</u></b></p>	PC009/E-001/P-II/ SEC-11.0	P	
		Document No.	Rev	
		Sheet 4 OF 4		

## 2.0 OWNER'S ENGINEERS IN LSTK CONTRACTOR'S DETAILED ENGINEERING OFFICE:

**2.1** LSTK Contractor's Detailed Engineering Contractor shall provide to Owner's Engineers in their office the following facilities and services free of charge:

The basis is .....man months not exceeding..... Engineers at any time.

**2.1.1** Fully furnished offices, three double occupancy offices, one single occupancy office. A conference table shall be provided in the single occupancy office.

**2.1.2** Office equipment for exclusive use by Owner's Engineers shall be:

- ❖ 1 Fax machine
- ❖ 1 Scanning machine
- ❖ 1 Speaker-type telephone per office
- ❖ 1 Small desk calculator per office
- ❖ 1 PC with internet per engineer and printing facility
- ❖ 1 Photocopying machine
- ❖ 1 Table for reviewing drawings

**2.1.3** Office stationery

**2.1.4** Telephone and fax services in LSTK Contractor's Detailed Engineering office as follows:

- a) Cost of facsimile transmissions is in LSTK Contractor's fixed price
- b) Cost of domestic telephone calls up to a maximum of **15(fifteen)** hours per month are in LSTK Contractor's fixed price.
- c) Cost of international telephone calls up to a maximum of 15 (fifteen) hours per month are in LSTK Contractor's fixed price.

**2.1.5** Owner's Engineers Offices should be near LSTK Contractor's project team. Owner's engineers should be authorized to access LSTK Contractor's general computer services/computer network of the non-confidential nature and Resident Engineers should be authorized to use E-Mail for interoffice and other countries if possible.

	PROJECTS & DEVELOPMENT INDIA LIMITED	PC0288/E/001/P-II/ SEC-12.0	P	
		Document No.	Rev	
		Sheet 1 of 8		

## PART II: TECHNICAL(2)



### SECTION – 12.0

#### TRAINING OF OWNER'S PERSONNEL

**PLANT : SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT**

**PROJECT: COAL TO AMMONIUM NITRATE COMPLEX, AT LAKHANPUR, ODISHA (INDIA)**

P	05/03/2024	05/03/2024	Issued for Client's comment	SR	SK	MN
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD



	<p><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM</u></b> <b><u>NITRATE PLANT</u></b> <b><u>Bharat Coal Gasification and Chemicals Limited</u></b>  <b><u>TRAINING OF OWNER'S PERSONNEL</u></b></p>	PC0288/E/001/P-II/ SEC-12.0	P	
		Document No.	Rev	
		Sheet 2 of 8		

## **CONTENTS**

Section Number	Description	Sheet Number
1.0	General	3
2.0	Objectives of Manpower Training	3
3.0	Requirement of Trained Personnel	3
4.0	Training program: Content and Timing	4
5.0	Evaluating and Reporting Trainee's Progress	6
6.0	Integrating Trainees into their Work Environment	7
7.0	Language of Training	7
8.0	Training services by LSTK Contractor	7
9.0	Management and Co-ordination of Training Services	8
10.0	Miscellaneous	8

## **LIST OF ATTACHMENT**

Attachment Number	Description	Number of Sheets

	<p><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM</u></b> <b><u>NITRATE PLANT</u></b> <b><u>Bharat Coal Gasification and Chemicals Limited</u></b>  <b><u>TRAINING OF OWNER'S PERSONNEL</u></b></p>	PC0288/E/001/P-II/ SEC-12.0	P	
		Document No.	Rev	
		Sheet 3 of 8		

## 1.0 GENERAL:

*Given below is a typical program to train Owner's Operations' and Maintenance manpower in similar plants. Under this program nominated personnel shall be trained at:*

- ❖ LSTK Contractor's Licensor's Office.
- ❖ LSTK Contractor's Detailed Engineering Office
- ❖ Equipment / DCS manufacturer's workshops
- ❖ New Plant Site



## 2.0 OBJECTIVES OF MANPOWER TRAINING:

**2.1** The objectives of LSTK Contractor's training program shall be to transfer Process Technology and develop technical expertise in a core of individuals so that there is a pool of knowledge among Owner's personnel which can be used to operate and maintain complete plants and to give continuous long term training to junior operations and maintenance staff. The basic objective of training shall comprise of following main elements:

- 2.1.1** Owner's manpower shall receive sufficient detailed instructions on the plants to enable them to carry out normal operations, to take corrective action in the event of upset conditions, and to set up routine operating and maintenance procedures.
- 2.1.2** Owner's manpower shall be able to develop a thorough understanding of the plants and the know-how and processes behind it, be in a position to take positive and corrective action to prevent any upset and breakdown conditions from occurring, and to optimize plants' operations, maintenance and organization.

## 3.0 REQUIREMENT OF TRAINED PERSONNEL:

Requirement of Technical Personnel for the plants shall be demonstrated to Owner by LSTK Contractor based on organisation chart of similar Plants indicating the total number of personnel required or operation, maintenance, laboratory works, etc.

	<p><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM</u></b> <b><u>NITRATE PLANT</u></b> <b><u>Bharat Coal Gasification and Chemicals Limited</u></b>  <b><u>TRAINING OF OWNER'S PERSONNEL</u></b></p>	PC0288/E/001/P-II/ SEC-12.0	P	
		Document No.	Rev	
		Sheet 4 of 8		

#### 4.0 TRAINING PROGRAM: CONTENT AND TIMING:

##### 4.1 Title: Process Technology Training Course



<b>Objective</b>	To train Process Engineers and Senior Operations' Personnel. It provides participation with theoretical and practical knowledge and skills required for efficient and safe operation of the plants.
<b>Content</b>	This course describes the process flow and equipment, process control, maintenance procedures, analytical procedures, metallurgy and safety. Process and catalyst and adsorbent and desorbent chemistry and effects of process variables are carefully explained. Plants start-up, shutdown, emergency procedures and production quality control are discussed in detail along with a trouble shooting analysis. Each participant will receive a Process Technology Training Manual.
<b>Duration</b>	4 weeks
<b>Trainers</b>	One LSTK Contractor's Instructor for each individual process training period. The instructor will be specialists in their respective areas.
<b>Participants</b>	Maximum Thirty (Max. Two Batches)(20 for each License Plant)
<b>Location</b>	Licenser's Plant .

##### 4.2 Title: Training at Equipment/DCS Manufacturer's Shops:

The Selected Personnel shall receive specialized training at vendor's shops. Training shall cover major equipment, items and systems incorporated in the subject plants such as DCS, compressors, FCS and the like.

A typical compressor training syllabus at vendor shop premises is given below:

- Overall description and illustration of unit operating principles.
- Detailed examination of unit component parts: Fabrication, Materials, Stress and Corrosion criteria.
- Discussion of Control systems, Alarms, Interlock and Logic circuits.
- Instrument calibration.
- Review of Lube and Seal oil system.
- Detailed instruction of unit operations; control of operating parameters: Pressure, Temperature, Speed, Power cycles.

	<p><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM</u></b> <b><u>NITRATE PLANT</u></b> <b><u>Bharat Coal Gasification and Chemicals Limited</u></b>  <b><u>TRAINING OF OWNER'S PERSONNEL</u></b></p>	PC0288/E/001/P-II/ SEC-12.0	P	
		Document No.	Rev	
		Sheet 5 of 8		

- g. Analysis of Routine/Scheduled/Emergency maintenance techniques; criteria and methods of troubleshooting.
- h. Hands-on training in inspection and test techniques: non-destructive tests; dimensional checking; inspection frequency criteria.
- i. Spare parts: ordering, coding, care of spares.
- j. Running and Workshop testing.

**Duration** : As required and to be mutually agreed.

**Participants** : Maximum 4 per each vendor (Total max. 4 man months \_\_\_\_ s).

#### 4.3 Training Courses at the New Plant Site:



##### 4.3.1 Title: Process Operation training Course

<b>Objective</b>	To provide a basic overview of process chemistry, operating variables and process control suitable for foreman, control room operators and outside.
<b>Content</b>	Description of Process flow and control, Equipment of Plants, Routine duties and operating emergency procedures.
<b>Duration</b>	2 week
<b>Trainers</b>	Two LSTK Contractor's Technical Advisors.
<b>Participants</b>	Maximum Thirty (Max. Two batches) (20 for each Plant)
<b>Location</b>	Owner's Site at <b>Lakhanpur, District Jharsuguda ,Odisha, India.</b>

##### 4.3.2 Title: Start-up Training Course

<b>Objective</b>	To reinforce the theoretical aspects of the operation presented in the Process Operation Training Course.
<b>Content</b>	On-site instruction and on-the job training during Pre-commissioning and Commissioning phase with classroom instruction as far as necessary.
<b>Duration</b>	4 weeks
<b>Trainers</b>	Two LSTK Contractor's Training Advisors.
<b>Participants</b>	Maximum Thirty (20 for each Plant)
<b>Location</b>	Owner's Site at <b>Lakhanpur, District Jharsuguda ,Odisha, India.</b>

##### 4.3.3 Title: On-the-job Training Course

	<p><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM</u></b> <b><u>NITRATE PLANT</u></b> <b><u>Bharat Coal Gasification and Chemicals Limited</u></b>  <b><u>TRAINING OF OWNER'S PERSONNEL</u></b></p>	PC0288/E/001/P-II/ SEC-12.0	P	
		Document No.	Rev	
		Sheet 6 of 8		

<b>Objective</b>	To develop training skills and techniques of participants who will be Involved in operator training services.
<b>Content</b>	Program includes review of on-the-job training and module development material, determining of training needs and objectives, organization and preparation of training materials, curriculum design and lesson plan development. Participants must have attended the Process Technology or Process Operations training course.
<b>Duration</b>	Thirty (30) working days
<b>Trainers</b>	One LSTK Contractor's Training Advisor.
<b>Participants</b>	Maximum Thirty (20 for each Plant)
<b>Location</b>	Owner's Site at <b>Lakhanpur, District Jharsuguda ,Odisha, India.</b>

4.3.4 Title : Training on Smart Plant Tools and Integrated information Management System (SPF).



<b>Objective</b>	To develop training skills and techniques of participants who will be Involved in review and operation /maintenance.
<b>Content</b>	Program includes review of on-the-job training and module development material, determining of training needs and objectives, organization and preparation of training materials, curriculum design and lesson plan development. Participants must have attended the Process Technology or Process Operations training course.
<b>Duration</b>	1.0 For Core Group of 10 members 10 working days. 2.0 For User group 24 members for 30 working days.
<b>Trainers</b>	One LSTK Contractor's Training Advisor.
<b>Location</b>	Owner's Site at <b>Lakhanpur, District Jharsuguda ,Odisha, India.</b> or elsewhere in India

## 5.0 EVALUATING AND REPORTING TRAINEE'S PROGRESS:

LSTK Contractor's training team shall evaluate performance of trainees and submit report based on following:

- ❖ Oral test
- ❖ Written test
- ❖ Observation at work
- ❖ Performance test



	<p><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM</u></b> <b><u>NITRATE PLANT</u></b> <b><u>Bharat Coal Gasification and Chemicals Limited</u></b>  <b><u>TRAINING OF OWNER'S PERSONNEL</u></b></p>	PC0288/E/001/P-II/ SEC-12.0	P	
		Document No.	Rev	
		Sheet 7 of 8		

## 6.0 INTEGRATING TRAINEES INTO THEIR WORK ENVIRONMENT:

LSTK Contractor shall recognize the need to integrate Owner's personnel into the new Plants organization as an essential part of their training program. From the start of the training period, LSTK Contractor shall apply a "team concept" to organize trainees into study groups, each with its own responsibilities and duties. The team concept shall be fully developed throughout the training period to reinforce the overall learning process and trainee's attitude, all duly adapted to Plants organization requirements and Owner's objectives.

Later, during Pre-commissioning, the team concept shall be further emphasized as Owner's personnel shall work side by side along with the LSTK Contractor's Commissioning specialists.

## 7.0 LANGUAGE OF TRAINING:



Both in India and outside India all training shall be conducted in English language.

All personnel to receive training must have a sufficient knowledge of reading, speaking and writing in the English language.

## 8.0 TRAINING SERVICES BY LSTK CONTRACTOR:

**8.1** To achieve the training objectives set forth herein, LSTK Contractor shall provide following services as a minimum:

- Task analysis of plant positions, followed by development of job profiles for all manpower included in LSTK Contractor's training program.
- General and detailed training program for all manpower to be trained.
- Written training aids tailored to each phase of training and for each job position included in the training program.
- Instructions by specialized training personnel inside and outside India.
- Periodic evaluation of individual trainee's progress during all phases of training, in and outside India.
- Comprehensive management of training services included in the training program.

	<p><b><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM</u></b> <b><u>NITRATE PLANT</u></b> <b><u>Bharat Coal Gasification and Chemicals Limited</u></b>  <b><u>TRAINING OF OWNER'S PERSONNEL</u></b></p>	PC0288/E/001/P-II/ SEC-12.0	P	
		Document No.	Rev	
		Sheet 8 of 8		

g. Advice and assistance in respect of travel, housing and subsistence problems related to training overseas.

h. All risks insurance and emergency medical coverage of trainees.

## 9.0 MANAGEMENT AND COORDINATION OF TRAINING SERVICES:

LSTK Contractor shall appoint a Training Manager to manage and coordinate training services for this Project. Owner for his part shall appoint a Training Manager to coordinate with LSTK Contractor. Owner's training Manager shall be responsible for discipline of trainees during all phases of training, inside and outside India.

## 10.0 MISCELLANEOUS:

For training courses in India, Owner shall provide services and facilities for LSTK Contractor's trainers. For training courses outside India, LSTK Contractor shall provide for Owner's trainees the following services and facilities for the duration of such training courses:

- ❖ 1 meal per day in respective canteen
- ❖ Local transportation from place of accommodation outside India to respective place of training course

Owner shall bear the following:

- ❖ Travel cost to/from India to location of training course
- ❖ Accommodation and living cost outside India.

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		Document No.	Rev	
		Sheet 1 OF 7		

## PART - II: TECHNICAL (2)

### SECTION – 13.0



#### INFORMATION REQUIRED IN THE TECHNICAL PROPOSAL

**PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT**

**PROJECT: COAL TO AMMONIUM NITRATE COMPLEX, AT LAKHANPUR, ODISHA (INDIA)**

P	05/03/2024	05/03/2024	Issued for Client's comment	SR	SK	MN
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD



	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>Bharat Coal Gasification and Chemicals Limited</b> <b>INFORMATION REQUIRED IN THE TECHNICAL PROPOSAL</b>	PC0288/E/001/P-II/ SEC-13.0	P	
		Document No.	Rev	
		Sheet 3 OF 7		



## 1.0 PLANT DATA:

### 1.1 PURIFICATION PLANT:

(Note-1: Based on on-stream factor of 330 days/year).

#### 1.1.1 PRODUCT AMMONIA SYN GAS:

Sl.No	Description	Units	At 100% capacity	At 110 % capacity	At 50% capacity
i	Capacity (Note:1)	TPA of Ammonia Syn. Gas			
ii	Capacity (Note:1)	Nm <sup>3</sup> /hr of Ammonia Syn. Gas			
iii	Plant Turn-down ratio	%			
iv	Product Ammonia Syn Gas				
	Hydrogen (H <sub>2</sub> )	Vol %			
	Nitrogen (N <sub>2</sub> )	Vol %			
	Argon (Ar)	Vol %			
	Pressure	Kg/Cm <sup>2</sup> abs			
	Temperature	°C			
v	Feed Consumption				
	Raw Syngas	Nm <sup>3</sup> /hr			
		kg/hr			
	Process Liquid Nitrogen.	Nm <sup>3</sup> /hr			
vi	Export H.P./M.P./L.P. steam if any				
	Quantity	MT/hr			
	Pressure	kg/cm <sup>2</sup> g			
	Temperature	deg C			
vii	Power for balance of plants				
	Quantity	MWhr/hr			
	Voltage	KV			
	Frequency	Hz			
	Phase				

	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>Bharat Coal Gasification and Chemicals Limited</b> <b>INFORMATION REQUIRED IN THE TECHNICAL PROPOSAL</b>	PC0288/E/001/P-II/ SEC-13.0	P	
		Document No.	Rev	
		Sheet 4 OF 7		

### 1.1.2 BY-PRODUCT CARBON DI-OXIDE GAS:

Sl.No	Description	Units	At 100% capacity	At 110 % capacity	At 50% capacity
i	Capacity (Note:1)	TPA of Carbon di-oxide Gas			
ii	Capacity (Note:1)	Nm <sup>3</sup> /hr of Carbon di-oxide Gas			
iii	Plant Turn-down ratio	%			
iv	By-Product Carbon di-oxide Gas				
	Carbon di-oxide Gas (CO <sub>2</sub> )	Vol %			
	Hydrogen (H <sub>2</sub> )	Vol %			
	Nitrogen (N <sub>2</sub> )	Vol %			
	Methane (CH <sub>4</sub> )	Vol %			
	Moisture (H <sub>2</sub> O)	Vol %			
	Pressure	Kg/Cm <sup>2</sup> abs			
	Temperature	°C			



### 1.1.4 BY-PRODUCT SULPHUR:

Sl.No	Description	Units	At 100% capacity	At 110 % capacity	At 50% capacity
i	Capacity (Note:1)	TPA of Sulphur (Solid)			
ii	Capacity (Note:1)	TPH of Sulphur (Solid)			
iii	Plant Turn-down ratio	%			
iv	By-Product Sulphur (Solid)	Wt%			
	Hydrogen Sulphide (H <sub>2</sub> S)	Wt.ppm			

## 2.0 UTILITY CONSUMPTION:

### 2.1 PURIFICATION PLANT:

Sl.No	Utility	Units	At 100%	At 110 %	At 50 %
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	<b>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>Bharat Coal Gasification and Chemicals Limited</b> <b>INFORMATION REQUIRED IN THE TECHNICAL PROPOSAL</b>	PC0288/E/001/P-II/ SEC-13.0	P	
		Document No.	Rev	
		Sheet 5 OF 7		

			capacity	capacity	capacity
i	Power	KWH			
ii	DM Water	m <sup>3</sup> /hr			
iii	Cooling water circulation	m <sup>3</sup> /hr			
iv	Cooling water Make-up	m <sup>3</sup> /hr			
v	HP/MP/LP Steam Export	MT/hr			
vi	MP Steam Import	MT/hr			
vii	Instrument Air	Nm <sup>3</sup> /hr			

### 3.0 PLANT START UP REQUIREMENT:

#### 3.1 PURIFICATION PLANT

Sl.No	Item (Bidder to specify)	Units	
i			Bidder to specify
	Normal		Item-wise quantity, quality at B.L.
	Peak, including duration		required for start-up
	B/L Pressure		
	B/L Temperature		
	Minimum purity required		
	Minimum acceptable limit of		

### 4.0 CATALYST / SOLVENT REQUIREMENT :

Bidder to specify Item-wise information on catalysts used in their process as per pro-forma given below:




Type	Supplier	Loaded Volume	Expected Life (Only For Catalyst)
		m <sup>3</sup>	Years

### 5.0 EFFLUENTS AND EMISSIONS:

#### 5.1 Liquid Effluents (If Any.):





<div><div><div>पी डी आई एल</div><div>PDIL</div></div><div></div></div>	<div><div><div><u>SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM</u></div><div><u>NITRATE PLANT</u></div><div><u>Bharat Coal Gasification and Chemicals Limited</u></div><div><u>INFORMATION REQUIRED IN THE TECHNICAL PROPOSAL</u></div></div></div>	PC0288/E/001/P-II/ SEC-13.0	P	<div><div><div><div>को एच ई एल</div></div><div></div></div></div>
		Document No.	Rev	
		Sheet 7 OF 7		

## 10.0 OTHER TECHNICAL INFORMATION TO BE SUBMITTED ALONG WITH THE BID:(to be discussed)



In addition to the requirements indicated in the earlier paragraphs, the following technical information in accordance with the offer is to be furnished (but not limited to) in the Technical proposal:

### 10.1 Salient features and description of process along with flow diagram indicating operating temperature and pressure conditions of all equipment used in the process.

- a) Process description indicating the functions of various sections.
- b) Process datasheet for equipments.
- c) Details of standards and test protocols being adopted.
- d) Turndown capability and operating range.
- e) System suggested for on-line product quality control.
- f) The details of effluent treatment facilities included in the battery limit and the quantities of gaseous, liquid and solid wastes released from the plant along with their specifications for normal operation and during regeneration, if any.
- g) Utility summary including the requirements of start-up / shutdown of Purification Plant
- h) Flare load summary for various failure cases (cooling water, reflux, power, blocked out, fire).
- i) Plant battery limit tie point details.

### 10.2 Equipment Layout plan:

Equipment Layout plan showing location of various equipment based on relevant appropriate norms.

 <div>पो डी आई एल PDIL</div>	PROJECTS & DEVELOPMENT INDIA LTD.	PNCN/ PC288/E/PART-II-SEC -14.0	P	 <div>भारतीय वैद्युत मशीन निगम BHEL</div>
		Document No.	Rev	
		Sheet 1 of 13		

## SECTION –14.0



### SITE WORKING AND SAFETY CONDITIONS

**PLANT : SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE.**

**PROJECT : SETTING UP OF HIGH ASH COAL-TO-AMMONIUM NITRATE PLANT IN MAHANADI COALFIELDS LIMITED (MCL).**

**CLIENT : BHARAT COAL GASIFICATION AND CHEMICALS LIMITED**



P	25.02.24	Issued for Tender Purpose	JKY	JKY	RRK
REV	REV ATE	PURPOSE	PREPD	REVWD	APPD

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>SITE WORKING AND SAFETY CONDITIONS</b>	PNCN/ PC288/E/PART-II-SEC -14.0	P	
		Document No.	Rev	
		Sheet 2 of 13		

### TABLE OF CONTENTS

SL. NO.	DESCRIPTION	SHEET NUMBER
1.	SITE LOCATION	
2.	SITE ESTABLISHMENT	
3.	SUPERVISION OF WORK	
4.	INSPECTION	
5.	EMPLOYMENT OF LABOUR	
6.	COMPLETION OF WORK	
7.	WORKING AND SAFETY REGULATIONS	
8.	ELECTRICAL SAFETY REGULATIONS	
9.	REPORTING	
10.	GENERAL SAFETY REQUIREMENTS TO BE OBSERVED DURING SITE FABRICATION AND ERECTION BY THE CONTRACTOR	

1.0 **SITE LOCATION** The proposed project site is under mine lease hold area of Lakhanpur Open cast mines located in Lakhanpur Tehsil, Jharsuguda district of



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR</u></b> <b><u>COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and</u></b> <b><u>Chemicals Limited</u></b></p> <p><b>SITE WORKING AND SAFETY</b> <b>CONDITIONS</b></p>	PNCN/ PC288/E/PART-II-SEC -14.0	P	
		Document No.	Rev	
		Sheet 3 of 13		

Odisha with coordinates of 21o46'0"N and 83o46'0"E . It comes under Lakhanpur Area of Mahanadi Coalfields Limited (MCL).

The proposed site is at a distance of 32.0 Km from Jharsuguda & 81 Kms from Sambalpur (MCL's Head Quarter), which is well-connected by National Highway 49. Nearest Railway Station is Belpahar at a distance of 10 km. Veer Surendra Sai Airport, Jharsuguda is the closest airport, which is 38 kms away.

## 2.0 SITE ESTABLISHMENT

- 2.1 The LSTK CONTRACTOR shall provide all huts, stores, tarpaulins and other covers for the accommodation of his staff, workmen and materials. All materials likely to deteriorate in the open shall be stored under suitable cover.
- 2.2 The LSTK contractor shall advise the owner within 15 days of the placement of LOI his space requirement which shall include for office, covered storage, open storage, fabrication space, etc. Depending on availability & requirement, space shall be allotted to the contractor for the duration of this contract. He will not be permitted to make use of any other space without the sanction of the Owner. The use of this space shall strictly be made for the execution of this contract only. The sanitary conditions of the ground in or around such structures shall, at all times, be maintained by the contractor in a manner satisfactory to the owner.
- 2.3 The security of the LSTK contractor's equipment and materials is his own responsibility.
- 2.4 The LSTK contractor's shall clear away periodically any rubbish, scrap materials, etc. and dump the same in the area indicated by the OWNER/PMC. All construction material shall be neatly stacked in an orderly manner as directed by the owner and care shall be taken to allow proper access to workmen and easy movement of men, vehicles, cranes and materials.
- 2.5 The LSTK contractor shall maintain all the drawings carefully mounted on the board of appropriate size and well protected from the ravages of weather termites and other insects.
- 2.6 The LSTK contractor shall not permit the entry to the site of any person not directly connected/concerned with the work without first having obtained the written permission of OWNER.
- 2.7 The LSTK contractor shall submit a list of plant, equipments, tools, tackles, etc. which he will use, to perform the work. The contractor shall submit a list in duplicate of all materials, tools and tackles etc. brought inside the plant site duly signed by owner's security staff as per the rules laid by owner. These tools, etc. shall not be removed from the site till the completion of job. A gate pass must be obtained from the owner in order to remove from site any plant, machinery, tools, materials and equipment.

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR</u></b> <b><u>COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and</u></b> <b><u>Chemicals Limited</u></b></p> <p><b>SITE WORKING AND SAFETY</b> <b>CONDITIONS</b></p>	PNCN/ PC288/E/PART-II-SEC -14.0	P	
		Document No.	Rev	
		Sheet 4 of 13		

- 2.8 All items such as instructions and other pertinent data regarding erection/commissioning and maintenance should be typed and classified for transmittal in a manner approved by the owner.
- 2.9 All employees of the LSTK contractor shall conform to any rules of conduct, etc. established by owner. Failure to comply with the rules of conduct will be sufficient cause for removal of such person from the site.
- 2.10 The LSTK contractor will be responsible for providing all plant, tools and tackles, consumables and scaffolding required for the execution of his work as per the best engineering practices.
- 2.11 The receipt, unloading, movement and storage at site of all the LSTK contractor plant, tools and materials is his responsibility. The receipt, movement & storage of material issued by owner also shall be the responsibility of the LSTK CONTRACTOR/CONSTRUCTION CONTRACTOR.

## 2.12 **ELECTRICITY**

DELETED

## 2.13 **CONSTRUCTION WATER**

DELETED

## 2.14 **FIRST AID**

The LSTK contractor may have access to the Owner's qualified first aid personnel and ambulance, in case of accidents, if available. The contractor will, however provide a first aid post for minor injuries to their staff.



## 3.0 **SUPERVISION OF WORK**

- 3.1 The LSTK contractor shall submit to the Owner resume of his site supervisors for approval prior to commencement of the work. Once approved, the LSTK contractor shall not remove his site supervisors without prior concurrence of the Owner.
- 3.2 The entire work is to be completed as per the agreed time schedule. The programme of work in details shall be submitted by the LSTK contractor before commencement of work. The detailed programmes prepared by the LSTK contractor shall conform to the targets set forth in the time schedule and will be subject to the approval of the owner. All the work shall be carried out in such a manner that the work of other agencies at site is not hampered due to any action of the LSTK contractor.

## 4.0 **INSPECTION**

The work of the LSTK contractor shall be subject to inspection by the OWNER/PMC at all times.

## 5.0 **EMPLOYMENT OF LABOUR**

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR</u></b> <b><u>COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and</u></b> <b><u>Chemicals Limited</u></b></p> <p><b>SITE WORKING AND SAFETY</b> <b>CONDITIONS</b></p>	PNCN/ PC288/E/PART-II-SEC -14.0	P	
		Document No.	Rev	
		Sheet 5 of 13		



- 5.1 The LSTK contractor will be expected to employ on the work only his regular skilled employees with experience of this particular work. The permission of the Owner must be obtained before tradesman is recruited locally for the work. This rule does not apply to unskilled labour. No female labour shall be employed in dark hours/ i.e. hours prohibited under the applicable law. No person below the age of eighteen years shall be employed at any point of time.
- 5.2 All traveling expenses including provision of all necessary transport to and from site, lodging allowances and other payments to the LSTK contractor employees are his own responsibility.
- 5.3 The hours of work on LSTK Contractors / Owner and contractor shall adhere to the same.
- 5.4 All Construction contractors employees shall wear safety helmet and such identification marks as may be provided by LSTK contractor on work site and duly approved by Owner.
- 5.5 All notices displayed on the site and any instructions issued by the Owner shall be strictly adhered to by the LSTK Contractors and/or his LSTK contractor employees.
- 5.6 It shall be the responsibility of LSTK contractor to provide suitable accommodation including necessary facilities for their labour and staff.
- 5.7 LSTK contractor will arrange ID-CARD and Permits for labour as per statutory provisions for its labour, as necessary.
- 5.8 The LSTK contractor shall be required to maintain employment records as covered in relevant Acts and produce documentary evidence to the effect that he has discharged his obligations under the Employees Provident Fund Act 1952 for the workmen working at site.
- 5.9 In case the Owner becomes liable to pay any wages or dues to the labour of the LSTK Contractors or his contractor or any Govt. agency under any of the provision of the Minimum Wages Act, Workmen Compensation Act or any other law due to act of omission of the contractor, the Owner may make such payment and shall recover the sum from Contractor's bills or any other dues.

## 6.0 COMPLETION OF WORK



Before finally leaving site, all the LSTK contractor store, huts, plant, tools and rubbish shall be removed and the site left clean and tidy. The space allocated by Owner shall be vacated and handed over to the Owner.

## 7.0 WORKING AND SAFETY REGULATIONS

- 7.1 The LSTK Contractor shall observe all statutory safety and legal requirements regulations issued by Central and State Governments applicable to the work as well as any local regulations applicable to the site issue by the consultant or any other authority.
- 7.2 Particular attention is drawn to the following:

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR</u></b> <b><u>COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and</u></b> <b><u>Chemicals Limited</u></b></p> <p><b>SITE WORKING AND SAFETY</b> <b>CONDITIONS</b></p>	PNCN/ PC288/E/PART-II-SEC -14.0	P	
		Document No.	Rev	
		Sheet 6 of 13		

- a) In case of accident, the Owner shall be informed in writing forthwith.  
The LSTK Contractor shall strictly follow regulations laid down by Factory Inspector, Govt. and State authorities in this regard.
  - b) LSTK contractor shall fence his plant, platforms, excavations etc.
  - c) Compliance with all electricity regulations.
  - d) Compliance with statutory requirements for inspection and test of all lifting appliances and auxiliary lifting gear.
  - e) Safety belts proposed to be used, shall be got checked by Fire & Safety Department of LSTK Contractor / OWNER in written before use.
  - f) Before using the lifting or pulling equipment, LSTK contractor shall carryout load test which shall be witnessed by LSTK Contractor / OWNER.
- 7.3 Staircase, doors or gangways shall not be obstructed in any way that will interfere with means of access of escape.
- 7.4 No excavations will be started without the permission of the PMC / OWNER, who will inform the LSTK contractor of the position of any pipes or cables known to be buried in the area. All excavations must be effectively railed off at all times, or completely boarded over properly marked during the hours of darkness by red warning lamps, using Flame proof warning lamps in non smoking areas. Debris or material which cannot be immediately removed must be heaped in such a way as to be immediately remove and also to leave adequate passage way. Any finds such as relics or antiques coins or fossils etc. shall be promptly handed over to the Owner.
- 7.5 The LSTK contractor will notify the Owner of his intention to bring on the site any equipment, such as, space heating or welding apparatus or any container holding liquid or gaseous fuel or other substance which might create a hazard. The Owner will have a right to prohibit the use of such equipment or to prescribe the conditions under which such equipment may be used. The LSTK Contractor will have the right to inspect any construction plant, and to forbid its use if in his opinion it is un-suitable or unsafe. No claim arising there from shall be made by the LSTK Contractor.
- The LSTK contractor or any one acting on his instructions will not bring on to the site any radio active substance or any apparatus using such substances or any X ray apparatus until written permission and direction regarding the use of such equipment has been received from the Owner.
- The LSTK contractor shall be responsible for the safe storage of the radio graphic sources or those of his Construction contractors.
- 7.6 The LSTK contractor will meet all requirements, and act on the instructions of the Owner where it is necessary to operate a permit to work system.
- 7.7 Where it is necessary to provide and/or store petroleum products or petroleum mixtures and explosive, the LSTK contractor shall be responsible for carrying out such provision and/or storage in accordance with the rules and regulation laid down in Petroleum Act 1934, Explosive Act 1948 and Petroleum and Carbide of Calcium Manual Published by the Chief Inspector of Explosive of India. All such storage shall have prior approvals of the OWNER/PMC. In case any approval or clearance from

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR</u></b> <b><u>COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and</u></b> <b><u>Chemicals Limited</u></b></p> <p><b>SITE WORKING AND SAFETY</b> <b>CONDITIONS</b></p>	PNCN/ PC288/E/PART-II-SEC -14.0	P	
		Document No.	Rev	
		Sheet 7 of 13		



Explosive or any statutory authorities is required, the contractor shall be responsible for obtaining the same.

- 7.8 The LSTK contractor shall have his own Fire Fighting Extinguishers and Equipment.
- 7.9 The LSTK contractor shall be responsible for the provision of all safety notices safety equipments including the safety gadgets for his workmen required by both the relevant legislation and such as the Owner may deem necessary.
- 7.10 While working at heights, safety belts with lifeline shall necessarily be used.
- 7.11 “LSTK contractor shall employ a safety officer for safe executing the construction activities of the project who will be responsible for implementing safety requirement contained in the documents.  
The safety officer shall possess a recognised degree in engineering discipline preferably, F&S or (Any branch of engineering) and had a post qualification construction experience of minimum two years.  
In addition, he/she shall also possess a recognised degree or diploma in industrial safety and preferably have adequate knowledge of the language spoken by majority of the workers at the construction sites.  
Contractor shall ensure physical presence of safety personnel at each work location wherever Hot Work permit is required. No work shall be started at site until above safety personnel are physically present at site. The contractor shall submit a safety organogram clearly indicating the lines of responsibility and reporting system and elaborate the responsibilities of safety personnel in the HSE MAUAL/Program. The contractor should furnish Bio-Data/Resume of the safety personnel as above, at least 01 month before the mobilization for PMC/OWNER’S approval.
- 7.12 LSTK contractor shall use only steel planks and clamps executing scaffolding. Wooden planks and rope shall not be allowed for this purpose.
- 7.13 LSTK contractor shall use asbestos cloth to ensure falling of weld spatters down below during above ground welding to ensure safety of electrical cables and personnel and avoiding any fire hazards.

## 8.0 ELECTRICAL SAFETY REGULATIONS

- 8.1 In no circumstances will the LSTK contractor interfere with fuse and electrical equipment belonging to the owner or other contractors.
- 8.2 Before the LSTK contractor connects any electrical appliances to any plug or socket belonging to the other contractor or owner, he will -
- Satisfy the Owner that the appliance is in good working condition.
  - Uses of matching sixes plug & does not uses bare wire to insert in socket.
  - Inform the Owner of the maximum current rating, voltage and phase of appliance.
  - Obtain permission of the Owner dealing the sockets to which the appliance may be connected.



	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR</u></b> <b><u>COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and</u></b> <b><u>Chemicals Limited</u></b></p> <p><b>SITE WORKING AND SAFETY</b> <b>CONDITIONS</b></p>	PNCN/ PC288/E/PART-II-SEC -14.0	P	
		Document No.	Rev	
		Sheet 8 of 13		

v. Use distribution board with ELCB for feeding power to hand held tools.

8.3 The Owner will not grant permission to plug in until he is satisfied that-

- i. The appliance is in good condition and is fitted with a suitable plug.
- ii. The appliance is fitted with a suitable cable having two earth conductors, one of which shall be earthed metal sheath surrounding the cores.

8.4 No electric cable in use by the other LSTK contractor/owner will be distributed without prior permission. No weight of any description be imposed on any such cable and no ladder or similar equipment will rest against or be attached to it. Cables / Wires used shall be in good condition without cuts & in insulation & joints.

8.5 The voltage for all portable equipment e.g. drilling machines, temporary lighting etc. will not exceed 240 volts.

8.6 No work must be carried out on any live equipment. The equipment must be made safe and a "permit to work" issued before any work is carried out.

8.7 LSTK contractor shall employ electrician to maintain his temporary electrical installation.

8.8 Take necessary clearance for working in hazardous area.

## 9.0 REPORTING



a) The LSTK contractor must report the following information to the Owner in writing daily. Number of men employed, trades-wise,

- Progress achieved;
- Concrete pour card, if any.

b) If during excavation any materials such as but not limited to precious materials or treasure troves etc are found, the same shall be reported to owner immediately and shall be the property of owner.



## 10.0 GENERAL SAFETY REQUIREMENTS TO BE OBSERVED DURING SITE FABRICATION AND ERECTION BY THE CONSTRUCTION CONTRACTOR

1. Before starting the work, **LSTK contractor** should get safety work permit and should strictly follow instructions written by the concerned authority in work permit. Permit is required for all types of job i.e. Hot, Cold Excavation, Chipping, Grinding etc.
2. Smoking is strictly prohibited inside factory areas.
3. Safety appraisal and equipments shall be provided to workmen as per the nature of work. Welders shall use gloves, goggles, shields etc. during welding, gas cutting etc. All technicians shall use gloves, goggles during

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR</u></b> <b><u>COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and</u></b> <b><u>Chemicals Limited</u></b></p> <p><b>SITE WORKING AND SAFETY</b> <b>CONDITIONS</b></p>	PNCN/ PC288/E/PART-II-SEC -14.0	P	
		Document No.	Rev	
		Sheet 9 of 13		



grinding, chipping etc. If any unsafe practice is observed Fire & Safety Sections or the authority issuing the work permit is authorized to stop the work without any prior notice.

4. Temporary fire extinguishers, water hose shall be available near work place and in case of fire, Owner's Fire & Safety Section should be immediately informed by LSTK contractor from nearest available telephone. Project Manager should also be immediately informed.
5. LSTK contractor shall secure necessary insurance of his workmen for the entire duration of works under the contract. Owner is not responsible for any accident/injury caused whatsoever, to any person employed by the Construction Contractor. However, LSTK contractor has to inform Owner's Fire & Safety Section about accident, if any, immediately.
6. Temporary switch boards, cables, wires and electrical equipments should be installed in accordance with standard electrical practice with proper earthing etc. and should have prior approval of LSTK Contractor / Owner electrical engineer. Switch board shall be suitably protected against rainwater. The cable used for welding machine should have flexible tough rubber sheathing.
7. Temporary cables and wires including welding cables should be routed as not to cluster the work areas. Also any possibility of damage to live wires by falling objects should be avoided. Temporary electrical lines for power & lighting shall run overhead or underground so that they should not hinder the movement of men, materials and vehicles.
8. Portable hand lamps being used by construction crew shall be preferably of 24 Volts supply bulb to be protected with safety shields.
9. Earthing for welding shall not be taken through existing structure or equipments due to the very explosive nature of the plant, raw materials, reaction during process and final product. There is every possibility of fire and explosion in the equipment due to electric spark caused by loose earthing connection etc.
10. LSTK contractor should be careful while excavating so that no underground cable or pipe line is damaged. As soon as any brick cover or under ground cables are exposed he should stop the work and inform Construction Manager immediately for necessary action.
11. LSTK contractor should not leave any welding machine etc. running after the work is stopped. Before leaving the work place, Contractor should ensure that welding sets are disconnected from welding socket outlet.
12. All work areas shall be kept reasonably clear and clean for easy movement of men & material. Also all approach roads shall be free from obstacles for easy movement of cranes, vehicles, fork-lifts, trollies etc. and all debris shall be periodically removed.
13. All temporary structure and supports for erection purpose such as scaffolding, ladders, walkways, platform, shuttering etc. shall be sufficiently

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>SITE WORKING AND SAFETY CONDITIONS</b>	PNCN/ PC288/E/PART-II-SEC -14.0	P	
		Document No.	Rev	
		Sheet 10 of 13		

strong for safe use and to prevent collapse & accidental fall of workman. Same shall be removed immediately after the work is completed.

14. All workmen working at unsafe elevation during the construction activity such as concreting, plastering, welding, erection work, painting, insulation etc. shall be safe and sufficient passage and should be properly instructed to take necessary safety precautions and observe safe practice to prevent accidental fall. Safety belts and helmets shall be used wherever necessary.
15. All supervisors, welders, electricians, technicians, riggers, engaged in the work shall be adequately skilled, experienced and acquainted with standard rules, regulation & practices of the work.
16. All open trenches, pits and other excavation carried shall be barricaded out by Construction Contractor, to avoid accident.
17. All lifting tools, tackles & accessories shall be in good working condition and of suitable capacity for the purpose for which they are used. All certificates/permits/licenses etc. required under any law or regulation for the same shall be available and valid during the entire period of the execution of the work under this Work Order/Contract.
18. LSTK contractor shall not use any structure or equipments erected or under erection for fastening, lifting or flying tackle guy-ropes etc. which may impose such loads for which structure or equipments are not designed to carry. However, LSTK contractor has to get prior approval from Construction Manager of Owner before using beams, permanent structure for the above purpose.
19. When work is carried out at high elevations, it is the responsibility of the LSTK contractor to ensure that tools and materials are not left in a position where they can fall on peoples moving /working below. Where necessary, places below should be cordoned off and caution boards be provided by contractor. Also, LSTK contractor should not cut existing hand railing/structure.
20. Contractor's men must not tamper with any machines, switches, valve or equipment not connected with their work. Welding holders should not be tested on running pipe lines.
21. Nylon rope should not be used for scaffolding where hot line is running near by, because there is every possibility of wire rope catching the fire. Also, no scaffolding is to be made on hot as well as insulated lines.
22. Necessary sign boards clearly indicating "RADIOGRAPHY HAZARDS" on all the four sides of the cordoned area surrounding radiography source will have to be displayed by Construction Contractor. Surrounding area will be cordoned with the help of manila rope and his personnel will be kept for watching/guard on all the four sides to prevent entry of personnel till the radiography work is completed. Construction Contractor's personnel should be able to communicate clearly/properly to stop entry of unauthorized personnel within the area cordoned for the radiography work.

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>SITE WORKING AND SAFETY CONDITIONS</b>	PNCN/ PC288/E/PART-II-SEC -14.0	P	
		Document No.	Rev	
		Sheet 11 of 13		

### Refuse Disposal

23. Refuse must be removed daily to prevent accumulation. Materials liable to cause persons to slip or trip and fall should be cleared immediately.
24. Refuse removal teams working after work hour should be organized where normal cleaning can not cope with the build up of waste materials.
25. Projecting nails should be removed or bent over.

### Personal Protective Equipments

26. Helmets should be provided for all who are exposed to the dangers of falling material or structures they might strike against.
27. Suitable eye protection should be provided for all who are exposed to flying particles, harmful glare and dangerous substances.
28. In the handling of rough objects, gloves should be provided and used.
29. Safety footwear should be provided to all who are exposed to foot injury, should be good fitting and comfortable to wear.
30. Safety belts should be provided where other means are not practicable. Both the anchorage points and lifelines provided for attaching safety belts should be of adequate strength. The umbilical line should be fixed in such a way that user's freefall will not exceed 1 metre.
31. Catch net should be used where persons are liable to fall and these should be securely supported at a level as near as possible to the working level.
32. Noise defenders should be provided for work area where the noise level exceeds 85 dBA.
33. Respiratory protection should be provided by employers and used by workers where the dust level remains high and where control at source is not practicable.



### Inspection & Record Keeping

34. Where defects render the scaffolds unsafe, they should be rectified immediately. Where this is not practicable, a sign should be put warning against using it.

### Winches

35. Adequate foundations should be provided for winches.

### Lifting Gear

	<b>PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT</b> <b>OWNER: Bharat Coal Gasification and Chemicals Limited</b> <b>SITE WORKING AND SAFETY CONDITIONS</b>	PNCN/ PC288/E/PART-II-SEC -14.0	P	
		Document No.	Rev	
		Sheet 12 of 13		

36. All lifting gear and slinging should be tested before use and thereafter inspected regularly by competent engineers. Workers should also check the lifting gear visually before using them.
37. Each piece of lifting gear should bear its safe working load, its identification number and its last inspection date. It could in addition be colour coded according to due date of inspection.
38. Wire ropes should be preserved against rusting, kinking, fraying, birdcaging and heat damage. Defective wires should be destroyed to prevent recycling.

#### Concrete Mixers

39. Moving parts which are liable to become nip points, such as gears, chains and rollers should be guarded.
40. Where concrete mixers are driven by internal combustion engines, exhaust points should be located away from the workers' work station so as to eliminate their exposure to obnoxious fumes.

#### Electrical Components

41. All components and conductors used must be in good condition.
42. Proper junction boxes and distribution boards from which electric power could be tapped should be provided at every floor level.



#### Demolition: General Provisions

43. Uncontrolled collapse of walls or other structures under demolition should be prevented.
44. The throwing of materials over the sides of the buildings should not be permitted.

#### Waste Handling

45. Where demolition is carried out near public areas:
  - a) Hoardings slopping inwards should be erected around the building.
  - b) Protective nettings should be hung around the building to prevent materials falling outside the periphery shelter.
  - c) Where asbestos materials are present, appropriate dust control and respiratory protection approved by the local authority must be used.

#### Excavation: General Provisions

	<p><b><u>PLANT: SYNGAS PURIFICATION UNIT FOR</u></b> <b><u>COAL TO AMMONIUM NITRATE PLANT</u></b> <b><u>OWNER: Bharat Coal Gasification and</u></b> <b><u>Chemicals Limited</u></b></p> <p><b>SITE WORKING AND SAFETY</b> <b>CONDITIONS</b></p>	PNCN/ PC288/E/PART-II-SEC -14.0	P	
		Document No.	Rev	
		Sheet 13 of 13		

46. Test for toxic gases should be carried out where their presence is suspected.
47. Exposure of shorings to vibration such as that produced by engines or vehicular traffic should be kept to a minimum.

#### **General – Ventilation, Fire Protection/Fighting**

48. Where flammable gas concentration could reach explosive levels, it may be necessary to provide intrinsically safe electrical equipments.
49. Adequate lighting and emergency lighting should be provided.
50. Adequate evacuation stairways should be provided for rapid evacuation in case of an emergency.

#### **First Aid**

51. Sufficient First Aid Boxes containing simple dressings and supplies should be provided on the site under the control of the foreman.

#### **Awareness**

52. The contractor shall brief the visitor about HSE precautions which are required to be taken before proceeding to site and make necessary arrangement to issue appropriate PPE's like HELMET, Safety shoes etc. to the visitors.  
The contractor shall promote and develop consciousness about Health, safety and environment among all personnel working for the contractor. Regular awareness programmes and fabrication shop/work site meeting at least on fortnightly basis shall be arranged on HSE activities to cover hazards involved in various operations during construction phase. During the awareness program, step shall be taken by the contractor to motivate & encourage the workmen and supervisory staff by issuing/awarding them the tokens/gifts/mementos/ Monitory incentives.  
A verbal warning shall be given to the workers during the first HSE violations. A written warning shall be issued on second violations and thereafter for the third volitions; the services of worker shall be terminated. For all these violations, penalties' shall be imposed, separately on the contractor. Records of warning for each worker shall be kept in the records.

 <b>PROJECTS &amp; DEVELOPMENT INDIA LTD.</b>	PC0288/E/001/P-II/ SEC-15	P1	
	Document No.	Rev	

## SECTION 15.0

### VENDOR LIST

**PLANT: SYNGAS PURIFICATION UNIT FOR COAL TO AMMONIUM NITRATE PLANT**

**PROJECT: COAL TO AMMONIUM NITRATE COMPLEX, AT LAKHANPUR, ODISHA (INDIA)**

	<b>VENDORS LIST FOR PROJECTS</b>	04-00MM-0011	18
		DOCUMENT NO	REV

CONTENTS

SECTION NUMBER	DESCRIPTION	PAGE NO.
1.0	MECHANICAL ITEMS (PR.VESSELS/HEAT EXCHANGERS)	MV-1 to MV-87
2.0	MECHANICAL ITEMS (PIPING )	MP-1 to MP-88
3.0	MECHANICAL ITEMS (MACHINERY)	MM-1 to MM-62
4.0	MECHANICAL ITEMS (REFORMER)	MR-1 to MR-16
5.0	MECHANICAL ITEMS (MATERIALS HANDLING)	MH-1 to MH-38
6.0	INSTRUMENT ITEMS CIVIL	IN-1 to IN-148
7.0	ENGG. ITEMS PROCESS	CV-1 to CV-22
8.0	ENGG. ITEMS ELECTRICAL	PR-1 to PR-39
9.0	ENGG. ITEMS CUSTOMS	EL-1 to EL-141
10.0	CLEARANCE & TRANSPORTATION ITEMS	TR-1 to TR-2



	<b>MASTER VENDORS LIST FOR PROJECTS</b>	04-00MM-0011	18
		DOCUMENT NO	REV

## MASTER VENDORS LIST

FOR

PROJECTS

MECHANICAL ITEMS (PR.VESSELS/HEAT EXCHANGERS)

## INDEX MECHANICAL (PV/HE) ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE NO.
<b>1101</b>	<b>BOILERS</b>	
110101	INDUSTRIAL & POWER BOILERS	3
110103	W.H. BOILER (RG/CG/SYNLOOP,STEAM SUP. & STEAM DRUMS)	4
110104	WASTE HEAT BOILER (SULPHURIC / NITRIC ACID ETC)	5
<b>1102</b>	<b>PRESSURE VESSELS,GAS HOLDERS, COLUMNS ETC.</b>	
110201	AMMONIA CONVERTER (PRESSURE SHELL)	6
110202	CONVERTER BASKET	7
110203	UREA REACTOR	9
110204	SECONDARY REFORMER, METHANATOR & OTHER REACTORS	10
110205	VESSELS IN CS/AS/SS PRESSURE UPTO 10 Kg/cm <sup>2</sup> g	12
110206	VESSELS IN CS/AS/SS PRESSURE 11 TO 60 Kg/cm <sup>2</sup> g	17
110207	VESSELS IN CS/AS/SS PRESSURE ABOVE 60 Kg/cm <sup>2</sup> g	22
110208	TALL COLUMNS	25
110209	SMALL COLUMNS	28
110211	VACUUM SEPARATOR, PRECONCENTRATOR FOR UREA PLANT	32
110212	LPG BULLETS	34
110213	HORTON SPHERE	35
110214	GAS HOLDERS	37
110215	DEARATORS (Vendor Design)	38
<b>1103</b>	<b>TANKS</b>	
110301	SHOP FABRICATED TANKS & NONCODED VESSELS	40
110302	STORAGE TANKS (Site Fabricated)	43
110303	FLOATING ROOF TANKS	45
<b>1104</b>	<b>TOWER INTERNALS</b>	
110401	METALLIC TOWER PACKINGS	46
110403	TRAYS, DISTRIBUTORS & INTERNALS	47
110404	DEMISTERS	49
<b>1105</b>	<b>HEAT EXCHANGERS</b>	
110501	H.P. UREA STRIPPER	50
110502	H.P. CARBAMATE CONDENSER	51

## INDEX CUSTOM CLEARANCE & TRANSPORTATION ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE NO.
110503	HEAT EXCHANGERS UPTO 30 Kg/cm <sup>2</sup> g	52
110504	HEAT EXCHANGERS 30 TO 60 Kg/cm <sup>2</sup> g	57
110505	HEAT EXCHANGERS ABOVE 60 Kg/cm <sup>2</sup> g	60
110506	EXCHANGERS AIRCOOLED/ FINNED TYPE	62
110507	PLATE TYPE HEAT EXCHANGERS	64
110508	SAMPLE COOLERS	65
<b>1106</b>	<b>FRP/PVC/RUBBER/GLASS/LEAD LINED TANKS &amp; VESSELS AND LINING</b>	
110601	FRP/PVC TANKS & VESSELS	67
110607	FRP/PVC LINING	68
110608	RUBBER LINING	69
<b>1107</b>	<b>MISC ITEMS(PV/HE)</b>	
110702	NITROGEN BOTTLES	70
110703	DISHED ENDS	71
<b>1108</b>	<b>MECHANICAL CONTRACTORS</b>	
110801	MECHANICAL WORKS(piping , machinery & equipment erection	72
110802	HEAVY LIFT	75
110803	HOT & COLD INSULATION OF EQUIPMENT & PIPING	76
110804	CAST IN-SITU TANK INSULATION	78
110805	CHEMICAL CLEANING	79
110806	EPOXY LINING	80
110807	PAINTING OF STRUCTURAL , EQUIPMENT & PIPING	81
110811	ONLY UNDERGROUND PIPING WORKS	83
110812	CROSS COUNTRY PIPELINE	84

## 110101 : INDUSTRIAL & POWER BOILERS

CODE	NAME
<b>INDIA</b>	
1 . P0110	B H P V (Oil fired boilers upto 130TPH and 105Kg/cm2)
2 . P0107	BHARAT HEAVY ELECTRICALS LTD.
3 . P0801	ISGEC HEAVY ENGINEERING LIMITED
4 . P0804	THERMAX BABCOCK & WILCOX LIMITED
<b>GERMANY</b>	
5 . P0499	BORSIG GmbH

## 110103 : W.H. BOILER (RG/CG/SYNLOOP,STEAM SUP. & STEAM DRUMS)

CODE	NAME
<b>INDIA</b>	
1 . P0483	LARSEN & TOUBRO LTD.
2 . P0497	LLOYDS STEELS INDUSTRIES LIMITED
3 . P1210	TRUST WELL ENGINEERS INDIA PVT.LTD. (RG/CG/SYNLOOP,STEAM SUP. & STEAM DRUM ONLY)
<b>GERMANY</b>	
4 . P0499	BORSIG GmbH
5 . P1036	L.C.STEINMULLER GmbH
6 . P0122	MAN TURBOMASCHINEN AG GHH BORSIG
<b>ITALY</b>	
7 . P0254	FBM HUDSON ITALIANA S.p.A.
<b>JAPAN</b>	
8 . P0356	HITACHI BABCOCK LTD
9 . P0437	KAWASAKI HEAVY INDUSTRIES LTD.
10 . P0769	SUMISHO MACHINERY TRADE CORPORATION
<b>U.S.A.</b>	
11 . P0761	STRUTHERS INDUSTRIES INC.

**110104 : WASTE HEAT BOILER (SULPHURIC / NITRIC ACID ETC)**

CODE	NAME
<b>INDIA</b>	
1 . P0483	LARSEN & TOUBRO LTD.
2 . P1133	THERMAL SYSTEMS (HYDERABAD) PVT. LTD.
3 . P0804	THERMAX BABCOCK & WILCOX LIMITED
4 . P1210	TRUST WELL ENGINEERS INDIA PVT.LTD. (SULPHURIC / NITRIC ACID ETC)

## 110201 : AMMONIA CONVERTER (PRESSURE SHELL)

CODE	NAME
<b>INDIA</b>	
1 . P0110	B H P V
2 . P0483	LARSEN & TOUBRO LTD.
3 . P1164	ISGEC HITACHI ZOSEN LIMITED
<b>AUSTRIA</b>	
4 . P0708	SCHOELLER-BLECKMANN NITEC GMBH
5 . P0867	VOEST ALPINE MASCHINENBAU
<b>ITALY</b>	
6 . P0073	ATB ACCIAIERIA E TUBIFICIO DI BRESCIA SP
7 . P0098	BELLELI S.P.A.
8 . P0254	FBM HUDSON ITALIANA S.p.A.
9 . P0594	GE POWER (NUOVO PIGNONE SPA)
<b>JAPAN</b>	
10 . P0358	HITACHI ZOSEN
11 . P0458	KOBE STEEL LIMITED
12 . P0540	mitsubishi heavy industries ltd.
<b>KOREA</b>	
13 . P0462	KOREA HEAVY INDUSTRIES & CONSTN. CO. LTD

## 110202 : CONVERTER BASKET

CODE	NAME
<b>INDIA</b>	
1 . P0110	B H P V
2 . P0483	LARSEN & TOUBRO LTD.
3 . P1164	ISGEC HITACHI ZOSEN LIMITED
<b>AUSTRIA</b>	
4 . P0708	SCHOELLER-BLECKMANN NITEC GMBH
<b>FRANCE</b>	
5 . P0133	BSL INDUSTRIES
<b>ITALY</b>	
6 . P0073	ATB ACCIAIERIA E TUBIFICIO DI BRESCIA SP
7 . P0098	BELLELI S.P.A.
8 . P0254	FBM HUDSON ITALIANA S.p.A.
9 . P0594	GE POWER (NUOVO PIGNONE SPA)
10 . P0123	WALTER TOSTO SpA
<b>JAPAN</b>	
11 . P0358	HITACHI ZOSEN
12 . P0422	JAPAN STEEL WORKS LTD
13 . P0458	KOBE STEEL LIMITED
14 . P0540	MTSUBISHI HEAVY INDUSTRIES LTD.
<b>KOREA</b>	



**110202: CONVERTER BASKET**

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CODE	NAME
15. P0462	KOREA HEAVY INDUSTRIES & CONSTN. CO. LTD

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## 110203 : UREA REACTOR

CODE	NAME
<b>INDIA</b>	
1 . P0110	B H P V
2 . P0483	LARSEN & TOUBRO LTD.
3 . P1164	ISGEC HITACHI ZOSEN LIMITED
<b>AUSTRIA</b>	
4 . P0708	SCHOELLER-BLECKMANN NITEC GMBH
<b>GERMANY</b>	
5 . P0812	THYSSEN RHEINSTAHL TECHNIK GMBH
<b>ITALY</b>	
6 . P0015	ACCIAI SPECIALI TERNI
7 . P0073	ATB ACCIAIERIA E TUBIFICIO DI BRESCIA SP
8 . P0594	GE POWER (NUOVO PIGNONE SPA)
<b>JAPAN</b>	
9 . P0458	KOBE STEEL LIMITED
10 . P0540	MITSUBISHI HEAVY INDUSTRIES LTD.
<b>U.S.A.</b>	
11 . P0761	STRUTHERS INDUSTRIES INC.

## 110204 : SECONDARY REFORMER, METHANATOR & OTHER REACTORS

CODE	NAME
<b>INDIA</b>	
1 . P0110	B H P V
2 . P0107	BHARAT HEAVY ELECTRICALS LTD.
3 . P0313	GODREJ & BOYCE MFG. CO. LTD. (except Secondary Reformer)
4 . P0801	ISGEC HEAVY ENGINEERING LIMITED ((Except Secondary Reformer))
5 . P0483	LARSEN & TOUBRO LTD.
6 . P1167	TECHNO PROCESS EQUIPMENTS (INDIA) PVT. LTD. (METHANATOR & OTHER REACTORS ONLY.)
7 . P1047	THE ANUP ENGINEERING LIMITED (OTHER REACTORS ONLY)
8 . P1164	ISGEC HITACHI ZOSEN LIMITED (For Secondary Reformer only.)
<b>FRANCE</b>	
9 . P0082	BABCOCK ENTERPRISE S.A. / CNIM
<b>GERMANY</b>	
10 . P0469	KRUPP INDUSTRIES-TECHNIK
11 . P0812	THYSSEN RHEINSTAHL TECHNIK GMBH
<b>ITALY</b>	
12 . P0073	ATB ACCIAIERIA E TUBIFICIO DI BRESCIA SP
13 . P0098	BELLELI S.P.A.
14 . P0254	FBM HUDSON ITALIANA S.p.A.
15 . P0594	GE POWER (NUOVO PIGNONE SPA)
<b>JAPAN</b>	

## 110204 : SECONDARY REFORMER, METHANATOR & OTHER REACTORS

CODE	NAME
16 . P0358	HITACHI Zosen
17 . P0458	KOBE STEEL LIMITED
18 . P0540	mitsubishi heavy industries LTD.
<b>KOREA</b>	
19 . P0334	DOOSAN MECATEC CO. LTD.
20 . P1035	HANJUNG DCM CO.LTD.
21 . P0369	HUNDAI HEAVY INDUSTRIES
22 . P1116	HYOSUNG CORPORATION (METHANATOR ONLY)
23 . P0462	KOREA HEAVY INDUSTRIES & CONSTN. CO. LTD
<b>U.K.</b>	
24 . P0280	FOSTER WHEELER POWER PRODUCTS LTD

## 110205 : VESSELS IN CS/AS/SS PRESSURE UPTO 10 Kg/cm<sup>2</sup>g

CODE	NAME
1 . P0861	
<b>INDIA</b>	
2 . P1180	BTL EPC LIMITED ((CS Only))
3 . P0643	PRECISION EQUIPMENTS (CHENNAI) PVT LTD
4 . P0018	AERO ENGINEERS
5 . P1048	AIRFRIGE INDUSTRIES
6 . P0060	ARTSON ENGINEERING LIMITED
7 . P1197	ATV PROJECTS INDIA LIMITED (CS ONLY)
8 . P0110	B H P V
9 . P0107	BHARAT HEAVY ELECTRICALS LTD.
10 . P1126	CHEM PROCESS SYSTEMS PVT. LTD. (CS/SS only)
11 . P3389	COPERION IDEAL PVT. LTD. (CS, SS and low Alloy Steel only)
12 . P1177	CRYOSTAR TANKS AND VESSELS PVT.LTD. (CS/AS/SS PRESSURE UPTO 10 Kg/cm <sup>2</sup> g)
13 . P1124	ESSAR HEAVY ENGINEERING SERVICES
14 . P1056	FABTECH PROJECTS & ENGINEERS LTD. (For CS Only.)
15 . P1214	FIL SEP EQUIPMENTS PVT. LTD.
16 . P1213	FLOWCHEM PROCESS EQUIPMENTS

## 110205 : VESSELS IN CS/AS/SS PRESSURE UPTO 10 Kg/cm<sup>2</sup>g

CODE	NAME
17 . P1105	FLOWLINK INDUSTRIES PVT. LTD. (CS/SS Except Urea service)
18 . P6053	FURNACE FABRICA (INDIA) LTD. (CS/SS)
19 . P0288	G R ENGINEERING PRIVATE LIMITED
20 . P0291	GANSONS LTD.
21 . P1045	GEMINI ENGI-FAB PVT. LTD. (Excluding AS Matl)
22 . P0308	GHANSHYAM STEEL WORKS LTD. (CS/SS)
23 . P0323	GMM PFAUDLER LIMITED
24 . P0313	GODREJ & BOYCE MFG. CO. LTD.
25 . P0318	GRAND PRIX ENGINEERING PVT. LTD. (upto 4m D x 6m L x 80mm Thk)
26 . P1011	GRASIM INDUSTRIES
27 . P0341	HEATEX INDIAN CORPORATION
28 . P1216	HEMALATHAA HI-TECH INDUSTRIES
29 . P1052	HINDUSTAN DORR-OLIVER LTD.
30 . P1019	ICEM ENGG. CO. LTD.
31 . P0380	INDIA TUBE MILLS & METAL INDUSTRIES LTD. (For CS/SS only)
32 . P0386	INDUS PROJECTS LTD.(FORMERLY INDUS ENGG)
33 . P0801	ISGEC HEAVY ENGINEERING LIMITED

## 110205 : VESSELS IN CS/AS/SS PRESSURE UPTO 10 Kg/cm<sup>2</sup>g

CODE	NAME
34 . P1110	ISHAN EQUIPMENTS PVT. LTD. (CS/SS only)
35 . P0450	KINETICS TECHNOLOGY INDIA LTD.
36 . P0483	LARSEN & TOUBRO LTD.
37 . P0497	LLOYDS STEELS INDUSTRIES LIMITED
38 . P1112	LOYAL EQUIPMENTS PVT. LTD. (CS/SS and Non IBR only)
39 . P0516	MARS DESIGN PVT.LTD.
40 . P0538	MISTRY PRABHUDAS MANJI ENGG. PVT. LTD.
41 . P1012	MOD FABRICATORS
42 . P1053	MULTI-MAX ENGINEERING WORKS PVT. LTD. ((CS and SS Materials only))
43 . P0565	NAVA BHARAT FERRO ALLOYS LTD
44 . P1113	NEW FIELD INDUSTRIAL EQUIPMENT PVT. LTD. (CS/SS Only)
45 . P1046	NIVITA ENGINEERING WORKS
46 . P1054	NOVATECH PROJECTS INDIA (P) LTD. ((CS and SS material only))
47 . P1136	NUBERG ENGINEERING LIMITED
48 .	NUBERG ENGINEERING LIMITED (CS/SS ONLY)
49 . P1107	ORIENTAL MANUFACTURERS(A DIVN.OF ORIENTAL ENTERPRISE PVT.LTD (CS/SS only)
50 . P1013	PATELS AIRTEMP (INDIA LIMITED

## 110205 : VESSELS IN CS/AS/SS PRESSURE UPTO 10 Kg/cm<sup>2</sup>g

CODE	NAME
51 . P1115	PHILS HEAVY ENGINEERING PVT. LTD. (For AS (P3 & P4) only)
52 . P1058	PRAJ INDUSTRIES LIMITED (CS/SS only)
53 . P1198	PRECISION GASIFICATION SERVICES PRIVATE LIMITED ((NON IBR))
54 . P0648	PROJECT TECHNOLOGISTS PVT. LTD.
55 . P1021	R.D.ENGINEERS (INDIA) PVT. LTD.
56 . P1014	RAJ ENGG. CO.
57 . P1050	RELIANCE FABRICATIONS PVT. LTD.
58 . P0671	REYNOLDS CHEMEQUIP PRIVATE LIMITED (CS/SS)
59 . P1215	S. MARK OIL FIELD ENGINEERING PRIVATE LIMITED
60 . P1015	SHRENO LTD. (UNIT 2)
61 . P1125	SPETECH PLANT EQUIPMENT PVT. LTD. (CS only)
62 . P0785	TAS ENGINEERING CO.(P) LIMITED
63 . P0786	TATA CHEMICALS LTD
64 . P0790	TECHNO PROCESS EQUIPMENTS (INDIA) PVT. LTD.
65 . P1183	TECKSON STEEL INDUSTRIES (SS & CS ONLY)
66 . P1047	THE ANUP ENGINEERING LIMITED
67 . P1168	THE KCP LIMITED



## 110205 : VESSELS IN CS/AS/SS PRESSURE UPTO 10 Kg/cm<sup>2</sup>g

CODE	NAME
68 . P1049	TITANIUM EQUIPMENT AND ANODE MFG. CO. LTD.
69 . P0833	TRIVENI STRUCTURALS LTD.
70 . P0842	UNITOP ENGINEERS PVT. LTD. (Max. shell Dia 4.65, Water vol.140m <sup>3</sup> )
71 . P1123	UNIVERSAL HEAT EXCHANGERS LIMITED (CS/SS/LTCS Only)
72 . P1129	VIJAY TANKS & VESSELS LTD., (KANDLA) (CS/SS only)
<b>AUSTRIA</b>	
73 . P1022	APPARATEBAU SCHWEISSTECHNIK GMBH
74 . P0708	SCHOELLER-BLECKMANN NITEC GMBH
<b>ITALY</b>	
75 . P0602	OLMI SPA
<b>JAPAN</b>	
76 . P0422	JAPAN STEEL WORKS LTD
<b>KOREA</b>	
77 . P0334	DOOSAN MECATEC CO. LTD.
78 . P1035	HANJUNG DCM CO.LTD.
79 . P0369	HUNDAI HEAVY INDUSTRIES
80 . P1116	HYOSUNG CORPORATION (CS/SS/LAS only)
81 . P0462	KOREA HEAVY INDUSTRIES & CONSTN. CO. LTD
82 . P1060	SUNGJIN GEOTEC CO., LTD. (CS and SS only)

## 110206 : VESSELS IN CS/AS/SS PRESSURE 11 TO 60 Kg/cm<sup>2</sup>g

CODE	NAME
1 . P0861	(UPTO 37 Kg/cm <sup>2</sup> g)
<b>INDIA</b>	
2 . P1180	BTL EPC LIMITED ( (Upto 30 Kg/cm <sup>2</sup> g, CS only))
3 . P0643	PRECISION EQUIPMENTS (CHENNAI) PVT LTD (Upto 44 kg/cm <sup>2</sup> g)
4 . P0018	AERO ENGINEERS (CS only)
5 . P1057	ALTECH INFRASTRUCTURE PVT. LTD. (Upto 20 Kg/cm <sup>2</sup> (g) CS Material)
6 . P6063	ARIEN NEW DELHI PRIVATE LIMITED (CS/SS UP TO 11 to 30 kg/cm <sup>2</sup> (g))
7 . P1166	AVADH INDUSTRIES (Upto 34 Kg/cm <sup>2</sup> g (CS Only))
8 . P0110	B H P V
9 . P0107	BHARAT HEAVY ELECTRICALS LTD.
10 . P1126	CHEM PROCESS SYSTEMS PVT. LTD. (CS/SS upto 30 Kg/cm <sup>2</sup> g only)
11 . P1143	CICB-CHEMICON PVT. LTD. (Upto 30 Kg/cm <sup>2</sup> g (CS only))
12 . P1177	CRYOSTAR TANKS AND VESSELS PVT.LTD. (PRESSURE 11 TO 60 KG/CM <sup>2</sup> G, (SS UPTO 30 KG/CM <sup>2</sup> G & CS UPTO 60 KG/CM <sup>2</sup> G))
13 . P1124	ESSAR HEAVY ENGINEERING SERVICES
14 . P1106	EXPO GAS CONTAINERS LTD. (CS only. For SS Material : Upto 30 Kg/cm <sup>2</sup> g)
15 . P1131	FAB-TECH WORKS & CONSTRUCTIONS PRIVATE LIMITED
16 . P1056	FABTECH PROJECTS & ENGINEERS LTD. (For CS Only.)

## 110206 : VESSELS IN CS/AS/SS PRESSURE 11 TO 60 Kg/cm<sup>2</sup>g

CODE	NAME
17 . P1214	FIL SEP EQUIPMENTS PVT. LTD.
18 . P1213	FLOWCHEM PROCESS EQUIPMENTS
19 . P6053	FURNACE FABRICA (INDIA) LTD. (CS/SS UP TO 11 to 30 kg/cm <sup>2</sup> (g))
20 . P0288	G R ENGINEERING PRIVATE LIMITED
21 . P0291	GANSONS LTD.
22 . P1045	GEMINI ENGI-FAB PVT. LTD. (Upto 40 Kg/cm <sup>2</sup> g)
23 . P0308	GHANSHYAM STEEL WORKS LTD. (CS/SS)
24 . P0323	GMM PFAUDLER LIMITED (CS/SS Only)
25 . P0313	GODREJ & BOYCE MFG. CO. LTD.
26 . P0318	GRAND PRIX ENGINEERING PVT. LTD.
27 . P1011	GRASIM INDUSTRIES (upto 30Kg/cm <sup>2</sup> g)
28 . P0341	HEATEX INDIAN CORPORATION
29 . P1216	HEMALATHAA HI-TECH INDUSTRIES
30 . P1052	HINDUSTAN DORR-OLIVER LTD. (CS/SS Only)
31 . P1137	INDCON PROJECTS & EQUIPMENT LIMITED (CS/LTCS/SS upto 30 Kg/cm <sup>2</sup> g)
32 . P0380	INDIA TUBE MILLS & METAL INDUSTRIES LTD. (For CS/SS only upto 30 Kg/cm <sup>2</sup> g)
33 . P0386	INDUS PROJECTS LTD.(FORMERLY INDUS ENGG)

## 110206 : VESSELS IN CS/AS/SS PRESSURE 11 TO 60 Kg/cm<sup>2</sup>g

CODE	NAME
34 . P0801	ISGEC HEAVY ENGINEERING LIMITED
35 . P1110	ISHAN EQUIPMENTS PVT. LTD. (CS/SS Upto 30 Kg/Cm <sup>2</sup> (g) only)
36 . P1154	JINDAL STEEL & POWER LTD. (MACHINERY DIVISION) (CS only)
37 . P0436	KAVERI ENGG. INDUSTRIES LTD.,
38 . P0483	LARSEN & TOUBRO LTD.
39 . P0497	LLOYDS STEELS INDUSTRIES LIMITED
40 . P1112	LOYAL EQUIPMENTS PVT. LTD. (Upto 11-30 Kg/cm <sup>2</sup> , CS/SS and Non IBR only.)
41 . P1138	MEENAKSHI ASSOCIATES (P) LTD. (CS/LTCS/SS upto 30 Kg/cm <sup>2</sup> g)
42 . P1053	MULTI-MAX ENGINEERING WORKS PVT. LTD. (Up to 30 Kg/cm <sup>2</sup> g (CS and SS Materials only))
43 . P1113	NEW FIELD INDUSTRIAL EQUIPMENT PVT. LTD. (Upto 30 Kg/cm <sup>2</sup> g (CS/SS Only))
44 . P0572	NEWTON ENGG. & CHEMICALS LTD. (Upto 36 Kg/cm <sup>2</sup> (CS/SS only))
45 . P1136	NUBERG ENGINEERING LIMITED (CS/SS up to 30 Kg/cm <sup>2</sup> g)
46 . P1107	ORIENTAL MANUFACTURERS(A DIVN.OF ORIENTAL ENTERPRISE PVT.LTD (CS/SS only)
47 . P1013	PATELS AIRTEMP (INDIA LIMITED ((CS & SS only))
48 . P1115	PHILS HEAVY ENGINEERING PVT. LTD. (Up to 30 Kg/cm <sup>2</sup> (g))
49 . P1058	PRAJ INDUSTRIES LIMITED (CS/SS only)
50 . P1021	R.D.ENGINEERS (INDIA) PVT. LTD. (UPTO 30 KG/CM <sup>2</sup> g)

## 110206 : VESSELS IN CS/AS/SS PRESSURE 11 TO 60 Kg/cm<sup>2</sup>g

CODE	NAME
51 . P1014	RAJ ENGG. CO. (Up to 30kg/cm <sup>2</sup> (g) CS/SS/AS (P3 & P4 only))
52 . P1140	RELIANCE FABRICATIONS PVT. LTD. (CS/SS upto 30 Kg/cm <sup>2</sup> g)
53 . P1215	S. MARK OIL FIELD ENGINEERING PRIVATE LIMITED
54 . P1125	SPETECH PLANT EQUIPMENT PVT. LTD. (CS upto 30 Kg/cm <sup>2</sup> g only)
55 . P0790	TECHNO PROCESS EQUIPMENTS (INDIA) PVT. LTD.
56 . P1167	TECHNO PROCESS EQUIPMENTS (INDIA) PVT. LTD. (NON IBR ONLY)
57 . P1047	THE ANUP ENGINEERING LIMITED
58 . P1055	THE INDIAN SUGAR & GENERAL ENGG. CORPN.(ISGEC), DAHEJ (Except Urea Plant Critical Equipment)
59 . P1168	THE KCP LIMITED
60 . P1134	UNIQUE CHEMOPLANT EQUIPMENTS (CS/SS only up to 30 Kg/cm <sup>2</sup> g)
61 . P1123	UNIVERSAL HEAT EXCHANGERS LIMITED (CS/SS/LTCS upto 30 Kg/cm <sup>2</sup> g)
62 . P1129	VIJAY TANKS & VESSELS LTD., (KANDLA) (CS/SS upto 30 Kg/cm <sup>2</sup> g only)
<b>KOREA</b>	
63 . P1149	ALPEC CO. LTD. (CS & AS only)
<b>AUSTRIA</b>	
64 . P0708	SCHOELLER-BLECKMANN NITEC GMBH
<b>GERMANY</b>	
65 . P0499	BORSIG GmbH
<b>ITALY</b>	

## 110206 : VESSELS IN CS/AS/SS PRESSURE 11 TO 60 Kg/cm2g

CODE	NAME
66 . P0098	BELLELI S.P.A.
67 . P0254	FBM HUDSON ITALIANA S.p.A.
68 . P0594	GE POWER (NUOVO PIGNONE SPA)
69 . P1042	ROLLE S.P.A (11 to 60 kg/cm2 pr.)
70 . P0123	WALTER TOSTO SpA
<b>JAPAN</b>	
71 . P0358	HITACHI Zosen
72 . P0458	KOBE STEEL LIMITED
73 . P0540	mitsubishi heavy industries LTD.
74 . P0541	MITSUI ENGINEERING & SHIPBUILDING CO.LTD
<b>KOREA</b>	
75 . P0334	DOOSAN MECATEC CO. LTD.
76 . P1035	HANJUNG DCM CO.LTD.
77 . P0335	HANTECH LIMITED
78 . P1116	HYOSUNG CORPORATION (CS/SS/LAS only)
79 . P0462	KOREA HEAVY INDUSTRIES & CONSTN. CO. LTD
80 . P1060	SUNGJIN GEOTEC CO., LTD. (CS and SS only)
<b>SPAIN</b>	
81 . P0524	MECANICA DE LA PENA S.A.

**110206: VESSELS IN CS/AS/SS PRESSURE 11 TO 60 Kg/cm2g**

CODE	NAME
<b>U.S.A.</b>	
82. P0096	BEAIRD INDUSTRIES LOUISIANA

## 110207 : VESSELS IN CS/AS/SS PRESSURE ABOVE 60 Kg/cm<sup>2</sup>g

CODE	NAME
<b>INDIA</b>	
1 . P0110	B H P V
2 . P0107	BHARAT HEAVY ELECTRICALS LTD.
3 . P1213	FLOWCHEM PROCESS EQUIPMENTS
4 . P0288	G R ENGINEERING PRIVATE LIMITED
5 . P0313	GODREJ & BOYCE MFG. CO. LTD.
6 . P1192	GRAND PRIX ENGINEERING PRIVATE LIMITED (CS ONLY)
7 . P1216	HEMALATHAA HI-TECH INDUSTRIES
8 . P1052	HINDUSTAN DORR-OLIVER LTD. (CS/SS/LTCS/LAS only)
9 . P0801	ISGEC HEAVY ENGINEERING LIMITED ((Except Urea Plant Critical Equipment))
10 . P0483	LARSEN & TOUBRO LTD.
11 . P1013	PATELS AIRTEMP (INDIA LIMITED ((CS only))
12 . P1058	PRAJ INDUSTRIES LIMITED (CS/SS only)
13 . P1215	S. MARK OIL FIELD ENGINEERING PRIVATE LIMITED
14 . P1167	TECHNO PROCESS EQUIPMENTS (INDIA) PVT. LTD. (NON IBR ONLY)
15 . P1047	THE ANUP ENGINEERING LIMITED
16 . P1055	THE INDIAN SUGAR & GENERAL ENGG. CORPN.(ISGEC), DAHEJ (Except Urea Plant Critical Equipment)
<b>KOREA</b>	



## 110207 : VESSELS IN CS/AS/SS PRESSURE ABOVE 60 Kg/cm<sup>2</sup>g

CODE	NAME
17 . P1149	ALPEC CO. LTD. (CS & AS only)
<b>INDIA</b>	
18 . P1164	ISGEC HITACHI ZOSEN LIMITED
<b>AUSTRIA</b>	
19 . P0708	SCHOELLER-BLECKMANN NITEC GMBH
<b>GERMANY</b>	
20 . P0499	BORSIG GmbH (upto 1500 Deg.C & upto 35000KPa)
21 . P0257	FERROSTAAL AKTIENGES ELLSCHAFTG
22 . P0469	KRUPP INDUSTRIES-TECHNIK
23 . P0812	THYSSEN RHEINSTAHL TECHNIK GMBH
<b>ITALY</b>	
24 . P0015	ACCIAI SPECIALI TERNI
25 . P0073	ATB ACCIAIERIA E TUBIFICIO DI BRESCIA SP
26 . P0098	BELLELI S.P.A.
27 . P0254	FBM HUDSON ITALIANA S.p.A.
28 . P0594	GE POWER (NUOVO PIGNONE SPA)
29 . P0602	OLMI SPA
30 . P0123	WALTER TOSTO SpA
<b>JAPAN</b>	
31 . P0437	KAWASAKI HEAVY INDUSTRIES LTD.

**110207 : VESSELS IN CS/AS/SS PRESSURE ABOVE 60 Kg/cm<sup>2</sup>g**

<b>CODE</b>	<b>NAME</b>
32 . P0458	KOBE STEEL LIMITED
33 . P0540	MITSUBISHI HEAVY INDUSTRIES LTD.
34 . P0769	SUMISHO MACHINERY TRADE CORPORATION
<b>KOREA</b>	
35 . P0334	DOOSAN MECATEC CO. LTD.
36 . P1035	HANJUNG DCM CO.LTD.
37 . P0369	HUNDAI HEAVY INDUSTRIES
38 . P1116	HYOSUNG CORPORATION (CS/SS/LAS only)
39 . P0462	KOREA HEAVY INDUSTRIES & CONSTN. CO. LTD
40 . P1060	SUNGJIN GEOTEC CO., LTD. (CS and SS only)

## 110208 : TALL COLUMNS

CODE	NAME
1 . P0861	
<b>INDIA</b>	
2 . P0110	B H P V
3 . P1124	ESSAR HEAVY ENGINEERING SERVICES
4 . P1106	EXPO GAS CONTAINERS LTD.
5 . P1131	FAB-TECH WORKS & CONSTRUCTIONS PRIVATE LIMITED
6 . P1056	FABTECH PROJECTS & ENGINEERS LTD. (For CS only)
7 . P0288	G R ENGINEERING PRIVATE LIMITED
8 . P1045	GEMINI ENGI-FAB PVT. LTD.
9 . P0323	GMM PFAUDLER LIMITED
10 . P0313	GODREJ & BOYCE MFG. CO. LTD.
11 . P1052	HINDUSTAN DORR-OLIVER LTD.
12 . P0380	INDIA TUBE MILLS & METAL INDUSTRIES LTD.
13 . P0801	ISGEC HEAVY ENGINEERING LIMITED (CS/SS/AS)
14 . P1154	JINDAL STEEL & POWER LTD. (MACHINERY DIVISION) (CS only)
15 . P0483	LARSEN & TOUBRO LTD.
16 . P0497	LLOYDS STEELS INDUSTRIES LIMITED

## 110208 : TALL COLUMNS

CODE	NAME
17 . P1115	PHILS HEAVY ENGINEERING PVT. LTD.
18 . P1058	PRAJ INDUSTRIES LIMITED
19 . P1021	R.D.ENGINEERS (INDIA) PVT. LTD.
20 . P1014	RAJ ENGG. CO. (CS/SS only)
21 . P1215	S. MARK OIL FIELD ENGINEERING PRIVATE LIMITED
22 . P1167	TECHNO PROCESS EQUIPMENTS (INDIA) PVT. LTD.
23 . P1047	THE ANUP ENGINEERING LIMITED
24 . P1055	THE INDIAN SUGAR & GENERAL ENGG. CORPN.(ISGEC), DAHEJ (CS/SS/AS)
25 . P1168	THE KCP LIMITED
26 . P1123	UNIVERSAL HEAT EXCHANGERS LIMITED
27 . P1129	VIJAY TANKS & VESSELS LTD., (KANDLA)
<b>KOREA</b>	
28 . P1149	ALPEC CO. LTD.
<b>INDIA</b>	
29 . P1164	ISGEC HITACHI ZOSEN LIMITED
<b>AUSTRIA</b>	
30 . P1022	APPARATEBAU SCHWEISSTECHNIK GMBH
31 . P0708	SCHOELLER-BLECKMANN NITEC GMBH

### **GERMANY**

## 110208 : TALL COLUMNS

CODE	NAME
32 . P0499	BORSIG GmbH
<b>ITALY</b>	
33 . P0098	BELLELI S.P.A.
<b>JAPAN</b>	
34 . P0358	HITACHI Zosen
35 . P0458	KOBE STEEL LIMITED
36 . P0540	mitsubishi heavy industries LTD.
<b>KOREA</b>	
37 . P0334	DOOSAN MECATEC CO. LTD.
38 . P1035	HANJUNG DCM CO.LTD.
39 . P0369	HUNDAI HEAVY INDUSTRIES
40 . P1116	HYOSUNG CORPORATION
41 . P0462	KOREA HEAVY INDUSTRIES & CONSTN. CO. LTD
42 . P1060	SUNGJIN GEOTEC CO., LTD. (CS and SS only)
<b>SPAIN</b>	
43 . P0524	MECANICA DE LA PENA S.A.

## 110209 : SMALL COLUMNS

CODE	NAME
1 . P0861	
<b>INDIA</b>	
2 . P0643	PRECISION EQUIPMENTS (CHENNAI) PVT LTD
3 . P0060	ARTSON ENGINEERING LIMITED
4 . P0110	B H P V
5 . P1177	CRYOSTAR TANKS AND VESSELS PVT.LTD.
6 . P1124	ESSAR HEAVY ENGINEERING SERVICES
7 . P1106	EXPO GAS CONTAINERS LTD.
8 . P1056	FABTECH PROJECTS & ENGINEERS LTD. (For CS only)
9 . P0288	G R ENGINEERING PRIVATE LIMITED
10 . P1045	GEMINI ENGI-FAB PVT. LTD.
11 . P0323	GMM PFAUDLER LIMITED
12 . P0313	GODREJ & BOYCE MFG. CO. LTD.
13 . P1011	GRASIM INDUSTRIES
14 . P1052	HINDUSTAN DORR-OLIVER LTD.
15 . P0380	INDIA TUBE MILLS & METAL INDUSTRIES LTD.
16 . P0801	ISGEC HEAVY ENGINEERING LIMITED

## 110209 : SMALL COLUMNS

CODE	NAME
17 . P1154	JINDAL STEEL & POWER LTD. (MACHINERY DIVISION) (CS only)
18 . P0436	KAVERI ENGG. INDUSTRIES LTD.,
19 . P0483	LARSEN & TOUBRO LTD.
20 . P0497	LLOYDS STEELS INDUSTRIES LIMITED
21 . P0572	NEWTON ENGG. & CHEMICALS LTD.
22 . P1054	NOVATECH PROJECTS INDIA (P) LTD. ((CS & SS only))
23 . P1136	NUBERG ENGINEERING LIMITED
24 . P1013	PATELS AIRTEMP (INDIA LIMITED ((CS & SS only))
25 . P1115	PHILS HEAVY ENGINEERING PVT. LTD.
26 . P1058	PRAJ INDUSTRIES LIMITED
27 . P1021	R.D.ENGINEERS (INDIA) PVT. LTD.
28 . P1014	RAJ ENGG. CO. (CS/SS only)
29 . P0786	TATA CHEMICALS LTD
30 . P0790	TECHNO PROCESS EQUIPMENTS (INDIA) PVT. LTD.
31 . P1167	TECHNO PROCESS EQUIPMENTS (INDIA) PVT. LTD.
32 . P1047	THE ANUP ENGINEERING LIMITED
33 . P1055	THE INDIAN SUGAR & GENERAL ENGG. CORPN.(ISGEC), DAHEJ (CS/SS/AS)

## 110209 : SMALL COLUMNS

CODE	NAME
34 . P1168	THE KCP LIMITED
35 . P1134	UNIQUE CHEMOPLANT EQUIPMENTS
36 . P1123	UNIVERSAL HEAT EXCHANGERS LIMITED
37 . P1129	VIJAY TANKS & VESSELS LTD., (KANDLA)
<b>KOREA</b>	
38 . P1149	ALPEC CO. LTD.
<b>AUSTRIA</b>	
39 . P1022	APPARATEBAU SCHWEISSTECHNIK GMBH
40 . P0708	SCHOELLER-BLECKMANN NITEC GMBH
<b>ITALY</b>	
41 . P0073	ATB ACCIAIERIA E TUBIFICIO DI BRESCIA SP
42 . P0098	BELLELI S.P.A.
43 . P0594	GE POWER (NUOVO PIGNONE SPA)
44 . P1042	ROLLE S.P.A (Small Column)
<b>JAPAN</b>	
45 . P0358	HITACHI Zosen
46 . P0437	KAWASAKI HEAVY INDUSTRIES LTD.
47 . P0542	MITSUI & COMPANY LTD.
<b>KOREA</b>	
48 . P0334	DOOSAN MECATEC CO. LTD.



## 110209 : SMALL COLUMNS

CODE	NAME
49 . P1035	HANJUNG DCM CO.LTD.
50 . P0369	HUNDAI HEAVY INDUSTRIES
51 . P1116	HYOSUNG CORPORATION
52 . P0462	KOREA HEAVY INDUSTRIES & CONSTN. CO. LTD
53 . P1060	SUNGJIN GEOTEC CO., LTD. (CS and SS only)
<b>SINGAPORE</b>	
54 . P0714	SEMBAWANG ENGG. (PTE) LTD.
<b>SPAIN</b>	
55 . P0524	MECANICA DE LA PENA S.A.

## 110211 : VACUUM SEPARATOR, PRECONCENTRATOR FOR UREA PLANT

CODE	NAME
<b>INDIA</b>	
1 . P0643	PRECISION EQUIPMENTS (CHENNAI) PVT LTD
2 . P0110	B H P V
3 . P0288	G R ENGINEERING PRIVATE LIMITED
4 . P0291	GANSONS LTD.
5 . P0313	GODREJ & BOYCE MFG. CO. LTD.
6 . P0801	ISGEC HEAVY ENGINEERING LIMITED
7 . P0436	KAVERI ENGG. INDUSTRIES LTD.,
8 . P0483	LARSEN & TOUBRO LTD.
9 . P1013	PATELS AIRTEMP (INDIA LIMITED
10 . P1014	RAJ ENGG. CO.
11 . P0786	TATA CHEMICALS LTD
12 . P1047	THE ANUP ENGINEERING LIMITED
<b>AUSTRIA</b>	
13 . P0708	SCHOELLER-BLECKMANN NITEC GMBH
<b>ITALY</b>	
14 . P0098	BELLELI S.P.A.
15 . P0254	FBM HUDSON ITALIANA S.p.A.
16 . P0594	GE POWER (NUOVO PIGNONE SPA)

## 110211 : VACUUM SEPARATOR, PRECONCENTRATOR FOR UREA PLANT

CODE	NAME
17 . P0597	OFFICIENE LUIGI RESTA S.P.A.
<b>JAPAN</b>	
18 . P0541	mitsui ENGINEERING & SHIPBUILDING CO.LTD
19 . P0769	SUMISHO MACHINERY TRADE CORPORATION
<b>KOREA</b>	
20 . P0334	DOOSAN MECATEC CO. LTD.
21 . P1035	HANJUNG DCM CO.LTD.
22 . P0370	HYUNDAI CORPORATION
23 . P0462	KOREA HEAVY INDUSTRIES & CONSTN. CO. LTD
<b>SPAIN</b>	
24 . P0524	MECANICA DE LA PENA S.A.

## 110212 : LPG BULLETS

CODE	NAME
1 . P0861	
<b>INDIA</b>	
2 . P0110	B H P V
3 . P0107	BHARAT HEAVY ELECTRICALS LTD.
4 . P1106	EXPO GAS CONTAINERS LTD.
5 . P1131	FAB-TECH WORKS & CONSTRUCTIONS PRIVATE LIMITED
6 . P1056	FABTECH PROJECTS & ENGINEERS LTD.
7 . P0291	GANSONS LTD.
8 . P0386	INDUS PROJECTS LTD.(FORMERLY INDUS ENGG)
9 . P1110	ISHAN EQUIPMENTS PVT. LTD. (Above Ground only)
10 . P0483	LARSEN & TOUBRO LTD.
11 . P0497	LLOYDS STEELS INDUSTRIES LIMITED
12 . P1013	PATELS AIRTEMP (INDIA LIMITED (ABOVE GROUND)
13 . P1023	R&C LIMITED
14 . P1014	RAJ ENGG. CO. (Upto 150 MT)
15 . P1016	SHARP TANKS & STRUCTURALS PVT. LTD.
16 . P0833	TRIVENI STRUCTURALS LTD.

**110212: LPG BULLETS**

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CODE	NAME
17. P1129	VIJAYTANKS & VESSELS LTD.,(KANDLA)

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## 110213 : HORTON SPHERE

CODE	NAME
1 . P0861	
<b>INDIA</b>	
2 . P0110	B H P V
3 . P1131	FAB-TECH WORKS & CONSTRUCTIONS PRIVATE LIMITED
4 . P0288	G R ENGINEERING PRIVATE LIMITED
5 . P0380	INDIA TUBE MILLS & METAL INDUSTRIES LTD.
6 . P0483	LARSEN & TOUBRO LTD.
7 . P1016	SHARP TANKS & STRUCTURALS PVT. LTD.
8 . P0833	TRIVENI STRUCTURALS LTD.
9 . P1129	VIJAY TANKS & VESSELS LTD., (KANDLA)
<b>AUSTRIA</b>	
10 . P0708	SCHOELLER-BLECKMANN NITEC GMBH
11 . P0867	VOEST ALPINE MASCHINENBAU
<b>GERMANY</b>	
12 . P0469	KRUPP INDUSTRIES-TECHNIK
13 . P0494	LINDE AG
14 . P0812	THYSSEN RHEINSTAHL TECHNIK GMBH
<b>ITALY</b>	
15 . P0073	ATB ACCIAIERIA E TUBIFICIO DI BRESCIA SP

## 110213 : HORTON SPHERE

CODE	NAME
16 . P0098	BELLELI S.P.A.
17 . P0594	GE POWER (NUOVO PIGNONE SPA)
<b>JAPAN</b>	
18 . P0358	HITACHI ZOSEN
19 . P0437	KAWASAKI HEAVY INDUSTRIES LTD.
20 . P0458	KOBE STEEL LIMITED
21 . P0540	MITSUBISHI HEAVY INDUSTRIES LTD.
<b>KOREA</b>	
22 . P0334	DOOSAN MECATEC CO. LTD.
23 . P1035	HANJUNG DCM CO.LTD.
24 . P0369	HUNDAI HEAVY INDUSTRIES
25 . P0462	KOREA HEAVY INDUSTRIES & CONSTN. CO. LTD

## 110214 : GAS HOLDERS

CODE	NAME
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1 . P0861

### **INDIA**

2 . P0128      BRIDGE & ROOF CO.

3 . P0251      FACT ENGINEERING WORKS

4 . P0833      TRIVENI STRUCTURALS LTD.



## 110215 : DEARATORS (Vendor Design)

CODE	NAME
<b>INDIA</b>	
1 . P1057	ALTECH INFRASTRUCTURE PVT. LTD.
2 . P0110	B H P V
3 . P0107	BHARAT HEAVY ELECTRICALS LTD.
4 . P0297	GEA ENERGY SYSTEM (I) LTD.
5 . P0372	IAEC INDUSTRIES MADRAS LTD
6 . P0406	ION EXCHANGE (I) LIMITED
7 . P0409	ISGEC JOH.THOMPSON
8 . P1154	JINDAL STEEL & POWER LTD. (MACHINERY DIVISION) (CS only)
9 . P1102	LARSEN & TOUBRO LIMITED
10 . P0804	THERMAX BABCOCK & WILCOX LIMITED
11 . P1210	TRUST WELL ENGINEERS INDIA PVT.LTD. (Vendor Design)
<b>FRANCE</b>	
12 . P0034	ALSTHOM ATLANTIQUE
<b>JAPAN</b>	
13 . P0437	KAWASAKI HEAVY INDUSTRIES LTD.
14 . P0542	MITSUI & COMPANY LTD.
<b>KOREA</b>	
15 . P0369	HUNDAI HEAVY INDUSTRIES
<b>U.K.</b>	

## 110215 : DEARATORS (Vendor Design)

CODE	NAME
16 . P0280	FOSTER WHEELER POWER PRODUCTS LTD
17 . P0566	NEI JOHN THOMPSON

## 110301 : SHOP FABRICATED TANKS & NONCODED VESSELS

CODE	NAME
1 . P0861	
<b>INDIA</b>	
2 . P1180	BTL EPC LIMITED ((CS only))
3 . P0643	PRECISION EQUIPMENTS (CHENNAI) PVT LTD
4 . P1057	ALTECH INFRASTRUCTURE PVT. LTD.
5 . P0060	ARTSON ENGINEERING LIMITED
6 . P1197	ATV PROJECTS INDIA LIMITED (NON CODED VESSEL, CS ONLY)
7 . P1033	BAKSHI CHEMPHARMA EQUIPMENTS PVT.LTD
8 . P1177	CRYOSTAR TANKS AND VESSELS PVT.LTD.
9 . P1124	ESSAR HEAVY ENGINEERING SERVICES
10 . P1213	FLOWCHEM PROCESS EQUIPMENTS
11 . P1105	FLOWLINK INDUSTRIES PVT. LTD. (CS/SS only)
12 . P0288	G R ENGINEERING PRIVATE LIMITED
13 . P0291	GANSONS LTD.
14 . P1051	GAYATRI TANKS & VESSELS
15 . P1045	GEMINI ENGI-FAB PVT. LTD.
16 . P0305	GENERAL MECH.& PROCESS EQUIPT.(P)LTD.

## 110301 : SHOP FABRICATED TANKS & NONCODED VESSELS

CODE	NAME
17 . P0313	GODREJ & BOYCE MFG. CO. LTD.
18 . P0318	GRAND PRIX ENGINEERING PVT. LTD.
19 . P1216	HEMALATHAA HI-TECH INDUSTRIES
20 . P0380	INDIA TUBE MILLS & METAL INDUSTRIES LTD.
21 . P1024	INDUS ENGG. COMPANY
22 . P1110	ISHAN EQUIPMENTS PVT. LTD. (CS/SS only)
23 . P0450	KINETICS TECHNOLOGY INDIA LTD.
24 . P1108	LAXMI ENGINEERING INDUSTRIES (BHOPAL) PRIVATE LIMITED (CS/SS Only)
25 . P0497	LLOYDS STEELS INDUSTRIES LIMITED
26 . P1017	MABEL ENGINEERS PVT. LTD.
27 . P1053	MULTI-MAX ENGINEERING WORKS PVT. LTD.
28 . P0572	NEWTON ENGG. & CHEMICALS LTD.
29 . P1046	NIVITA ENGINEERING WORKS
30 . P1054	NOVATECH PROJECTS INDIA (P) LTD.
31 . P1136	NUBERG ENGINEERING LIMITED
32 . P1107	ORIENTAL MANUFACTURERS(A DIVN.OF ORIENTAL ENTERPRISE PVT.LTD (CS/SS only)
33 . P1157	OSWAL INFRASTRUCTURE LIMITED

## 110301 : SHOP FABRICATED TANKS & NONCODED VESSELS

CODE	NAME
34 . P0644	PRECISION TANKS & VESSELS
35 . P0648	PROJECT TECHNOLOGISTS PVT. LTD.
36 . P1021	R.D.ENGINEERS (INDIA) PVT. LTD.
37 . P1014	RAJ ENGG. CO.
38 . P1132	RELIABLE FABRICATING & ENGINEERING INDUSTRIES
39 . P1050	RELIANCE FABRICATIONS PVT. LTD.
40 . P1140	RELIANCE FABRICATIONS PVT. LTD.
41 . P1215	S. MARK OIL FIELD ENGINEERING PRIVATE LIMITED
42 . P1016	SHARP TANKS & STRUCTURALS PVT. LTD.
43 . P0785	TAS ENGINEERING CO.(P) LIMITED
44 . P0786	TATA CHEMICALS LTD
45 . P1183	TECKSON STEEL INDUSTRIES
46 . P1127	TITANIUM TANTALUM PRODUCTS LTD
47 . P0842	UNITOP ENGINEERS PVT. LTD. (Max shell Dia 4.65m, Vol 140m3)
48 . P1129	VIJAY TANKS & VESSELS LTD., (KANDLA)
49 . P0864	VIPJ INDUSTRIAL ENTERPRISES PVT. LTD.

## 110302 : STORAGE TANKS (Site Fabricated)

CODE	NAME
1 . P0861	
<b>INDIA</b>	
2 . P0060	ARTSON ENGINEERING LIMITED
3 . P1033	BAKSHI CHEMPHARMA EQUIPMENTS PVT.LTD
4 . P0128	BRIDGE & ROOF CO.
5 . P1106	EXPO GAS CONTAINERS LTD.
6 . P1131	FAB-TECH WORKS & CONSTRUCTIONS PRIVATE LIMITED
7 . P1056	FABTECH PROJECTS & ENGINEERS LTD. (For CS only)
8 . P0251	FACT ENGINEERING WORKS
9 . P0291	GANSONS LTD.
10 . P0313	GODREJ & BOYCE MFG. CO. LTD.
11 . P0380	INDIA TUBE MILLS & METAL INDUSTRIES LTD.
12 . P0386	INDUS PROJECTS LTD.(FORMERLY INDUS ENGG)
13 . P0483	LARSEN & TOUBRO LTD.
14 . P0497	LLOYDS STEELS INDUSTRIES LIMITED
15 . P0500	MABEL ENGINEERS PRIVATE LIMITED
16 . P0516	MARS DESIGN PVT.LTD.

## 110302 : STORAGE TANKS (Site Fabricated)

CODE	NAME
17 . P0572	NEWTON ENGG. & CHEMICALS LTD.
18 . P1054	NOVATECH PROJECTS INDIA (P) LTD.
19 . P0644	PRECISION TANKS & VESSELS
20 . P0648	PROJECT TECHNOLOGISTS PVT. LTD.
21 . P1014	RAJ ENGG. CO.
22 . P1016	SHARP TANKS & STRUCTURALS PVT. LTD.
23 . P0749	SPS ENGINEERING LIMITED
24 . P0785	TAS ENGINEERING CO.(P) LIMITED
25 . P0786	TATA CHEMICALS LTD
26 . P0790	TECHNO PROCESS EQUIPMENTS (INDIA) PVT. LTD.

## 110303 : FLOATING ROOF TANKS

CODE	NAME
1 . P0861	
<b>INDIA</b>	
2 . P0128	BRIDGE & ROOF CO.
3 . P1106	EXPO GAS CONTAINERS LTD.
4 . P1131	FAB-TECH WORKS & CONSTRUCTIONS PRIVATE LIMITED
5 . P1056	FABTECH PROJECTS & ENGINEERS LTD. (For CS only)
6 . P0380	INDIA TUBE MILLS & METAL INDUSTRIES LTD.
7 . P1016	SHARP TANKS & STRUCTURALS PVT. LTD.
8 . P1025	SRINIVAS PLATE & VESSELS
9 . P0790	TECHNO PROCESS EQUIPMENTS (INDIA) PVT. LTD.
10 . P0833	TRIVENI STRUCTURALS LTD.



## 110401 : METALLIC TOWER PACKINGS

CODE	NAME
<b>INDIA</b>	
1 . P0338	HAVER STANDARD INDIA PVT.LTD.
2 . P0359	HI-PACK MASS TRANSFER PRODUCTS, (ALL CAPACITY)
3 . P0460	KOCH CHEMICAL TECHNOLOGY GROUP INDIA PVT. LTD.
4 . P7122	MASS TRANSFER PRODUCTS INDUSTRIES
5 . P0447	MUNTERS INDIA HUMIDITY CONTROL PRIVATE LIMITED(FORMERLY KEVI
<b>GERMANY</b>	
6 . P0660	RASCHIG GMBH
<b>ITALY</b>	
7 . P0461	KOCH GLITSCH ITALIA SRL
<b>NETHERLAND</b>	
8 . P0531	SULZER CHEMTECH NEDERLAND B.V.
<b>U.S.A.</b>	
9 . P0459	KOCH ENGG. CO. INC.
10 . P0592	NORTON CHEMICAL PROCESS PRODUCTS CORPN.

## 110403 : TRAYS, DISTRIBUTORS & INTERNALS

CODE	NAME
<b>INDIA</b>	
1 . P0313	GODREJ & BOYCE MFG. CO. LTD.
2 . P0338	HAVER STANDARD INDIA PVT.LTD.
3 . P0431	KAMAL ENGINEERING CORPORATION,
4 . P0460	KOCH CHEMICAL TECHNOLOGY GROUP INDIA PVT. LTD.
5 . P7122	MASS TRANSFER PRODUCTS INDUSTRIES
6 . P0447	MUNTERS INDIA HUMIDITY CONTROL PRIVATE LIMITED(FORMERLY KEVI
7 . P0766	SULZER INDIA PRIVATE LTD.
<b>AUSTRIA</b>	
8 . P1022	APPARATEBAU SCHWEISSTECHNIK GMBH
<b>FRANCE</b>	
9 . P0140	B.S.L. INDUSTRIES
<b>GERMANY</b>	
10 . P0660	RASCHIG GMBH
<b>ITALY</b>	
11 . P0311	GLITSH ITALIANA, SPA
12 . P0461	KOCH GLITSCH ITALIA SRL
<b>JAPAN</b>	
13 . P0157	CHIYODA CORPORATION
14 . P0540	MITSUBISHI HEAVY INDUSTRIES LTD.
<b>NETHERLAND</b>	

## 110403 : TRAYS, DISTRIBUTORS & INTERNALS

CODE	NAME
15 . P0531	SULZER CHEMTECH NEDERLAND B.V.
<b>U.K.</b>	
16 . P0299	GEA SPIRO GILLS LTD.
<b>U.S.A.</b>	
17 . P0592	NORTON CHEMICAL PROCESS PRODUCTS CORPN.

## 110404 : DEMISTERS

CODE	NAME
<b>INDIA</b>	
1 . P0246	EVERGREEN INDUSTRIES
2 . P0318	GRAND PRIX ENGINEERING PVT. LTD.
3 . P0338	HAVER STANDARD INDIA PVT.LTD. ( Demister pads with grids)
4 . P0342	HEIN LEHMANN (I) LTD.
5 . P1111	MISTER - MESH WIRE PRODUCTS
6 . P0447	MUNTERS INDIA HUMIDITY CONTROL PRIVATE LIMITED(FORMERLY KEVI
<b>ITALY</b>	
7 . P0179	COSTACURTA VICO S.P.A.
8 . P0311	GLITSH ITALIANA, SPA
<b>U.K.</b>	
9 . P0457	KNITMESH LTD.

## 110501 : H.P. UREA STRIPPER

CODE	NAME
<b>INDIA</b>	
1 . P0110	B H P V
2 . P1101	LARSEN & TOUBRO LIMITED
3 . P1164	ISGEC HITACHI ZOSEN LIMITED
<b>AUSTRIA</b>	
4 . P0708	SCHOELLER-BLECKMANN NITEC GMBH
<b>GERMANY</b>	
5 . P0494	LINDE AG
<b>ITALY</b>	
6 . P0098	BELLELI S.P.A.
7 . P0254	FBM HUDSON ITALIANA S.p.A.
8 . P0594	GE POWER (NUOVO PIGNONE SPA)
9 . P0602	OLMI SPA
<b>JAPAN</b>	
10 . P0458	KOBE STEEL LIMITED
11 . P0540	mitsubishi heavy industries LTD.

## 110502 : H.P. CARBAMATE CONDENSER

CODE	NAME
<b>INDIA</b>	
1 . P0110	B H P V
2 . P1101	LARSEN & TOUBRO LIMITED
3 . P0786	TATA CHEMICALS LTD
4 . P1164	ISGEC HITACHI ZOSEN LIMITED
<b>AUSTRIA</b>	
5 . P0708	SCHOELLER-BLECKMANN NITEC GMBH
<b>ITALY</b>	
6 . P0015	ACCIAI SPECIALI TERNI
7 . P0073	ATB ACCIAIERIA E TUBIFICIO DI BRESCIA SP
8 . P0098	BELLELI S.P.A.
9 . P0254	FBM HUDSON ITALIANA S.p.A.
10 . P0594	GE POWER (NUOVO PIGNONE SPA)
11 . P0602	OLMI SPA
<b>JAPAN</b>	
12 . P0458	KOBE STEEL LIMITED
13 . P0540	MITSUBISHI HEAVY INDUSTRIES LTD.
<b>KOREA</b>	
14 . P0369	HUNDAI HEAVY INDUSTRIES

## 110503 : HEAT EXCHANGERS UPTO 30 Kg/cm<sup>2</sup>g

CODE	NAME
<b>INDIA</b>	
1 . P1180	BTL EPC LIMITED ((CS only))
2 . P0643	PRECISION EQUIPMENTS (CHENNAI) PVT LTD
3 . P0018	AERO ENGINEERS (CS ONLY)
4 . P0060	ARTSON ENGINEERING LIMITED
5 . P0110	B H P V
6 . P0107	BHARAT HEAVY ELECTRICALS LTD.
7 . P1126	CHEM PROCESS SYSTEMS PVT. LTD. (CS/SS only)
8 . P1177	CRYOSTAR TANKS AND VESSELS PVT.LTD. (UPTO 30 KG/CM <sup>2</sup> G (CS ONLY))
9 . P1124	ESSAR HEAVY ENGINEERING SERVICES
10 . P1106	EXPO GAS CONTAINERS LTD. (Upto 30 Kg/sq cm (g) CS/SS Material.)
11 . P1131	FAB-TECH WORKS & CONSTRUCTIONS PRIVATE LIMITED
12 . P1056	FABTECH PROJECTS & ENGINEERS LTD. (For CS Only.)
13 . P1213	FLOWCHEM PROCESS EQUIPMENTS
14 . P1105	FLOWLINK INDUSTRIES PVT. LTD. (CS/SS Except Urea service)
15 . P0288	G R ENGINEERING PRIVATE LIMITED
16 . P0291	GANSONS LTD.
17 . P1045	GEMINI ENGI-FAB PVT. LTD.

## 110503 : HEAT EXCHANGERS UPTO 30 Kg/cm<sup>2</sup>g

CODE	NAME
18 . P0308	GHANSHYAM STEEL WORKS LTD. (CS/SS)
19 . P0323	GMM PFAUDLER LIMITED
20 . P0313	GODREJ & BOYCE MFG. CO. LTD.
21 . P1011	GRASIM INDUSTRIES
22 . P0341	HEATEX INDIAN CORPORATION
23 . P1216	HEMALATHAA HI-TECH INDUSTRIES (CS Only)
24 . P1052	HINDUSTAN DORR-OLIVER LTD.
25 . P0380	INDIA TUBE MILLS & METAL INDUSTRIES LTD.
26 . P0386	INDUS PROJECTS LTD.(FORMERLY INDUS ENGG)
27 . P0801	ISGEC HEAVY ENGINEERING LIMITED
28 . P1101	LARSEN & TOUBRO LIMITED
29 . P1108	LAXMI ENGINEERING INDUSTRIES (BHOPAL) PRIVATE LIMITED (CS/SS only Except Urea service)
30 . P0497	LLOYDS STEELS INDUSTRIES LIMITED
31 . P1017	MABEL ENGINEERS PVT. LTD.
32 . P1018	MANISH UDYOG HEAT EXCHANGERS PVT. LTD.
33 . P0538	MISTRY PRABHUDAS MANJI ENGG. PVT. LTD.
34 . P1053	MULTI-MAX ENGINEERING WORKS PVT. LTD. ((CS and SS Materials only))



## 110503 : HEAT EXCHANGERS UPTO 30 Kg/cm<sup>2</sup>g

CODE	NAME
35 . P1136	NUBERG ENGINEERING LIMITED
36 . P1013	PATELS AIRTEMP (INDIA LIMITED
37 . P1115	PHILS HEAVY ENGINEERING PVT. LTD. (For AS (P3 & P4) only.)
38 . P1021	R.D.ENGINEERS (INDIA) PVT. LTD.
39 . P1114	RADIANT HEAT EXCHANGER PVT. LTD. (CS/SS only)
40 . P1014	RAJ ENGG. CO.
41 . P1140	RELIANCE FABRICATIONS PVT. LTD. (CS/SS only)
42 . P0671	REYNOLDS CHEMEQUIP PRIVATE LIMITED (CS/SS)
43 . P0785	TAS ENGINEERING CO.(P) LIMITED
44 . P0786	TATA CHEMICALS LTD
45 . P0790	TECHNO PROCESS EQUIPMENTS (INDIA) PVT. LTD.
46 . P0796	TEMA INDIA LIMITED (ACHHAD UNIT-I)
47 . P1118	TEMA INDIA LIMITED (PANOLI, ANKLESHWAR-UNIT-III & UNIT IV) (In Non ASME Certification like U, U2, R etc. Category)
48 . P1117	TEMA INDIA LIMITED (SILVASSA, UNIT-II) (In Non IBR Category)
49 . P1047	THE ANUP ENGINEERING LIMITED
50 . P1049	TITANIUM EQUIPMENT AND ANODE MFG. CO. LTD.
51 . P1127	TITANIUM TANTALUM PRODUCTS LTD (CS & SS Materials)

## 110503 : HEAT EXCHANGERS UPTO 30 Kg/cm<sup>2</sup>g

CODE	NAME
52 . P1134	UNIQUE CHEMOPLANT EQUIPMENTS
53 . P1123	UNIVERSAL HEAT EXCHANGERS LIMITED (CS/SS/LTCS Only)
<b>AUSTRIA</b>	
54 . P1022	APPARATEBAU SCHWEISSTECHNIK GMBH
55 . P0708	SCHOELLER-BLECKMANN NITEC GMBH
<b>BELGIUM</b>	
56 . P0218	D'HONDT S.A.
<b>GERMANY</b>	
57 . P0499	BORSIG GmbH
<b>ITALY</b>	
58 . P0098	BELLELI S.P.A.
59 . P0254	FBM HUDSON ITALIANA S.p.A.
60 . P0594	GE POWER (NUOVO PIGNONE SPA)
61 . P0602	OLMI SPA
62 . P0123	WALTER TOSTO SpA
<b>JAPAN</b>	
63 . P0358	HITACHI Zosen
64 . P0437	KAWASAKI HEAVY INDUSTRIES LTD.
65 . P0458	KOBE STEEL LIMITED
66 . P0541	MITSUI ENGINEERING & SHIPBUILDING CO.LTD

## 110503 : HEAT EXCHANGERS UPTO 30 Kg/cm<sup>2</sup>g

CODE	NAME
<b>KOREA</b>	
67 . P0334	DOOSAN MECATEC CO. LTD.
68 . P1035	HANJUNG DCM CO.LTD.
69 . P0335	HANTECH LIMITED
70 . P0369	HUNDAI HEAVY INDUSTRIES
71 . P0462	KOREA HEAVY INDUSTRIES & CONSTN. CO. LTD
72 . P1060	SUNGJIN GEOTEC CO., LTD. (CS and SS only)
<b>SPAIN</b>	
73 . P0524	MECANICA DE LA PENA S.A.
<b>U.S.A.</b>	
74 . P0510	MANNING & LEWIS ENGINEERING CO.,

## 110504 : HEAT EXCHANGERS 30 TO 60 Kg/cm<sup>2</sup>g

CODE	NAME
<b>INDIA</b>	
1 . P0643	PRECISION EQUIPMENTS (CHENNAI) PVT LTD
2 . P0018	AERO ENGINEERS (Upto 46 Kg/cm <sup>2</sup> g (CS only))
3 . P1166	AVADH INDUSTRIES (Upto 44 Kg/cm <sup>2</sup> g (CS Only))
4 . P0110	B H P V
5 . P0107	BHARAT HEAVY ELECTRICALS LTD.
6 . P1143	CICB-CHEMICON PVT. LTD. (CS only)
7 . P1124	ESSAR HEAVY ENGINEERING SERVICES
8 . P1106	EXPO GAS CONTAINERS LTD. (CS only)
9 . P1131	FAB-TECH WORKS & CONSTRUCTIONS PRIVATE LIMITED
10 . P1056	FABTECH PROJECTS & ENGINEERS LTD. (For CS only)
11 . P0288	G R ENGINEERING PRIVATE LIMITED
12 . P1045	GEMINI ENGI-FAB PVT. LTD.
13 . P0323	GMM PFAUDLER LIMITED
14 . P0313	GODREJ & BOYCE MFG. CO. LTD.
15 . P1011	GRASIM INDUSTRIES
16 . P1052	HINDUSTAN DORR-OLIVER LTD. (CS/SS only)
17 . P1137	INDCON PROJECTS & EQUIPMENT LIMITED (CS/SS only)

## 110504 : HEAT EXCHANGERS 30 TO 60 Kg/cm<sup>2</sup>g

CODE	NAME
18 . P0801	ISGEC HEAVY ENGINEERING LIMITED
19 . P1101	LARSEN & TOUBRO LIMITED
20 . P1108	LAXMI ENGINEERING INDUSTRIES (BHOPAL) PRIVATE LIMITED (CS/SS only Except Urea service)
21 . P0497	LLOYDS STEELS INDUSTRIES LIMITED
22 . P1138	MEENAKSHI ASSOCIATES (P) LTD. (CS/SS only)
23 . P1053	MULTI-MAX ENGINEERING WORKS PVT. LTD. (CS & SS ONLY)
24 . P0572	NEWTON ENGG. & CHEMICALS LTD. (Upto 36 Kg/cm <sup>2</sup> )
25 . P1136	NUBERG ENGINEERING LIMITED (CS Only up to 40 kg/cm <sup>2</sup> g)
26 . P1013	PATELS AIRTEMP (INDIA) LIMITED ((CS & SS only))
27 . P1058	PRAJ INDUSTRIES LIMITED (CS/SS only)
28 . P0790	TECHNO PROCESS EQUIPMENTS (INDIA) PVT. LTD.
29 . P0796	TEMA INDIA LIMITED (ACHHAD UNIT-I)
30 . P1117	TEMA INDIA LIMITED (SILVASSA, UNIT-II) (In Non IBR Category)
31 . P1047	THE ANUP ENGINEERING LIMITED
32 . P1055	THE INDIAN SUGAR & GENERAL ENGG. CORPN.(ISGEC), DAHEJ (Except Urea Plant Critical Equipment)
<b>KOREA</b>	
33 . P1149	ALPEC CO. LTD. (CS & AS only)

### **AUSTRIA**

## 110504 : HEAT EXCHANGERS 30 TO 60 Kg/cm<sup>2</sup>g

CODE	NAME
34 . P1022	APPARATEBAU SCHWEISSTECHNIK GMBH
35 . P0708	SCHOELLER-BLECKMANN NITEC GMBH
<b>GERMANY</b>	
36 . P0499	BORSIG GmbH
<b>ITALY</b>	
37 . P0254	FBM HUDSON ITALIANA S.p.A.
38 . P0597	OFFICIENE LUIGI RESTA S.P.A.
39 . P1042	ROLLE S.P.A (30 to 60 kg/cm <sup>2</sup> pr.)
<b>JAPAN</b>	
40 . P0358	HITACHI Zosen
41 . P0540	mitsubishi heavy industries LTD.
<b>KOREA</b>	
42 . P0334	DOOSAN MECATEC CO. LTD.
43 . P1035	HANJUNG DCM CO.LTD.
44 . P0335	HANTECH LIMITED
45 . P0369	HUNDAI HEAVY INDUSTRIES
46 . P1060	SUNGJIN GEOTEC CO., LTD. (CS and SS only)
<b>SPAIN</b>	
47 . P0524	MECANICA DE LA PENA S.A.

## 110505 : HEAT EXCHANGERS ABOVE 60 Kg/cm<sup>2</sup>g

CODE	NAME
<b>INDIA</b>	
1 . P0643	PRECISION EQUIPMENTS (CHENNAI) PVT LTD
2 . P0110	B H P V
3 . P0107	BHARAT HEAVY ELECTRICALS LTD.
4 . P1045	GEMINI ENGI-FAB PVT. LTD.
5 . P0313	GODREJ & BOYCE MFG. CO. LTD.
6 . P1052	HINDUSTAN DORR-OLIVER LTD.
7 . P0801	ISGEC HEAVY ENGINEERING LIMITED (Except Urea Plant Critical Equipment)
8 . P1101	LARSEN & TOUBRO LIMITED
9 . P1053	MULTI-MAX ENGINEERING WORKS PVT. LTD. (CS & SS ONLY)
10 . P1013	PATELS AIRTEMP (INDIA LIMITED ((CS only))
11 . P1058	PRAJ INDUSTRIES LIMITED (CS/SS only)
12 . P0796	TEMA INDIA LIMITED (ACHHAD UNIT-I)
13 . P1047	THE ANUP ENGINEERING LIMITED
14 . P1055	THE INDIAN SUGAR & GENERAL ENGG. CORPN.(ISGEC), DAHEJ (Except Urea Plant Critical Equipment)
15 . P1200	VIJAY TANKS & VESSELS PRIVATE LIMITED (CS ONLY)
<b>KOREA</b>	
16 . P1149	ALPEC CO. LTD. (CS & AS only)
<b>INDIA</b>	

## 110505 : HEAT EXCHANGERS ABOVE 60 Kg/cm<sup>2</sup>g

CODE	NAME
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17 . P1164 ISGEC HITACHI ZOSEN LIMITED

### **AUSTRIA**

18 . P1022 APPARATEBAU SCHWEISSTECHNIK GMBH

### **BELGIUM**

19 . P0218 D'HONDT S.A.

### **GERMANY**

20 . P0499 BORSIG GmbH

### **ITALY**

21 . P0597 OFFICIENE LUIGI RESTA S.P.A.

22 . P0602 OLMI SPA

### **KOREA**

23 . P0369 HUNDAI HEAVY INDUSTRIES

24 . P1060 SUNGJIN GEOTEC CO., LTD. (CS and SS only)



## 110506 : EXCHANGERS AIRCOOLED/ FINNED TYPE

CODE	NAME
<b>INDIA</b>	
1 . P0110	B H P V
2 . P1122	BGR ENERGY SYSTEMS LIMITED - AIR FIN COOLER DIVN.
3 . P1059	ENGINEMATES HEAT TRANSFER PVT. LTD.,
4 . P1213	FLOWCHEM PROCESS EQUIPMENTS
5 . P0297	GEA ENERGY SYSTEM (I) LTD.
6 . P0301	GEI INDUSTRIAL SYSTEMS LTD.
7 . P1045	GEMINI ENGI-FAB PVT. LTD.
8 . P1043	JORD ENGINEERS INDIA LTD.
9 . P1101	LARSEN & TOUBRO LIMITED
10 . P0497	LLOYDS STEELS INDUSTRIES LIMITED
11 . P1018	MANISH UDYOG HEAT EXCHANGERS PVT. LTD.
12 . P0615	PAHARPUR COOLING TOWERS (P) LTD.
13 . P1013	PATELS AIRTEMP (INDIA LIMITED
<b>UK</b>	
14 . P7129	CHART ENERGY & CHEMICALS INC. (HEAT EXCHANGERS AIRCOOLED ONLY)
<b>FRANCE</b>	
15 . P1034	CREUSOT LOIRE INDUSTRIES
16 . P0184	USINOR INDUSTEEL (FRANCE)

## 110506 : EXCHANGERS AIRCOOLED/ FINNED TYPE

CODE	NAME
<b>GERMANY</b>	
17 . P0494	LINDE AG
<b>ITALY</b>	
18 . P0019	AEROTO SRL
19 . P0602	OLMI SPA
<b>JAPAN</b>	
20 . P0358	HITACHI ZOSEN
21 . P0437	KAWASAKI HEAVY INDUSTRIES LTD.
22 . P0458	KOBE STEEL LIMITED
23 . P0540	MITSUBISHI HEAVY INDUSTRIES LTD.
24 . P0541	mitsui ENGINEERING & SHIPBUILDING CO.LTD
25 . P0701	SASAKURA ENGG. CO. LTD.
<b>KOREA</b>	
26 . P0370	HYUNDAI CORPORATION
<b>U.K.</b>	
27 . P0056	APV SPIRO GILLS LTD
<b>U.S.A.</b>	
28 . P0515	MARLEY COOLING TOWERS CO.

## 110507 : PLATE TYPE HEAT EXCHANGERS

CODE	NAME
<b>INDIA</b>	
1 . P0032	ALFA LAVAL INDIA LIMITED
2 . P1031	APV (PRAJ)
3 . P1020	DOVER INDIA LTD (TRANter PHE DIVN)
4 . P1141	HRS PROCESS SYSTEMS LIMITED
5 . P1109	KELVION INDIA PRIVATE LIMITED (FORMERLY GEA ECOFLEX INDIA PV
6 . P1101	LARSEN & TOUBRO LIMITED
7 . P0433	SHRACHI ENGINEERINF & INDUSTRIES LTD.
8 . P1195	SONDEX HEAT EXCHANGERS INDIA PRIVATE LIMITED
9 . P1128	TRANter INDIA PVT. LTD.
10 . P0848	URISAN HEAT EXCHANGERS PVT. LTD.,
<b>GERMANY</b>	
11 . P0494	LINDE AG
<b>JAPAN</b>	
12 . P0771	SUMITOMO METAL INDUSTRIES LTD.
<b>SPAIN</b>	
13 . P0524	MECANICA DE LA PENA S.A.
<b>U.S.A.</b>	
14 . P0510	MANNING & LEWIS ENGINEERING CO.,
15 . P0826	TRANter PHE, INC.

## 110508 : SAMPLE COOLERS

CODE	NAME
<b>INDIA</b>	
1 . P0643	PRECISION EQUIPMENTS (CHENNAI) PVT LTD
2 . P0018	AERO ENGINEERS
3 . P0047	ANAND ENGINEERING PVT.LTD.
4 . P0110	B H P V
5 . P1213	FLOWCHEM PROCESS EQUIPMENTS
6 . P0318	GRAND PRIX ENGINEERING PVT. LTD.
7 . P1108	LAXMI ENGINEERING INDUSTRIES (BHOPAL) PRIVATE LIMITED (CS/SS Only)
8 . P0516	MARS DESIGN PVT.LTD.
9 . P0538	MISTRY PRABHUDAS MANJI ENGG. PVT. LTD.
10 . P1012	MOD FABRICATORS (small sample coolers)
11 . P0561	NATIONAL ENGINEERING CO. (small sample coolers)
12 . P0563	NATIONAL HEAVY ENGG.CO.OPERATIVE LTD.
13 . P0654	P.J.SUROTIA & CO.
14 . P0635	POLYQUIP FABRICATION INDUSTRIES
15 . P0648	PROJECT TECHNOLOGISTS PVT. LTD.
16 . P0649	PROJECTS & DEVELOPMENT INDIA LIMITED
17 . P0785	TAS ENGINEERING CO.(P) LIMITED

## 110508 : SAMPLE COOLERS

CODE	NAME
18 . P0790	TECHNO PROCESS EQUIPMENTS (INDIA) PVT. LTD.
19 . P1183	TECKSON STEEL INDUSTRIES
20 . P0842	UNITOP ENGINEERS PVT. LTD. (upto tube OD 50mm, tubesheet thk 125mm)
<b>AUSTRIA</b>	
21 . P1022	APPARATEBAU SCHWEISSTECHNIK GMBH
<b>ITALY</b>	
22 . P0598	OFFICINE COSTRUZIONI SPECIALI S.P.A
<b>KOREA</b>	
23 . P0334	DOOSAN MECATEC CO. LTD.
24 . P1035	HANJUNG DCM CO.LTD.
<b>U.S.A.</b>	
25 . P0028	AITKEN INC.

## 110601 : FRP/PVC TANKS &amp; VESSELS

CODE	NAME
<b>INDIA</b>	
1 . P0290	GANDHI AND ASSOCIATES
2 . P1039	SONAL ENGG. PLASTIC FABRICATOR
3 . P1165	EPP COMPOSITES PVT. LTD.
<b>AUSTRIA</b>	
4 . P1022	APPARATEBAU SCHWEISSTECHNIK GMBH (acid storage tanks upto 3.8 in dia.)

## 110607 : FRP/PVC LINING

CODE	NAME
<b>INDIA</b>	
1 . P0290	GANDHI AND ASSOCIATES
2 . P1165	EPP COMPOSITES PVT. LTD.



110608: RUBBER LINING

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CODE	NAME
<i>INDIA</i>	
1. P1148	ARUL RUBBERS PVT. LTD.

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## 110702 : NITROGEN BOTTLES

CODE	NAME
<b>INDIA</b>	
1 . P0496	AIR LIQUID ENGINEERING INDIA PVT. LTD.
2 . P0110	B H P V
3 . P0111	BHARAT PUMPS & COMPRESSORS LTD.
4 . P1037	LIQUID AIR ENGG.INDIA (P) LIMITED.
<b>KOREA</b>	
5 . P0335	HANTECH LIMITED
6 . P0462	KOREA HEAVY INDUSTRIES & CONSTN. CO. LTD

## 110703 : DISHED ENDS

CODE	NAME
<b>INDIA</b>	
1 . P1131	FAB-TECH WORKS & CONSTRUCTIONS PRIVATE LIMITED
2 . P1192	GRAND PRIX ENGINEERING PRIVATE LIMITED (CS ONLY)
3 . P1019	ICEM ENGG. CO. LTD. (uoto 6mm Dia x 100 mm thk.)
4 . P1154	JINDAL STEEL & POWER LTD. (MACHINERY DIVISION) (CS / AS only)
5 . P0497	LLOYDS STEELS INDUSTRIES LIMITED

## 110801 : MECHANICAL WORKS(piping , machinery & equipment erection

CODE	NAME
<b>INDIA</b>	
1 . P6040	ARIO BROTHERS (UPTO Rs. 3.0 Cr.)
2 . P6055	ARTSON ENGINEERING LIMITED (UPTO Rs. 7.5 Cr.)
3 . P6005	BRIDGE AND ROOF CO.(INDIA) LTD.
4 . P6047	CHEM CONTRACT PVT. LTD. (UPTO Rs. 3.0 Cr.)
5 . P3222	CORRTECH INTERNATIONAL PVT.LTD. (for plant piping)
6 . P1121	DEMAC TECHNOLOGIES PVT. LTD. (Rs. 1500 Lacs)
7 . P6048	DOWEL ERECTORS PVT. LTD. (UPTO Rs. 7.5 Cr.)
8 . P1120	DURHA CONSTRUCTIONS PVT. LIMITED (Upto 100 Crores)
9 . P1196	EDAC ENGINEERING LIMITED
10 . P6015	ENGINEERING PROJECTS(I) LTD. (UPTO Rs. 3.0 Cr.)
11 . P6103	ESP (ASIA) PVT. LTD. (Upto Rs. 25 Crore)
12 . P6053	FURNACE FABRICA (INDIA) LTD. (UPTO Rs. 3.0 Cr.)
13 . P6049	G.M.W. ENGINEERS PVT. LTD. (UPTO Rs. 3.0 Cr.)
14 . P6003	GANNON DUNKERLEY & CO. LIMITED
15 . P1176	GOLDEN EDGE ENGINEERING PVT.LTD.
16 . P6052	GOPINATH ENGINEERING CO. PVT. LTD. (UPTO Rs. 3.0 Cr.)
17 . P6020	JAIHIND PROJECTS LIMITED (UPTO Rs. 3.0 Cr.)

## 110801 : MECHANICAL WORKS(piping , machinery & equipment erection

CODE	NAME
18 . P6001	LARSEN & TOUBRO LTD( ECC Division)
19 . P1130	MCNALLY BHARAT ENGINEERING CO. LTD. (Upto Rs. 15 Crores)
20 . P6051	MUKUND ENGINEERS LTD. (UPTO Rs. 7.5 Cr.)
21 . P6042	NEO STRUCTO CONSTRUCTION LIMITED (UPTO Rs. 7.5 Cr.)
22 . P6044	NEWTON ENGG. COST. CO. LTD. (Upto 55 Cr.)
23 . P6104	NUBERG ENGINEERING LIMITED (UPTO RS. 15 CRORE)
24 . P6102	ONSHORE CONSTRUCTION COMPANY PVT. LTD. (Up to 50 Crore)
25 . P6012	PETRON CIVIL ENGINEERING LIMITED
26 . P6033	POWER MAX INDIA PVT. LTD. (UPTO Rs. 3.0 CRORE)
27 . P6054	PROJECT TECHNOLOGISTS PVT. LTD. (UPTO Rs. 3.0 Cr.)
28 . P1152	ROTODYNE ENGINEERING SERVICES PVT. LTD. (Upto 5.0 Cr.)
29 . P6046	SATNAM GLOBAL INFRAPROJECTS LTD. (UPTO Rs. 3.0 Cr.)
30 . P6043	SPIC JEL ENGG. CONSTRUCTION LTD. (UPTO Rs. 7.5 Cr.)
31 . P6045	STEWARTS & LLOYDS OF INDIA LTD.
32 . P0786	TATA CHEMICALS LTD
33 . P1191	TECHNO ELECTRIC & ENGINEERING CO. LIMITED
34 . P6038	U.B.ENGINEERING LIMITED

**110801 :MECHANICAL WORKS(piping, machinery & equipment erection**

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CODE	NAME
35. P1163	DAYNITE ENGINEERGS & CONTRACTORS PVT.LTD. (Rs. 1500 lacs)

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## 110802 : HEAVY LIFT

CODE	NAME
<b>INDIA</b>	
1 . P6056	ABG HEAVY INDUSTRIES LTD.
2 . P6047	CHEM CONTRACT PVT. LTD. (UPTO Rs. 1.0 Cr.)
3 . P1176	GOLDEN EDGE ENGINEERING PVT.LTD.
4 . P6052	GOPINATH ENGINEERING CO. PVT. LTD. (UPTO Rs. 1.0 Cr.)
5 . P6001	LARSEN & TOUBRO LTD( ECC Division)
6 . P6042	NEO STRUCTO CONSTRUCTION LIMITED (Upto 18 Cr.)
7 . P6102	ONSHORE CONSTRUCTION COMPANY PVT. LTD.
8 . P6012	PETRON CIVIL ENGINEERING LIMITED
9 . P6057	SANGHVI MOVERS (UPOT Rs. 1.0 Cr.)
10 . P6046	SATNAM GLOBAL INFRAPROJECTS LTD. (UPTO Rs. 1.0 Cr.)
11 . P6038	U.B.ENGINEERING LIMITED
12 . P1163	DAYNITE ENGINEERGS & CONTRACTORS PVT.LTD. (Rs. 1000 lacs)

## 110803 : HOT & COLD INSULATION OF EQUIPMENT & PIPING

CODE	NAME
<b>MAHATASHTRA</b>	
1 . P1178	INSULREF TECHNOLOGIES PRIVATE LIMITED
<b>INDIA</b>	
2 . P1162	ALP AEROFLEX INDIA PVT. LTD. (- 50 Deg C to 120 Deg C)
3 . P1150	AMOL DICALITE LIMITED (For Supply & Application of Perlite Block & Pipe Section)
4 . P1161	ARMACELL INDIA PVT. LTD. (ARMACELL ENGINEERED SYSTEMS) (Upto Rs. 3.0 Crore (For supply & application of Insulation & Acoustic Works).)
5 . P3203	ASIAN THERMAL INSULATION (I) PVT LTD
6 . P3214	ASSOCIATED INSULATION CO.
7 . P1186	ASSOCIATED INSULATION COMPANY
8 . P3210	CAPE INDUSTRIAL SERVICES (PVT) LTD
9 . P3212	CAPEX INSULATION & ENGINEERS (upto Rs 1.0 Crore)
10 . P3208	CONTINENTAL INSULATIONS PVT LTD (upto Rs 1.0 Crore)
11 . P1175	G+H INSULATION INDIA PVT.LTD.
12 . P1155	HI-TEC ROCK FIBRE PVT. LTD. (Upto Rs. 2 Crore (For the supply of Thermal Insulation materials only).)
13 . P3206	HYDERABAD INDUSTRIES LTD (For calcium silicate only)
14 . P3211	JD INSULATION (upto Rs 1.0 Crore)
15 . P3209	KAEFER PUNJ LLOYD LIMITED
16 . P3204	KHANDELWAL INSULATIONS PVT LTD

## 110803 : HOT & COLD INSULATION OF EQUIPMENT & PIPING

CODE	NAME
17 . P3201	LLOYDS INSULATION(i) LIMITED
18 . P3202	LLOYDS PROJECTS PVT LTD
19 .	LLOYDS PROJECTS PVT LTD (APPLICATION ONLY)
20 . P1119	MINWOOL ROCK FIBRES LIMITED (Upto 5 Crores)
21 . P3205	NEWKEM ENGINEERS PVT LTD
22 . P1201	PERMA-PIPE INDIA PRIVATE LIMITED
23 . P3213	POINEER INSULATION
24 . P1174	POLYBOND INSULATION PVT.LTD.
25 . P3207	SHARAD INSULATIONS & INTERIORS PVT LTD (upto Rs 1.0 Crore)
26 . P1217	STAIVE ENGINEERING AND TECHNICAL SERVICES PVT. LTD.
27 . P1191	TECHNO ELECTRIC & ENGINEERING CO. LIMITED
<b>1INDIA</b>	
28 . P1193	SUAVAL LORVEN INDIA PVT.LTD.



## 110804 : CAST IN-SITU TANK INSULATION

CODE	NAME
<b>MAHATASHTRA</b>	
1 . P1178	INSULREF TECHNOLOGIES PRIVATE LIMITED
<b>INDIA</b>	
2 . P1186	ASSOCIATED INSULATION COMPANY
3 . P3210	CAPE INDUSTRIAL SERVICES (PVT) LTD
4 . P1175	G+H INSULATION INDIA PVT.LTD.
5 . P1155	HI-TEC ROCK FIBRE PVT. LTD. (Upto Rs. 2 Crore)
6 . P3209	KAEFER PUNJ LLOYD LIMITED
7 . P3201	LLOYDS INSULATION(i) LIMITED
8 . P1217	STAIVE ENGINEERING AND TECHNICAL SERVICES PVT. LTD.

## 110805 : CHEMICAL CLEANING

CODE	NAME
<b>INDIA</b>	
1 . P3219	ALBATROSS FINE CHEM LTD
2 . P3217	ARUCHEM
3 . P3216	CHEM TREAT INDIA LTD
4 . P3218	D C INDUSTRIAL PLANT SERVICES LTD
5 . P3215	DYNAMIC INDL & CLEANING SERVICES(P) LTD
6 . P3220	KWALITY CHEMICAL INDUSTRIES
7 . P1026	MICRO CHEM LAB

## 110806 : EPOXY LINING

CODE	NAME
<b>INDIA</b>	
1 . P6063	ARIEN NEW DELHI PRIVATE LIMITED
2 . P6070	BARODA SURFACE PROTECTION SERVICES
3 . P2142	CIPY POLYURETHANES PVT. LTD. (On steel and concrete structure)
4 . P1171	JOTUN INDIA PRIVATE LIMITED
5 . P6059	M.PALLONJI & CO. PRIVATE LIMITED
6 . P6071	MAJOR GRAIND CORROSSION CONTROLLERS
7 . P6058	NATRAJ AND SIDDHARTH METACARE PVT. LTD.
8 . P6072	RESMET INDIA
9 . P1191	TECHNO ELECTRIC & ENGINEERING CO. LIMITED
10 . P6060	WASPRABHA
11 . P1170	MOHAN PAINTS

## 110807 : PAINTING OF STRUCTURAL , EQUIPMENT & PIPING

CODE	NAME
<b>MAHATASHTRA</b>	
1 . P1178	INSULREF TECHNOLOGIES PRIVATE LIMITED
<b>INDIA</b>	
2 . P1032	ARCOY INDUSTRIES
3 . P6063	ARIEN NEW DELHI PRIVATE LIMITED
4 . P6061	ASHISH DECORATORS
5 . P6068	BHARAT CHEMICALS & PAINTS (UPTO Rs. 1.0 Cr.)
6 . P6064	CP SYSTEMS PVT. LTD.
7 . P1145	GRAUER & WEIL (INDIA) LTD.
8 . P6062	HEERU PAINTS AND CONTRACTS PVT. LTD.
9 . P1171	JOTUN INDIA PRIVATE LIMITED
10 . P6059	M.PALLONJI & CO. PRIVATE LIMITED
11 . P6058	NATRAJ AND SIDDHARTH METACARE PVT. LTD.
12 . P6042	NEO STRUCTO CONSTRUCTION LIMITED
13 . P6067	POLY COATS (UPTO Rs. 1.0 Cr.)
14 . P6069	QUANTUM ENGINEERS ( UPTO Rs. 1.0 Cr.)
15 . P1146	RAMDEV RESINS PVT. LTD
16 . P6066	RESMET INDIA (UPTO Rs. 1.0 Cr.)

**110807 : PAINTING OF STRUCTURAL , EQUIPMENT & PIPING**

CODE	NAME
17 . P6065	SETWELL COATING INDIA PVT. LTD. (UPTO Rs. 1.0 Cr.)
18 . P1191	TECHNO ELECTRIC & ENGINEERING CO. LIMITED
19 . P6060	WASPRABHA
20 . P1170	MOHAN PAINTS

## 110811 : ONLY UNDERGROUND PIPING WORKS

CODE	NAME
<b>INDIA</b>	
1 . P6041	ABAN CONSTRUCTION
2 . P6040	ARIO BROTHERS
3 . P6005	BRIDGE AND ROOF CO.(INDIA) LTD.
4 . P6006	GAMMON INDIA LTD.
5 . P6003	GANNON DUNKERLEY & CO. LIMITED
6 . P1176	GOLDEN EDGE ENGINEERING PVT.LTD.
7 . P6001	LARSEN & TOUBRO LTD( ECC Division)
8 . P6042	NEO STRUCTO CONSTRUCTION LIMITED
9 . P6044	NEWTON ENGG. COST. CO. LTD.
10 . P6039	PUNJ LLOYD LTD.
11 . P6043	SPIC JEL ENGG. CONSTRUCTION LTD.
12 . P1191	TECHNO ELECTRIC & ENGINEERING CO. LIMITED
13 . P6038	U.B.ENGINEERING LIMITED

**110812 : CROSS COUNTRY PIPELINE**

<b>CODE</b>	<b>NAME</b>
<b>INDIA</b>	
1 . P6041	ABAN CONSTRUCTION
2 . P6040	ARIO BROTHERS
3 . P3222	CORRTECH INTERNATIONAL PVT.LTD. (upto 24" dia & 100km)
4 . P6006	GAMMON INDIA LTD.
5 . P6020	JAIHIND PROJECTS LIMITED
6 . P6001	LARSEN & TOUBRO LTD( ECC Division)
7 . P6044	NEWTON ENGG. COST. CO. LTD.
8 . P6039	PUNJ LLOYD LTD.



110813:

CODE	NAME
<i>INDIA</i>	
1 . P1208	CAPRICORN COATINGS & COLOURS



	<b>MASTER VENDORS LIST FOR PROJECTS</b>	04-00MM-0011	18
		DOCUMENT NO	REV

**MASTER VENDORS LIST**  
**FOR**  
**PROJECTS**  
**MECHANICAL ITEMS (PIPING)**

## INDEX MECHANICAL (PIPING) ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE NO.
<b>1201</b>	<b>PIPES, FITTINGS &amp; FLANGES</b>	
120101	CS PIPES IS-1239 (BLACK & GI)	3
120102	CS WELDED PIPES IS-3589	5
120103	CS WELDED PIPES TO API 5L SPIRAL/LONG. WELDED (SAW/EFSW)	7
120104	CS / AS / LTCS SEAMLESS PIPES	10
120105	SS SEAMLESS/WELDED PIPES	13
120106	SS SEAMLESS TUBES	17
120107	SS PIPES UREA GRADE	18
120110	HDPE/ MDPE PIPES & PIPE FITTINGS	20
120111	SS WELDED TUBES	21
120113	FITTINGS: CS/AS/SS SEAMLESS & FORGED	22
120114	FITTINGS: SS UREA GRADE	26
120115	FRP/PVC PIPE AND PIPE FITTINGS	28
120116	CAST IRON FITTINGS & PIPES	29
120117	FORGED FLANGES	30
120118	PLATE RING FLANGES	33
120119	FITTINGS: CS/AS/SS WELDED	34
120120	PIPE COATINGS	35
120121	CPVC PIPE AND PIPE FITTINGS	39
<b>1202</b>	<b>PIPING ACCESSORIES</b>	
120201	STRAINERS (PERMANENT INCLUDING Y-TYPE)	36
120202	STEAM TRAPS	37
120203	SPRING SUPPORTS	38
120204	FLAME ARRESTORS	39
120205	SPRAY NOZZLE ASSEMBLY	40
<b>1203</b>	<b>VALVES</b>	
120301	GATE/GLOBE/CHECK VALVES CS/SS/AS < 900 Lbs	41
120302	GATE/GLOBE/CHECK VALVES CS/SS/AS >=900 Lbs	46
120303	BALL VALVES (SOFT SEATED)	49
120304	BALL VALVES (METAL SEATED)	52
120305	BUTTERFLY VALVES	54
120306	BLOWDOWN VALVES	57
120307	SAMPLING VALVES/ NEEDLE VALVES	58
120308	PLUGVALVES(NONLUBRICATED)	59

## INDEX CUSTOM CLEARANCE & TRANSPORTATION ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE NO.
120309	PLUG VALVES (LUBRICATED)	61
120311	DIAPHRAGM VALVES / RUBBER LINED CHECK VALVES	62
120312	CAST IRON VALVES	63
120313	PVC/CPVC VALVES	64
<b>1204</b>	<b>GASKETS ,EXPANSION JOINTS &amp; FASTNERS</b>	
120401	ASBESTOS/RUBBER GASKETS	65
120402	SPIRALLY WOUND GASKETS	67
120403	LENS GASKETS & RING JOINT (METALLIC)	68
120405	EXPANSION JOINTS & BELLOWS	69
120406	FASTENERS	70
<b>1205</b>	<b>FIRE FIGHTING SYSTEM AND ASSOCIATED ITEMS</b>	
120501	FIRE FIGHTING SYSTEM	72
120503	HOSE PIPES(METALLIC) & CAM LOCK COUPLING	74
120504	HOSE PIPE (NON-METALLIC) & CAM LOCK COUPLING	75
120505	FIRE WATER PUMPS	76
120506	PORTABLE FIRE EXTINGUISHERS & FIRE FIGHTING CHEMICALS	77
120507	SMOKE / GAS DETECTOR	78
120508	FIRE FIGHTING EQUIPMENTS	79
<b>1206</b>	<b>MARINE LOADING SYSTEM</b>	
120601	MARINE LOADING ARM	80
120602	TRUCK/WAGON LOADING ARM	81

## 120101 : CS PIPES IS-1239 (BLACK & GI)

CODE	NAME
<b>INDIA</b>	
1 . P0039	AMBICA TUBES CO.
2 . P2055	ANIL METAL CORPORATION
3 . P2253	BHARAT ENTERPRISES (All sizes from PDIL enlisted pipe mills/manufacturer)
4 . P2274	BMS INTERNATIONAL (BOMBAY) LLP (All Sizes & grades from PDIL enlisted pipe mills/manufacturer)
5 . P2216	CHETAN STEELS (Upto 6")
6 . P2196	DADU PIPES (P) LIMITED (½" to 6")
7 . P2075	GOOD LUCK STEEL TUBES LTD. (15 mm to 150 mm dia)
8 . P0326	GUJRAT STEEL TUBES LTD.
9 . P2166	HI-TECH PIPES LTD. (ERW MS / GI Pipes:½" NB to 6" NB, (Thickness 2.2 mm to 6.0 mm))
10 . P0814	INDIAN TUBE CO. (TATA DIV. OF TUBES & PIPES) (For >200M)
11 . P0387	INDUS TUBES LIMITED (½" to 6")
12 . P2121	JAY LAKSHMI STEEL & ENGINEERING CO.
13 . P0427	JINDAL PIPES LTD. (1/2" to 4")
14 . P2193	JOTINDRA STEEL & TUBES LTD. (½" to 6")
15 . P2111	KALPESH TUBE(INDIA), (TRADER) (upto a max order value Rs.25.0 lakh)
16 . P2264	KWALITY TUBES (All sizes and grades from PDIL enlisted pipes mill/manufacture)
17 . P2276	MOKSHI INDUSTRIES PVT. LTD. (All sizes and grades from PDIL enlisted pipes mills/manufacture)

## 120101 : CS PIPES IS-1239 (BLACK & GI)

CODE	NAME
18 . P0548	MUKAT PIPES LTD
19 . P2178	NAVRATAN PIPE AND PROFILE LTD. (Upto 6")
20 . P2040	P.K.FORGE & FITTING INDUSTRIES
21 . P2116	SAGAR STEEL CORPORATION (TRADER)
22 . P2110	SANGHVI METALS (TRADER)
23 . P2250	SHRIPAL METAL LIMITED (CS Pipes IS-1239 (Black & GI) All sizes from PDIL enlisted pipe mills/manufacturer)
24 . P0775	SURINDRA ENGINEERING CO. PVT. LTD.
25 . P0776	SURYA ROSHNI LTD. (15mm to 150mm)
26 . P2123	THE BENGAL MILL STORES SUPPLY CO.(TRADER)
27 . P2152	WELSPUN GUJARAT STAHL ROHREN LIMITED (ANJAR) (Upto 6")
28 . P0894	ZENITH LIMITED
29 . P2252	` (UP TO 6" (BLACK), UPTO 4" (GI))

## 120102 : CS WELDED PIPES IS-3589

CODE	NAME
<b>INDIA</b>	
1 . P2055	ANIL METAL CORPORATION
2 . P2253	BHARAT ENTERPRISES (All sizes from PDIL enlisted pipe mills/manufacturer)
3 . P2274	BMS INTERNATIONAL (BOMBAY) LLP (All Sizes & grades from PDIL enlisted pipe mills/manufacturer)
4 . P2196	DADU PIPES (P) LIMITED (6" to 12" (Thickness up to 9.5 mm))
5 . P2069	EVERGREEN HARDWARE STORES
6 . P2075	GOOD LUCK STEEL TUBES LTD. (Upto 150mm dia , 8 mm thick.)
7 . P0326	GUJRAT STEEL TUBES LTD.
8 . P2077	HEAVY METAL & TUBES LIMITED
9 . P2166	HI-TECH PIPES LTD. (ERW MS / GI Pipes: 6" NB OD to 12", (Thickness 2.6 mm to 8.0 mm))
10 . P0387	INDUS TUBES LIMITED (6" to 12")
11 . P2121	JAY LAKSHMI STEEL & ENGINEERING CO.
12 . P0427	JINDAL PIPES LTD. (8" to 14")
13 . P2193	JOTINDRA STEEL & TUBES LTD. (6" to 14")
14 . P2111	KALPESH TUBE(INDIA), (TRADER)
15 . P2264	KWALITY TUBES (All sizes and grades from PDIL enlisted pipes mill/manufacture)
16 . P2124	LALIT PIPES & PIPES LIMITED (16" to 64", thickness upto 20mm)
17 . P2276	MOKSHI INDUSTRIES PVT. LTD. (All sizes and grades from PDIL enlisted pipes mills/manufacture)

## 120102 : CS WELDED PIPES IS-3589

CODE	NAME
18 . P0548	MUKAT PIPES LTD
19 . P2178	NAVRATAN PIPE AND PROFILE LTD. (Upto 10")
20 . P2040	P.K.FORGE & FITTING INDUSTRIES
21 . P2174	PRATIBHA INDUSTRIES LTD., (16" NB to 24" NB, Wall Thickness: 6 mm to 20 mm)
22 . P0661	RATNAMANI METALS & TUBES LIMITED
23 . P2116	SAGAR STEEL CORPORATION (TRADER)
24 . P2110	SANGHVI METALS (TRADER)
25 . P2095	SAW PIPES
26 . P2105	SHRI RAM METALS
27 . P2250	SHRIPAL METAL LIMITED (CS Welded Pipes IS-3589 All sizes from PDIL enlisted pipe mills/manufacturer)
28 . P0754	STEEL AUTHORITY OF INDIA LTD.
29 . P0775	SURINDRA ENGINEERING CO. PVT. LTD.
30 . P0776	SURYA ROSHNI LTD. (6" to 16" ,(150mm to 400mm))
31 . P2123	THE BENGAL MILL STORES SUPPLY CO.(TRADER)
32 . P2153	WELSPUN GUJARAT STAHL ROHREN LIMITED (DAHEJ) (Upto 72" (50 mm thk.))
33 . P2152	WELSPUN GUJARAT STAHL ROHREN LIMITED (ANJAR) (Upto 100" (30 mm thk.))

## 120103 : CS WELDED PIPES TO API 5L SPIRAL/LONG. WELDED (SAW/EFSW)

CODE	NAME
<b>INDIA</b>	
1 . P2253	BHARAT ENTERPRISES (All sizes from PDIL enlisted pipe mills/manufacture)
2 . P2274	BMS INTERNATIONAL (BOMBAY) LLP (All Sizes & grades from PDIL enlisted pipe mills/manufacture)
3 . P2198	HEAVY METAL PIPE CENTRE (Upto 24" (Upto SCHXXS) (PDIL approved Manufacturer's Make only))
4 . P0427	JINDAL PIPES LTD. (2" TO 14")
5 . P2193	JOTINDRA STEEL & TUBES LTD. (½" to 14")
6 . P2111	KALPESH TUBE(INDIA), (TRADER)
7 . P2264	KWALITY TUBES (All sizes and grades from PDIL enlisted pipes mill/manufacture)
8 . P2124	LALIT PIPES & PIPES LIMITED (16" to 64", thickness upto 20mm)
9 . P2276	MOKSHI INDUSTRIES PVT. LTD. (All sizes and grades from PDIL enlisted pipes mills/manufacture)
10 . P0548	MUKAT PIPES LTD
11 . P2040	P.K.FORGE & FITTING INDUSTRIES
12 . P2174	PRATIBHA INDUSTRIES LTD., (16" NB to 24" NB, Wall Thickness: 6 mm to 14.27)
13 . P0661	RATNAMANI METALS & TUBES LIMITED
14 . P2116	SAGAR STEEL CORPORATION (TRADER)
15 . P0754	STEEL AUTHORITY OF INDIA LTD.
16 . P0775	SURINDRA ENGINEERING CO. PVT. LTD.
17 . P0776	SURYA ROSHNI LTD. (Gr. A, 3" to 4", Gr. B, 6" to 14")



## 120103 : CS WELDED PIPES TO API 5L SPIRAL/LONG. WELDED (SAW/EFSW)

CODE	NAME
18 . P2123	THE BENGAL MILL STORES SUPPLY CO.(TRADER)
19 . P2153	WELSPUN GUJARAT STAHL ROHREN LIMITED (DAHEJ) (Upto 72" (50 mm thk.))
20 . P2152	WELSPUN GUJARAT STAHL ROHREN LIMITED (ANJAR) (Upto 100" (30 mm thk.))
<b>FRANCE</b>	
21 . P0834	ETS TROUVAY & CAUVIN
22 . P0629	PHOCEEENNE
<b>GERMANY</b>	
23 . P0509	MANNESMANN HANDEL AG
24 . P0813	THYSSEN-KRUPP STAHLUNION GmbH
<b>ITALY</b>	
25 . P0191	DALMINE SPA
26 . P2092	RACCORTUBI SRL
<b>JAPAN</b>	
27 . P0464	KOSEI SANGYO LTD
28 . P0517	MARUBENI ITOCHU STEEL
29 . P0539	MITSUBISHI CORPORATION
30 . P0583	NIPPON KOKAN
31 . P0585	NIPPON STEEL CORPORATION
32 . P0587	NISHITANI & CO. LTD.

## 120103 : CS WELDED PIPES TO API 5L SPIRAL/LONG. WELDED (SAW/EFSW)

CODE	NAME
33 . P0588	NISSHO IWAI CORPORATION
34 . P0601	OKURA & CO. LTD.
35 . P0575	SOJITZ CORPORATION
36 . P0770	SUMITOMO METAL INDUSTRIES LTD.
<b>KOREA</b>	
37 . P0370	HYUNDAI CORPORATION
<b>U.K.</b>	
38 . P2064	BRITISH STEEL CORPORATION
39 . P0129	CORUS TUBES LIMITED
<b>U.S.A.</b>	
40 . P0703	SAW PIPES USA,INC.

## 120104 : CS / AS / LTCS SEAMLESS PIPES

CODE	NAME
<b>INDIA</b>	
1 . P2224	ANAND SEAMLESS TUBES PVT. LTD. (CS Seamless Pipes Upto 2")
2 . P2253	BHARAT ENTERPRISES (All sizes from PDIL enlisted pipe mills/manufacturer)
3 . P0115	BHEL (VALVES DIVISION)
4 . P2274	BMS INTERNATIONAL (BOMBAY) LLP (All Sizes & grades from PDIL enlisted pipe mills/manufacturer)
5 . P2216	CHETAN STEELS (Upto 12" SCH 80)
6 . P2077	HEAVY METAL & TUBES LIMITED (Upto 8" (thickness upto 18.26 mm))
7 . P2198	HEAVY METAL PIPE CENTRE (Upto 24" (Upto SCHXXS) (PDIL approved Manufacturer's Make only))
8 . P0814	INDIAN TUBE CO. (TATA DIV. OF TUBES & PIPES)
9 . P0800	ISMT LIMITED
10 . P2121	JAY LAKSHMI STEEL & ENGINEERING CO.
11 . P2133	JINDAL SAW LIMITED
12 . P2264	KWALITY TUBES (All sizes and grades from PDIL enlisted pipes mill/manufacturer)
13 . P0503	MAHARASHTRA SEAMLESS LTD.
14 . P2276	MOKSHI INDUSTRIES PVT. LTD. (All sizes and grades from PDIL enlisted pipes mills/manufacture)
15 . P2040	P.K.FORGE & FITTING INDUSTRIES
16 . P2138	RATNADEEP METAL & TUBES PVT. LTD. (<=168.3mm OD)
17 . P2170	SAINEST TUBES PVT. LTD. (½" NB to 3" Upto Sch 160 (ASTM A106 Gr. B, A333 Gr.1 & 6 & A335 Gr. P11))

## 120104 : CS / AS / LTCS SEAMLESS PIPES

CODE	NAME
18 . P2250	SHRIPAL METAL LIMITED (CS/AS/LTCS Seamless Pipes All sizes from PDIL enlisted pipe mills/manufacturer)
<b>FRANCE</b>	
19 . P0834	ETS TROUVAY & CAUVIN
20 . P0629	PHOCEENNE
<b>GERMANY</b>	
21 . P0477	HORST KURVERS GmbH
22 . P0509	MANNESMANN HANDEL AG
<b>ITALY</b>	
23 . P0191	DALMINE SPA
24 . P2119	GAM RACCORDI S.P.A
25 . P0175	IBF SEAMLESS PIPES Spa
26 . P2092	RACCORTUBI SRL
<b>JAPAN</b>	
27 . P0517	MARUBENI ITOCHU STEEL
28 . P0539	MITSUBISHI CORPORATION
29 . P0585	NIPPON STEEL CORPORATION
30 . P0587	NISHITANI & CO. LTD.
31 . P0588	NISSHO IWAI CORPORATION
32 . P0601	OKURA & CO. LTD.

## 120104 : CS / AS / LTCS SEAMLESS PIPES

CODE	NAME
33 . P0575	SOJITZ CORPORATION
34 . P0770	SUMITOMO METAL INDUSTRIES LTD.
<b>KOREA</b>	
35 . P0370	HYUNDAI CORPORATION
<b>SWEDEN</b>	
36 . P0004	AB SANDVIK STEEL
<b>U.K.</b>	
37 . P2064	BRITISH STEEL CORPORATION
38 . P0129	CORUS TUBES LIMITED
39 . P0870	VOMAL INTERNATIONAL LIMITED

## 120105 : SS SEAMLESS/WELDED PIPES

CODE	NAME
<b>GERMANY</b>	
1 . P2189	H. BUTTING GmbH & CO. (Seamless : Upto 30" (upto 16mm thk) & Welded: Upto 72" (upto 64mm thk.))
<b>INDIA</b>	
2 . P2183	APEX TUBES PVT. LIMITED (Seamless: Upto 8" (Sch80S) & Welded: Upto 48" (Sch160))
3 . P2258	ASR MET TECH PRIVATE LIMITED (Item-SS(Seamless), Size- Up to 12", Thk/Sch -Up to 12.7mm/SCH80, Specification/Grade - A312 Gr. 304/304L/316/316L)
4 . P2181	BHANDARI FOILS & TUBES LIMITED (Seamless Upto 4" (Sch. 80) & Welded Upto 20" (Thk. <= 8 mm))
5 . P2253	BHARAT ENTERPRISES (All sizes from PDIL enlisted pipe mills/manufacturer)
6 . P2274	BMS INTERNATIONAL (BOMBAY) LLP (All Sizes & grades from PDIL enlisted pipe mills/manufacturer)
7 . P2216	CHETAN STEELS (Upto 6" SCH 40)
8 . P0158	CHOKSI TUBE COMPANY LTD.
9 . P2242	DIVINE TUBES PVT.LTD. (UPTO 8")
10 . P2077	HEAVY METAL & TUBES LIMITED (Upto 8" (thickness upto 18.26 mm))
11 . P2198	HEAVY METAL PIPE CENTRE (Upto 8" ( Upto SCH80S) (PDIL approved Manufacturer's Make only))
12 . P2121	JAY LAKSHMI STEEL & ENGINEERING CO.
13 . P2133	JINDAL SAW LIMITED
14 . P2167	KRYSTAL STEEL MANUFACTURING PVT. LTD. (Upto 2" (Material upto Grade SS 321))
15 . P2264	KWALITY TUBES (All sizes and grades from PDIL enlisted pipes mill/manufacturer)
16 . P2084	MARDALE PIPES PLUS LTD

## 120105 : SS SEAMLESS/WELDED PIPES

CODE	NAME
17 . P2168	MODERN TUBE INDUSTRIES LIMITED (Upto 2" (Upto SS Grade 321))
18 . P2276	MOKSHI INDUSTRIES PVT. LTD. (All sizes and grades from PDIL enlisted pipes mills/manufacturer)
19 . P0593	NUCLEAR FUEL COMPLEX
20 . P2040	P.K.FORGE & FITTING INDUSTRIES
21 . P2089	PRAKASH STEELAGE LIMITED (Seamless : Upto 12" & Welded: Upto 24")
22 . P2182	QUALITY STAINLESS PVT. LTD. ( Seamless: Upto 6" (SCH40S ), Welded: Upto 20" (SCH40S) (Upto SS Grade 316L))
23 . P2138	RATNADEEP METAL & TUBES PVT. LTD. (Seamless <=168.3mm.OD. Welded <=50.8mm OD)
24 . P0661	RATNAMANI METALS & TUBES LIMITED
25 . P0659	REMI EDELSTAHL TUBULARS LTD.(RAJENDRA MECHANICAL INDUSTRIES (Welded Upto 48" Seamless upto 8" (Thk. Upto 12.7 mm))
26 . P2268	S PLUS TUBE TECH (Upto 5" Seamless, SCH40S, A312 TP304L/316L, Upto 6" Welded, SCH40S, A312 TP304L/316L)
27 . P2206	SANDVIK ASIA PVT. LTD. (¾" to 2" (Thk: upto 8.74 mm))
28 . P2110	SANGHVI METALS (TRADER)
29 . P2169	SCORODITE STAINLESS (INDIA) PVT. LTD. (Seamless upto 16" NB, Welding upto 36")
30 . P2246	SHALCO INDUSTRIES PRIVATE LIMITED (SS Seamless Pipes - Up to 8", SS Welded Pipe - Up to 4")
31 . P2250	SHRIPAL METAL LIMITED (SS Seamless/Welded Pipes All sizes from PDIL enlisted pipe mills/manufacturer)
32 . P2157	SHUBHLAXMI METALS & TUBES PVT. LTD. (SS Seamless ¾" NB to 2" NB; Thk: 1.2 mm to 8 mm, L upto 14 mtr; SS Welded ¾" NB to 8" NB; Thk: 1.2 mm to 8 mm Lupto 14 mtr (Material: SS 304, SS 304L, SS316, SS 316L, SS 321, SS 347, SS 347H))
33 . P2275	SHUBHLAXMI METALS AND TUBES PRIVATE LIMITED (1. PIPE-SS(SEAMLESS), UPTO 12", SCH40S, A312 GR. 304/304L/316/316L 2. PIPE-SS(SEAMLESS), UPTO 16", SCH40S, A312/A358 TP304/304L//316/316L)

## 120105 : SS SEAMLESS/WELDED PIPES

CODE	NAME
34 . P2270	SUNCITY SHEETS PVT. LTD. (Upto 12" Welded, SCH 40S, A312 TP304L/316L)
35 . P2154	SURAJ LIMITED (SURAJ STAINLESS LIMITED)
36 . P2123	THE BENGAL MILL STORES SUPPLY CO.(TRADER)
37 . P1205	Venus Pipes & Tubes Private Limited (Up to 16")
38 . P2244	WELSPUN SPECIALITY SOLUTIONS LIMITED (Upto 4" (only for Seamless Pipes))
<b>THE NETHERLANDS</b>	
39 . P2202	SOSTA BV (Upto 72" ( thickness upto 25.4 mm))
<b>CHINA</b>	
40 . P2131	ZHEJIANG JIULI STAINLESS STEEL PIPE CO. LTD.
<b>FRANCE</b>	
41 . P0834	ETS TROUVAY & CAUVIN
42 . P0629	PHOCEENNE
<b>GERMANY</b>	
43 . P0477	HORST KURVERS GmbH
44 . P0509	MANNESMANN HANDEL AG
45 . P0813	THYSSEN-KRUPP STAHLUNION GmbH
<b>ITALY</b>	
46 . P0191	DALMINE SPA
47 . P2119	GAM RACCORDI S.P.A (thickness 2" to 24")
48 . P0175	IBF SEAMLESS PIPES Spa



## 120105 : SS SEAMLESS/WELDED PIPES

CODE	NAME
49 . P2092	RACCORTUBI SRL
<b>JAPAN</b>	
50 . P0517	MARUBENI ITOCHU STEEL
51 . P0539	MITSUBISHI CORPORATION
52 . P0585	NIPPON STEEL CORPORATION
53 . P0587	NISHITANI & CO. LTD.
54 . P0588	NISSHO IWAI CORPORATION
55 . P0601	OKURA & CO. LTD.
56 . P0575	SOJITZ CORPORATION
57 . P0770	SUMITOMO METAL INDUSTRIES LTD.
<b>KOREA</b>	
58 . P0370	HYUNDAI CORPORATION
<b>SPAIN</b>	
59 . P2151	T.T.I. - TUBACEX TUBOS INOXIDABLES, S.A. (Upto 10")
<b>SWEDEN</b>	
60 . P0004	AB SANDVIK STEEL
<b>U.K.</b>	
61 . P2064	BRITISH STEEL CORPORATION
62 . P0129	CORUS TUBES LIMITED
63 . P0870	VOMAL INTERNATIONAL LIMITED

## 120106 : SS SEAMLESS TUBES

CODE	NAME
<b>INDIA</b>	
1 . P2055	ANIL METAL CORPORATION
2 . P2183	APEX TUBES PVT. LIMITED (Upto 50.8 mm OD (Thickness Upto 4.00 mm))
3 . P2258	ASR MET TECH PRIVATE LIMITED (Item-SS(Seamless), Size101.60 mm Thk/Sch -Up to 4 mm, Specification/Grade - A213 Gr. 304/304L/316/316L/316TI/321)
4 . P2181	BHANDARI FOILS & TUBES LIMITED (Upto 50 mm OD)
5 . P2253	BHARAT ENTERPRISES (All sizes from PDIL enlisted pipe mills/manufacturer)
6 . P2274	BMS INTERNATIONAL (BOMBAY) LLP (All Sizes & grades from PDIL enlisted pipe mills/manufacturer)
7 . P2242	DIVINE TUBES PVT.LTD. (UPTO 3")
8 . P2077	HEAVY METAL & TUBES LIMITED (Upto 8" (thickness upto 18.26 mm))
9 . P2167	KRYSTAL STEEL MANUFACTURING PVT. LTD. (Upto 50.8 OD (Material upto Grade SS 321))
10 . P2264	KWALITY TUBES (All sizes and grades from PDIL enlisted pipes mill/manufacturer)
11 . P2168	MODERN TUBE INDUSTRIES LIMITED (Upto 50.80 OD (Upto SS Grade 321))
12 . P2089	PRAKASH STEELAGE LIMITED (114.3 mm OD Thickness upto 6 mm)
13 . P0661	RATNAMANI METALS & TUBES LIMITED
14 . P2268	S PLUS TUBE TECH (Upto 50.8mm OD x 2.11 mm THK SA213 TP304L/316L/321, Upto 76.02 mm OD x 3.18 mm THK SA269 TP304L/316L)
15 . P2206	SANDVIK ASIA PVT. LTD. (OD upto 60.33 (Thk: upto 8.74 mm))
16 . P2169	SCORODITE STAINLESS (INDIA) PVT. LTD. (19.05 mm OD to 50.80 mm OD, Thickness upto 3 mm)
17 . P2246	SHALCO INDUSTRIES PRIVATE LIMITED (Upto 76.2 mm OD)

## 120106 : SS SEAMLESS TUBES

CODE	NAME
18 . P2250	SHRIPAL METAL LIMITED (SS Seamless Tubes All sizes from PDIL enlisted pipe mills/manufacturer)
19 . P2275	SHUBHLAXMI METALS AND TUBES PRIVATE LIMITED (1. TUBE-SS(SEAMLESS), 42.04MM, UPTO 1.6MM, A213 GR. 304/304L/316/316L 2. TUBE-SS(SEAMLESS), 25.4MM, UPTO 2MM, A213 GR. 304/304L/316/316L)
20 . P2154	SURAJ LIMITED (SURAJ STAINLESS LIMITED)
21 . P1205	Venus Pipes & Tubes Private Limited (Up to 50.8 mm OD)
22 . P2244	WELSPUN SPECIALITY SOLUTIONS LIMITED (Upto 114.3 MM OD)
<b>SPAIN</b>	
23 . P2151	T.T.I. - TUBACEX TUBOS INOXIDABLES, S.A. (Upto 250.0 mm OD)

## 120107 : SS PIPES UREA GRADE

CODE	NAME
<b>INDIA</b>	
1 . P2274	BMS INTERNATIONAL (BOMBAY) LLP (All Sizes & grades from PDIL enlisted pipe mills/manufacturer)
2 . P2239	KEY-TECH ENGINEERING COMPNAY (Upto 8")
<b>AUSTRIA</b>	
3 . P0120	BHDT GMBH
4 . P0708	SCHOELLER-BLECKMANN NITEC GMBH
<b>FRANCE</b>	
5 . P0834	ETS TROUVAY & CAUVIN
6 . P0629	PHOCEENNE
<b>GERMANY</b>	
7 . P0477	HORST KURVERS GmbH
8 . P0509	MANNESMANN HANDEL AG
9 . P0813	THYSSEN-KRUPP STAHLUNION GmbH
<b>ITALY</b>	
10 . P0191	DALMINE SPA
11 . P0175	IBF SEAMLESS PIPES Spa
<b>JAPAN</b>	
12 . P0517	MARUBENI ITOCHU STEEL
13 . P0539	MITSUBISHI CORPORATION
14 . P0585	NIPPON STEEL CORPORATION

## 120107 : SS PIPES UREA GRADE

CODE	NAME
15 . P0587	NISHITANI & CO. LTD.
16 . P0588	NISSHO IWAI CORPORATION
17 . P0601	OKURA & CO. LTD.
18 . P0575	SOJITZ CORPORATION
19 . P0770	SUMITOMO METAL INDUSTRIES LTD.
<b>KOREA</b>	
20 . P0370	HYUNDAI CORPORATION
<b>SPAIN</b>	
21 . P2151	T.T.I. - TUBACEX TUBOS INOXIDABLES, S.A. (Upto 10")
<b>SWEDEN</b>	
22 . P0004	AB SANDVIK STEEL
<b>U.K.</b>	
23 . P2064	BRITISH STEEL CORPORATION
24 . P0129	CORUS TUBES LIMITED
25 . P0870	VOMAL INTERNATIONAL LIMITED

## 120110 : HDPE/ MDPE PIPES & PIPE FITTINGS

CODE	NAME
<b>INDIA</b>	
1 . P2057	ASTRAL
2 . P2059	AUQUAGUARD PLASTICS & POLYMERS
3 . P2066	CLIMAX SYNTHETICS
4 . P2071	FIBRO PLASTICHEM (I) PVT. LTD.
5 . P2085	NATIONAL ORG CHEMICAL INDIA LTD.
6 . P2207	PARTH POLY VALVES PVT. LTD. ( $\frac{3}{4}$ " to 8" (150#))
7 . P2001	PENNWALT AGRU PLASTICS LTD. (upto 250mm Dia)
8 . P2094	RELIANCE INDUSTRIES 'RELPIPE'
9 . P1203	SANGIR PLASTICS PRIVATE LIMITED (UPTO 1200 MM OD)
10 . P1039	SONAL ENGG. PLASTIC FABRICATOR

## 120111 : SS WELDED TUBES

CODE	NAME
<b>INDIA</b>	
1 . P2183	APEX TUBES PVT. LIMITED (Upto 102 mm OD (Thickness Upto 4.00 mm))
2 . P2274	BMS INTERNATIONAL (BOMBAY) LLP (All Sizes & grades from PDIL enlisted pipe mills/manufacturer)
3 . P2242	DIVINE TUBES PVT.LTD. (UPTO 4")
4 . P2167	KRYSTAL STEEL MANUFACTURING PVT. LTD. (Upto 50.8 OD (Material upto Grade SS 321))
5 . P3418	MAXIM TUBES COMPANY PVT. LTD. (6 mm to 114.3 mm (0.5 mm to 4.5 mm thk.))
6 . P2168	MODERN TUBE INDUSTRIES LIMITED (Upto 50.80 OD (Upto SS Grade 321))
7 . P2089	PRAKASH STEELAGE LIMITED (114.3 mm OD thickness upto 6 mm)
8 . P2182	QUALITY STAINLESS PVT. LTD. ( Upto 4"OD (Upto 4.0 mm Thick) (Upto SS Grade 316L))
9 . P0659	REMI EDELSTAHL TUBULARS LTD.(RAJENDRA MECHANICAL INDUSTRIES (50.8 mm OD)
10 . P2268	S PLUS TUBE TECH (Upto 19.05 mm OD x 0.711 mm THK SA249 TP304)
11 . P2235	SCODA TUBES LTD. (9.52 mm OD to 50.8 mm OD)
12 . P2169	SCORODITE STAINLESS (INDIA) PVT. LTD. (19.05 mm OD to 50.80 mm OD, Thickness upto 3 mm)
13 . P2275	SHUBHLAXMI METALS AND TUBES PRIVATE LIMITED (1. TUBE-SS(WELDED), UPTO 19.05MM, UPTO 1.2MM, SA249 TP 304/304L/316/316L & 2. TUBE-SS(WELDED), UPTO 38.01MM, UPTO 1.6MM, SA270 TP 304/304L/316/316L)
14 . P2240	STEAMLINE INDUSTRIES LTD. (6.00 mm OD to 50.8 mm OD)
15 . P2270	SUNCITY SHEETS PVT. LTD. (12.7mm to 127mm OD x 0.7mm to 4mmTHK SA249 TP 304/316L)
16 . P2230	SUNRISE STAINLESS PVT.LTD. (Upto 4" OD, thickness upto 6 mm.)
17 . P2154	SURAJ LIMITED (SURAJ STAINLESS LIMITED)

## 120111 : SS WELDED TUBES

CODE	NAME
18 . P1205	Venus Pipes & Tubes Private Limited (Up to 73.1 mm OD)
19 . P2244	WELSPUN SPECIALITY SOLUTIONS LIMITED (Upto 50.8 MM OD)



## 120113 : FITTINGS: CS/AS/SS SEAMLESS & FORGED

CODE	NAME
<b>INDIA</b>	
1 . P2120	AMFORGE INDUSTRIES (Upto 24")
2 . P2055	ANIL METAL CORPORATION
3 . P2216	CHETAN STEELS (Upto 6" SCH 80)
4 . P0166	COMMERCIAL SUPPLYING AGENCY
5 . P2195	CSA FITTINGS (Forged: ½" to 2" (Upto 9000#) & Seamless: 2" to 8" (Upto SCH XXS))
6 . P0221	EBY FASTNERS
7 . P0222	EBY INDUSTRIES
8 . P2150	FIT-TECH INDUSTRIES ( Upto 24")
9 . P2159	FLASH FORGE(P) LTD. (Forged: Upto 4" (Upto 9000#) & Seamless: Upto 42")
10 . P2002	GUJARAT INFRAPIPES PVT. LTD.
11 . P2121	JAY LAKSHMI STEEL & ENGINEERING CO.
12 . P2111	KALPESH TUBE(INDIA), (TRADER) (upto a max order value Rs.25.0 lakh)
13 . P2266	KISAAN STEELS PRIVATE LIMITED (1. UPTO 6" CS SMLS FITTINGS, 2. UPTO 2" CS/AS/SS FORGED FITTINGS)
14 . P0553	M.S.FITTINGS MANUFACTURING CO.PVT.LTD.
15 . P2084	MARDALE PIPES PLUS LTD
16 . P2269	N J ENGINEERS (½" TO 24"-SCH 40/80/100/160 SEAMLESS FITTINGS & ½" TO 4" 3000#, 6000#, 9000# ELBOW, TEE, CAP, COUPLING, CROSS, WELDOLET, SOCKOLET)
17 . P2162	NAVKAR FORGINGS & FITTINGS PVT. LTD. (Forged: 3" (Upto 6000#) & Seamless: Upto 16" (Sch XXS))

## 120113 : FITTINGS: CS/AS/SS SEAMLESS & FORGED

CODE	NAME
18 . P2251	NEOSEAL ENGINEERING PRIVATE LIMITED (1. I. Fittings(Forged), CS, Up To 1.5", ANSI Class -Up To 3000#, 2. Fittings(SMLS), CS, Up To 10", SCH -Up To 40, 3. Fittings(SMLS), AS, Up To 6", SCH -Up To 40, 4. Fittings(SMLS), SS, Up To 8", SCH -Up To
19 . P2003	NL HAZRA (up to SCH 80)
20 . P2215	P K TUBES & FITTINGS PVT. LTD. (Forged upto 1 ½" & Seamless upto 24" (SCH 160))
21 . P2040	P.K.FORGE & FITTING INDUSTRIES
22 . P2199	PARAS FITTINGS PVT. LTD. (Forged CS: ½" to 2" & CS Seamless: 2" to 8" (Upto Sch XXS))
23 . P2156	PARMAR TECHNO FORGE (Elbow-1/2" to 12", Tees-1/2" to 8", Reducer (conc. & eccn.)-1/2" to 12", CAPS-1/2" to 18" (CS&SS))
24 . P2088	PERFECT MARKETING (P) LTD,
25 . P2187	PETROCHEM INDUSTRIES (Seamless: upto 16" (all Fittings) & upto 36" (Only Caps) Sch : XXS / 80S, Forged : Upto 3" 6000#)
26 . P2210	RAJENDRA FORGE INDUSTRIES (CS: Upto 12" Sch 40 & SS: 6" Sch 40S)
27 . P0733	S & G ENGINEERS (P) LTD.
28 . P2116	SAGAR STEEL CORPORATION (TRADER)
29 . P2110	SANGHVI METALS (TRADER)
30 . P2280	SARDA PIPES & FITTINGS PVT. LTD. (1. Upto 18"/12"/4" for CS/AS/SS Seamless Fittings 2. Upto 2" 3000# for CS Forged Fittings)
31 . P2004	SAWAN ENGINEERS PVT. LIMITED ( Upto 36" (SCH 160))
32 . P0728	SHIVANANDA PIPE FITTINGS LTD.,
33 . P2272	SKY FORGE PRIVATE LIMITED (1/2" to 24" SMLS & 1/2" to 3" Forged)
34 . P0758	STEWARTS AND LLOYDS OF INDIA LIMITED

## 120113 : FITTINGS: CS/AS/SS SEAMLESS & FORGED

CODE	NAME
35 . P0793	TEEKAY TUBES PRIVATE LIMITED
36 . P2123	THE BENGAL MILL STORES SUPPLY CO.(TRADER)
37 . P2165	TOPAZ PIPING INDUSTRIES (2" to 36" (Sch 10 to Sch 160))
38 . P2006	TUBE BEND (CALCUTTA) PVT LTD (CS FITTINGS ONLY)
39 . P0835	TUBE PRODUCTS INCORPORATE
40 . P2261	UNITED FORGE INDUSTRIES (1. Upto 24" SCH 40 for CS SMLS Fittings, 2. Upto 10" SCH 10S for SS SMLS Fittings & 3. Upto 1.5" 3000# CS/SS Forged Flanges)
41 . P2135	ZOLOTO INDUSTRIES (15mm to 150mm (only CS-Galv.))

### **ITALY**

42 . P2188	PETROL RACCORD S.P.A. (Seamless: 1" - 42" (Elbows) & 1" - 56" (Tees/ Reducers/Caps))
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### **FRANCE**

43 . P0834	ETS TROUVAY & CAUVIN
44 . P0629	PHOCEENNE
45 . P0853	VALLOUREC

### **GERMANY**

46 . P0477	HORST KURVERS GmbH
47 . P0509	MANNESMANN HANDEL AG
48 . P0712	SEIKMANN ANLAGEN-TECHNIK GMPH.
49 . P0822	TPS-TECHNITUBE ROHRENWERKE GMBH

### **ITALY**

## 120113 : FITTINGS: CS/AS/SS SEAMLESS & FORGED

CODE	NAME
50 . P0191	DALMINE SPA
51 . P2119	GAM RACCORDI S.P.A
52 . P0175	IBF SEAMLESS PIPES Spa
53 . P0377	IND MECCANICA BASSI LUIGI & C. SPA
54 . P2083	MANTOVANI SpA
55 . P2092	RACCORTUBI SRL
56 . P0789	TECHNO FORGE SPA
<b>JAPAN</b>	
57 . P0517	MARUBENI ITOCHU STEEL
58 . P0583	NIPPON KOKAN
59 . P0587	NISHITANI & CO. LTD.
60 . P0588	NISSHO IWAI CORPORATION
61 . P0601	OKURA & CO. LTD.
62 . P0575	SOJITZ CORPORATION
63 . P0770	SUMITOMO METAL INDUSTRIES LTD.
<b>TAIWAN</b>	
64 . P2007	HAITIMA CORPORATION
<b>U.K.</b>	
65 . P2064	BRITISH STEEL CORPORATION

**120113 : FITTINGS: CS/AS/SS SEAMLESS & FORGED**

<b>CODE</b>	<b>NAME</b>
66 . P0129	CORUS TUBES LIMITED
67 . P0245	EUROTUBE LIMITED
68 . P0870	VOMAL INTERNATIONAL LIMITED
<b>U.S.A.</b>	
69 . P2063	BONNEY FORGE

## 120114 : FITTINGS: SS UREA GRADE

CODE	NAME
<b>INDIA</b>	
1 . P2239	KEY-TECH ENGINEERING COMPNAY (Upto 8")
<b>ITALY</b>	
2 . P2188	PETROL RACCORD S.P.A. (Size upto 14")
<b>AUSTRIA</b>	
3 . P0120	BHDT GMBH
<b>FRANCE</b>	
4 . P0834	ETS TROUVAY & CAUVIN
5 . P0629	PHOCEENNE
6 . P0853	VALLOUREC
<b>GERMANY</b>	
7 . P0477	HORST KURVERS GmbH
8 . P0509	MANNESMANN HANDEL AG
9 . P0712	SEIKMANN ANLAGEN-TECHNIK GMPH.
10 . P0822	TPS-TECHNITUBE ROHRENWERKE GMBH
<b>ITALY</b>	
11 . P0191	DALMINE SPA
12 . P0175	IBF SEAMLESS PIPES Spa
13 . P0377	IND MECCANICA BASSI LUIGI & C. SPA
14 . P2092	RACCORTUBI SRL

## 120114 : FITTINGS: SS UREA GRADE

CODE	NAME
15 . P0789	TECHNO FORGE SPA
<b>JAPAN</b>	
16 . P0517	MARUBENI ITOCHU STEEL
17 . P0583	NIPPON KOKAN
18 . P0587	NISHITANI & CO. LTD.
19 . P0588	NISSHO IWAI CORPORATION
20 . P0601	OKURA & CO. LTD.
21 . P0575	SOJITZ CORPORATION
22 . P0770	SUMITOMO METAL INDUSTRIES LTD.
<b>SWEDEN</b>	
23 . P0080	AVESTA CANDVITE TUBE AD
24 . P0343	HELENS ENERGY
<b>U.K.</b>	
25 . P2064	BRITISH STEEL CORPORATION
26 . P0129	CORUS TUBES LIMITED
27 . P0245	EUROTUBE LIMITED
28 . P0870	VOMAL INTERNATIONAL LIMITED

## 120115 : FRP/PVC PIPE AND PIPE FITTINGS

CODE	NAME
<b>INDIA</b>	
1 . P2278	ASHIRVAD PIPES PRIVATE LIMITED (Up to 8" SCH 80)
2 . P2058	ASTRAL POLYTECHNIK PVT. LTD. ( 1/2" TO 12" SIZE)
3 . P0290	GANDHI AND ASSOCIATES
4 . P2255	SATYAM COMPOSITES PVT. LTD. (Uo to 1800mm OD)
5 . P1039	SONAL ENGG. PLASTIC FABRICATOR



**120116 : CAST IRON FITTINGS & PIPES**

<b>CODE</b>	<b>NAME</b>
<b>INDIA</b>	
1 . P0182	CRAWLEY & RAY (F&E) PVT. LTD.
2 . P0374	IISCO LTD.
3 . P0445	KESORAM SPUN PIPES & FOUNDRIES
4 . P0704	SAYAJI IRON & ENGG.CO(P)LIMITED
5 . P0719	SHAKTI CAST (P)LIMITED
6 . P0720	SHALIMAR WORKS LTD
7 . P0727	SHIVA ENGINEERING WORKS
8 . P0866	VISVESARAYA IRON & STEEL LTD.

## 120117 : FORGED FLANGES

CODE	NAME
<b>INDIA</b>	
1 . P2053	AJAY FORGINGS PVT. LTD.
2 . P2120	AMFORGE INDUSTRIES (Upto 24" for upto 1500#; Upto 12" for 2500#)
3 . P0048	ANANDMAYEE FORGINGS PVT. LTD.
4 . P0141	C D ENGINEERING
5 . P2233	CHANDAN STEEL LIMITED (Only SS Flanges: Upto 36" - 150#, upto 24" - 300#, upto 20" - 600#, upto 16" - 900#, upto 12" - 1500#, upto 8" - 2500#)
6 . P2216	CHETAN STEELS (Upto 6" (150#))
7 . P0152	CHW FORGE PRIVATE LIMITED (FORMERLY CHAUDHARY HAMMER WORKS
8 . P0223	ECHJAY INDUSTRIES LIMITED
9 . P0255	FERROUS ALLOYS FORGINING PVT.LTD.,
10 . P0314	GOLDEN IRON & STEEL WORKS
11 . P2194	GOODLUCK ENGINEERING CO. (½"-12" (Upto 2500#), 14"-16" (Upto 900#), 18"-32" (Upto 600#), 34"-48" (Upto 300#))
12 . P0417	J K FORGINGS (½" to 60",ANSI B16.5,Class 150 to 2500)
13 . P2266	KISAAN STEELS PRIVATE LIMITED (1. UPTO 64" 150# CS, 2. UPTO 54" 300# CS, 3. UPTO 38" 600# CS, 4. UPTO 42" 300# AS/SS, 5. UPTO 20" 600# AS/SS & 6. UPTO 12" 2500# CS/AS/SS)
14 . P2160	KUNJ FORGINGS PVT. LTD. (Upto 60"(upto 300#) & Upto 12"(upto 2500#))
15 . P2175	MAHESH INDUSTRIES (½" to 8" NB, Rating: 150#- SWRF, SORF & BLRF Material: ASTM A105 only; 2" NB to 4" NB, Rating: 150#- Weld Neck RF Flange Material: ASTM A105 only)
16 . P2223	METAL FORGINGS PVT. LTD. (Upto 86" (150#); 60" (300# to 600#); 48" (900#); 24" (1500#); 12" (2500#))
17 . P2269	N J ENGINEERS (½" TO 24" -150#, 300#, 600#, 900#, 1500# & ABOVE 24" TO 56"-150#,300#)

## 120117 : FORGED FLANGES

CODE	NAME
18 . P2251	NEOSEAL ENGINEERING PRIVATE LIMITED (1. Flange (Blind/WN), CS, Up To 36", ANSI Class -Up To 150#, 2. Flange (Blind/WN), CS, Up To 24", ANSI Class -Up To 2500#, 3. Flange (Blind/WN), AS, Up To 24", ANSI Class -Up To 1500#, 4. Flange (Blind/WN), SS,
19 . P2215	P K TUBES & FITTINGS PVT. LTD. (Upto 24" (upto 1500#) & upto 12" (upto 2500#) (Spectacle Blinds and Spacer & Blind only).)
20 . P2214	PARAMOUNT FORGE (CS, AS & SS: ½" to 42" (Upto 600#), ½" to 24" (Upto 900#), ½" to 16" (Upto 1500#), ½" to 12" ( Upto 2500#))
21 . P2088	PERFECT MARKETING (P) LTD,
22 . P2008	PUNJAB STEEL
23 . P2155	R.D. FORGE (A UNIT OF R D CHEMICALS PVT LTD) ( ½" to 54" - 150#, ½" to 40" - 300#, ½" to 42" - 600#, ½" to 20" - 900#, ½" to 20" - 1500#, ½" to 12" - 2500# (CS, AS & SS))
24 . P2210	RAJENDRA FORGE INDUSTRIES (CS & SS : Upto 12", 300#)
25 . P0733	S & G ENGINEERS (P) LTD.
26 . P2005	SANGHVI FORGINGS & ENGINEERING LTD. (Upto 42" (upto 300#), 36"(600#), 24"(upto1500#) & 12"(2500#))
27 . P2110	SANGHVI METALS (TRADER)
28 . P2280	SARDA PIPES & FITTINGS PVT. LTD. (1. Upto 16"/14" for CS/AS 300 # for Forged Flanges)
29 . P2004	SAWAN ENGINEERS PVT. LIMITED
30 . P2272	SKY FORGE PRIVATE LIMITED (1/2" to 20")
31 . P2185	TECHNO FORGE LTD. (Upto 42" (upto 300#), upto 24" (600#), upto 20" (900#), upto 16" (1500#), upto 12" (2500#))
32 . P2006	TUBE BEND (CALCUTTA) PVT LTD
33 . P2261	UNITED FORGE INDUSTRIES (Upto 30" 600# CS Forged Flanges)

### FRANCE

34 . P0834 ETS TROUVAY & CAUVIN

## 120117 : FORGED FLANGES

CODE	NAME
35 . P0629	PHOCEENNE

### **GERMANY**

36 . P0477 HORST KURVERS GmbH

### **ITALY**

37 . P0414 I.S. INTERNATIONAL

38 . P2083 MANTOVANI SpA

39 . P0599 OFFICINE NICOLA GALPERTI & FIGLIO S.P.A

40 . P2092 RACCORTUBI SRL

### **JAPAN**

41 . P0576 NICHINAN SANGYO CO. LTD.,

42 . P0587 NISHITANI & CO. LTD.

43 . P0575 SOJITZ CORPORATION

### **U.K.**

44 . P0870 VOMAL INTERNATIONAL LIMITED

## 120118 : PLATE RING FLANGES

CODE	NAME
<b>INDIA</b>	
1 . P2070	FABWELL ENGINEERS
2 . P2175	MAHESH INDUSTRIES (½" to 16" NB, Rating: 150# & 300#- SWRF, SORF & BLRF, Material: MS Plate Flanges of IS 2062 Grade)
3 . P1012	MOD FABRICATORS
4 . P2269	N J ENGINEERS (Upto 42")
5 . P2215	P K TUBES & FITTINGS PVT. LTD. (Upto 48" (Spectacle Blinds and Spacer & Blind only).)
6 . P2214	PARAMOUNT FORGE (CS & SS : ½" to 84")
7 . P2088	PERFECT MARKETING (P) LTD,
8 . P2011	R SQUARE ENGINEERS
9 . P2110	SANGHVI METALS (TRADER)
10 . P2272	SKY FORGE PRIVATE LIMITED (Upto 1385 MM)
11 . P2261	UNITED FORGE INDUSTRIES (Upto 36" 150# CS Plate Ring Flanges)

## 120119 : FITTINGS: CS/AS/SS WELDED

CODE	NAME
<b>KOREA</b>	
1 . P2238	TK CORPORATION
<b>INDIA</b>	
2 . P2227	PARAS ENGINEERING WORKS ( 8" to 36" NB, Sch 5 to Sch XXS (CS & SS))
3 . P2216	CHETAN STEELS (Upto 10" SCH 80)
4 . P2150	FIT-TECH INDUSTRIES (Upto 48")
5 . P2159	FLASH FORGE(P) LTD. (Upto 42")
6 . P2269	N J ENGINEERS (½" to 42" Welded)
7 . P2162	NAV KAR FORGINGS & FITTINGS PVT. LTD. (Upto 24" (Sch XXS, Material: CS only))
8 . P2251	NEOSEAL ENGINEERING PRIVATE LIMITED (1. Fittings(Welded), CS, Up To 14", SCH -Up To 40, 2. Fittings(Welded), SS, Up To 14", SCH -Up To 10S)
9 . P2215	P K TUBES & FITTINGS PVT. LTD. (Upto 48" (SCH 160))
10 . P2187	PETROCHEM INDUSTRIES (6" to 36" (all Fittings) & 6" to 56" (Only Conc. / Ecc. Reducers) Sch : XXS/ 80S)
11 . P2210	RAJENDRA FORGE INDUSTRIES (CS & SS : Upto 12", Sch 40)
12 . P2280	SARDA PIPES & FITTINGS PVT. LTD. (1. Upto 14"/4"/4" for CS/AS/SS Welded Fittings)
13 . P2004	SAWAN ENGINEERS PVT. LIMITED (Upto 52" (SCH 160))
14 . P2165	TOPAZ PIPING INDUSTRIES (8" to 48" (Sch 10 to Sch 160))
15 . P2261	UNITED FORGE INDUSTRIES (Upto 36" SCH 40 for CS Welded Fittings)
<b>ITALY</b>	
16 . P2188	PETROL RACCORD S.P.A. (4" - 56" (Tees/ Reducers/ Elbows))

## 120120 : PIPE COATINGS

CODE	NAME
<b>INDIA</b>	
1 . P2174	PRATIBHA INDUSTRIES LTD., (External Coating: 4" to 24" Pipe OD)
2 . P2153	WELSPUN GUJARAT STAHL ROHREN LIMITED (DAHEJ) (4" to 64" for external coating & 16" to 64" for internal coating.)

**120121 : CPVC PIPE AND PIPE FITTINGS**

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CODE	NAME
<b>INDIA</b>	
1 . P2278	ASHIRVAD PIPES PRIVATE LIMITED (Up to 10" SCH 80)

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## 120201 : STRAINERS (PERMANENT INCLUDING Y-TYPE)

CODE	NAME
<b>INDIA</b>	
1 . P2262	ACME FLUID SYSTEMS (Upto 24")
2 . P2117	CHEMTECH INDUSTRIAL VALVES PVT. LTD
3 . P2072	FLAIR STRAINERS & FILTERS (Size upto 42" (Rating upto 1500#))
4 . P2248	FLOTEK INDUSTRIES (Strainer (Y Type) CS, Upto 8", ANSI Class -Upto 2500 #)
5 . P2277	FLOWJET VALVES PVT. LTD. (Strainer, CS/SS, Upto 12", Upto 150#)
6 . P0318	GRAND PRIX ENGINEERING PVT. LTD. (upto 60" pipeline, upto ANSI 1500#)
7 . P0322	GREAVES LIMITED
8 . P0324	GUJARAT OTOFILT
9 . P2218	HAWA ENGINEERS LTD. (½" to 24" (150# / 300# / PN10 / PN40))
10 . P2010	KWIKFLO FILTERS PVT. LTD.
11 . P0487	LEADER VALVES LIMITED (size <= 12" - upto 300#)
12 . P1012	MOD FABRICATORS
13 . P0549	MULTITEX FILTRATION ENGINEERS LTD
14 . P1204	SAP Industries Limited (Up to 6")
15 . P2135	ZOLOTO INDUSTRIES (15mm to 100mm)
<b>CHINA</b>	
16 . P2173	BOTELI VALVE GROUP CO. LTD. (Y - Type only: 14" (150#) & 3" (300# & 600#))

## 120202 : STEAM TRAPS

CODE	NAME
<b>INDIA</b>	
1 . P0320	GREAVES LTD.
2 . P1012	MOD FABRICATORS (for Drip rings)
3 . P0624	PENNANT ENGINEERING PVT. LTD.
4 . P0865	VIRGO ENGINEERS LTD. (½" to 4" (Upto 600#) (CS/SS))
5 . P2103	YARWAY CORPORATION
6 . P2135	ZOLOTO INDUSTRIES (15mm to 25mm)
<b>GERMANY</b>	
7 . P0307	GESTRA AG
<b>U.S.A.</b>	
8 . P0059	ARMSTRONG INTERNATIONAL INC.
9 . P2086	OGONTZ CORPORATION
10 . P0889	TYCO INTERNATIONAL INC.,U.S.A.

## 120203 : SPRING SUPPORTS

CODE	NAME
<b>INDIA</b>	
1 . P1185	PIPE SUPPORTS CO. (UPTO 14 MT)
<b>INDIA</b>	
2 . P2256	BERGEN PIPE SUPPORTS INDIA PRIVATE LIMITED (Variable & Constant)
3 . P2265	CARPENTER & PATERSON INDIA PVT. LTD. (VARIABLE, CONSTANT)
4 . P2106	MYRICS PIPING SYSTEM PVT.LTD.
5 . P0550	PIPE SUPPORTS INDIA PVT. LTD.
6 . P0632	PIPING & ENERGY PRODUCTS (P) LTD.
7 . P0699	SARATHI ENGG. ENTERPRISES PVT. LTD.
8 . P0747	SPRING SUPPORTS MFG. CO.
<b>ITALY</b>	
9 . P0271	FLEXIDER S.P.A.

## 120204 : FLAME ARRESTORS

CODE	NAME
<b>INDIA</b>	
1 . P0027	AIROIL FLAREGAS (INDIA) PVT.LIMITED,
2 . P0237	EMFA INDUSTRIES,
3 . P2082	M.H. VALVES PVT. LTD. (1/2"-1.5":800#, 2"-6":600#)
4 . P2211	NIRMAL INDUSTRIAL CONTROLS PVT. LTD. (½" to 8", Rating : 150#)
5 . P0627	PETROL SERVICE INDIA PVT LTD,
<b>U.S.A.</b>	
6 . P0480	L & J TECHNOLOGIES



120205: SPRAY NOZZLE ASSEMBLY

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CODE	NAME
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<i>INDIA</i>	
1 . P2229	CHEMTROLS SAMIL (INDIA) PVT. LTD.

## 120301 : GATE/GLOBE/CHECK VALVES CS/SS/AS < 900 Lbs

CODE	NAME
<b>INDIA</b>	
1 . P0003	A V VALVES LIMITED (Cast: Up to 42" (150#), 28" (300#), 24" (600#) & Forge:Upto 2" (800#))
2 . P2052	ADVANCE VALVES (2"- 80" (Upto 600#) (Dual Plate Check Valves only).)
3 . P0072	ASSOCIATED TOOLINGS (I) PVT. LTD. (½" to 2" (Rating upto : 800 #))
4 . P0077	AUDCO INDIA LIMITED(L&T VALVES DIVN.)
5 . P2136	AUTOCAP INDUSTRIES (1/2" to 2", 800 # (only CS & SS))
6 . P2060	BELL-O-SEAL VALVES PVT. LTD. (for zero leakage, hazardous fluids.)
7 . P0115	BHEL (VALVES DIVISION)
8 . P2146	BRIGHTCH VALVES AND CONTROLS PVT. LTD. (Upto 8" x 300# for CS, AS & SS Material)
9 . P2117	CHEMTECH INDUSTRIAL VALVES PVT. LTD
10 . P2229	CHEMTROLS SAMIL (INDIA) PVT. LTD. (Upto 12" - 150-# (Dual Plate Check Valves only))
11 . P2137	CRAWLEY & RAY (FOUNDERS & ENGINEERS) PVT. LTD ( ≤300 # (only CS))
12 . P0194	DATRE CORPORATION LTD. (Upto 300#, 2-8 "(Gate),2-6"(Globe&Check))
13 . P0202	DEWRANCE MACNEILL & CO. LTD.
14 . P0224	ECONO VALVES PVT.LTD.
15 . P2118	EXPERT ENGINEERING ENTERPRISES (Forged: upto 2"- 800#; Gate & Globe Valve: upto12"- 150# & 300#; Check Valve: upto 32"- 150# & 300#)
16 . P0273	FLOCON SYSTEMS PVT. LTD. (CS upto 6" 150#)
17 . P2248	FLOTEK INDUSTRIES (1. Gate [CAST] -CS, Upto 30", ANSI Class -Upto 300 # 2. Gate [CAST]-AS/SS, Upto 16", ANSI Class -Upto 600 # 3. Globe [CAST] -CS,Upto 14", ANSI Class-Upto 600 # 4.Check [SWING] -CS/AS, Upto 12", Upto 600# 5.Check [DUAL

## 120301 : GATE/GLOBE/CHECK VALVES CS/SS/AS < 900 Lbs

CODE	NAME
18 . P2172	FLOVEL VALVES PVT. LTD. (Single Disc, Dual Plate & Nozzle Check Valves only: Upto 48" (150#) & 24" (upto 600#))
19 . P2277	FLOWJET VALVES PVT. LTD. (Gate [CAST], CS, Up to 36"- 300#, Gate/Globe/Check [CAST], CS/SS/AS, Up to 18"- 600# & Check [SWING], CS, Up to 30"- 150#, Gate/Globe/Check Valve, CS/SS/AS, Up to 2"- 800#)
20 . P2219	FLUIDTECH EQUIPMENT PVT. LTD. (Cast# (CS and SS): 2" to 12" 150# & 2" to 8" 300# and Forged (CS and SS) ½" to 2" (800#))
21 . P2114	FORWARD ALLOYS & CASTINGS (upto 14")
22 . P2254	G M VALVE PVT. LTD. (Item - FORGED, Material- CS/SS/AS, Size-2", ANSI Class - Upto 800 #)
23 . P2145	GURU INDUSTRIAL VALVES PVT. LTD. (Cast CS only: Upto 24"(150#), 20"(300#), 10"(600# & Forged: Upto 2" (800#))
24 . P2218	HAWA ENGINEERS LTD. (Gate Valve:Upto 40" (150#),Upto 26"(300#),Upto 24"(600#),Upto 2" (800#); Globe Valve:Upto 20"(150#),Upto 16" (300#),Upto 12"(600#),Upto 2"(800#); Check Valve:Upto 36" (150#),Upto 24"(300#),Upto 16"(600#),Upto 2" (800#) (Dual Plate:36" (150#
25 . P2013	HAWA VALVES INDIA PVT. LTD. (CS upto 6",150#)
26 . P0897	HI-TECH VALVES PVT. LTD. (CS,<=800# size 1/2"-2", <=300# for size 2"-6)
27 . P0404	INTERVALVE POONAWALLA LIMITED (Cast upto 24" (Upto 300#) & Upto 12" (600#), Forged: Upto 2" (800#))
28 . P2161	JC VALVES & CONTROLS INDIA PVT. LTD. (Cast: Upto 48" (150#), 24" (upto 600#) & Forged: Upto 2" (800#))
29 . P0451	KIRLOSKAR BROTHERS LIMITED (CS upto 12" size, 300#)
30 . P0473	KSB PUMPS LIMITED (VALVES DIVN)
31 . P1101	LARSEN & TOUBRO LIMITED (1/2" to 24")
32 . P0487	LEADER VALVES LIMITED (Casting<=20"- upto 600# & 30"-150#, Forging<=2"- upto 800#)
33 . P2082	M.H. VALVES PVT. LTD. (1/2" to 1 1/2" - 800#, 2"to 6"- 600#)
34 . P2147	MICON ENGINEERS (HUBLI) PVT. LTD. (Cast : Upto 12" (150# & 300#), 6" (600#) & Forged: Upto 2" (800#))

## 120301 : GATE/GLOBE/CHECK VALVES CS/SS/AS < 900 Lbs

CODE	NAME
35 . P0094	MICROFINISH VALVES PVT. LTD.
36 . P2243	NEOSEAL ENGINEERING PRIVATE LIMITED (Upto 24" rating upto 600#)
37 . P0590	NITON VALVE INDUSTRIES PVT. LTD. (Forging upto 800#, <= 1.5" size)
38 . P2279	NOVEL VALVES INDIA PVT. LTD. (1. Gate/Globe - CS/AS/SS, Up to 30" 300 # 2. Gate/Globe/Check - CS/AS/SS, Up to 6" 600 # & 3. check [dual plate] - CS/AS/SS , Up to 12" 300 #)
39 . P2164	NSSL LIMITED (Cast: Upto 80"(150#), 56"(Upto 600#) & Forged: Upto 2" (800#))
40 . P1207	NUTECH CONTROLS (Gate/Check Valve (CS) Up to 12", ANSI Class up to 300#, Globe valve (CS) Up to 10", ANSI Class up to 300#, Gate/Globe/Check Valve (SS/AS) Up to 8", ANSI Class up to 300# & Gate/Globe/check valve (CS/SS/AS) Up to 2", ANSI Class up to 300#)
41 . P2041	OSWAL INDUSTRIES LTD. (Upto 48" (150#), 32" (300#) & 24" (600#))
42 . P2096	S & M INDUSTRIAL VALVES LIMITED (CS Gate & Globe valves 2"- 24" <=300#)
43 . P2249	SAKHI ENGINEERS PVT. LTD. (1. CS/AS/SS, upto 16" , ANSI Class upto 150# 2.CS/AS/SS, upto 12", ANSI Class upto 300)
44 . P1204	SAP Industries Limited (Up to 14")
45 . P2204	SHALIMAR VALVES PVT. LTD. (Cast: Upto 24"(Upto 600#), Forged: ½" to 1½" (800#))
46 . P0731	SHREERAJ INDUSTRIES (CS upto 150#)
47 . P2097	STEEL STRONG VALVES (I) PVT. LTD (Upto 42")
48 . P1206	VALVE TECH INDUSTRIES (<900 LBS (UPTO 24" 600# FOR CS, UPTO 12" 300# FOR SS/AS))
49 . P2014	VENUS PUMP & ENGINEERING WORKS
50 . P2144	VIBA FLUID CONTROL ((1) Gate/Globe/Check Valves (Cast), CS/AS/SS, Size- Up to 14", and Up to 12", 600# (2) Gate/Globe/Check Valves (Forged), CS/SS, Size- Up to 1.5", 800#)
51 . P0093	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Cast: Upto 36" (150#), 24" (300#), 12" (600#) & Forged: Upto 2"(800#))



## 120301 : GATE/GLOBE/CHECK VALVES CS/SS/AS < 900 Lbs

CODE	NAME
52 . P2149	ZED VALVES CO. PVT. LTD. (Upto 14" (600#))
53 . P2135	ZOLOTO INDUSTRIES (40mm to 200mm (Only CS & SS))
<b>CANADA</b>	
54 . P0857	VELAN INC. (Size upto 48" (Rating upto 600#))
<b>CHINA</b>	
55 . P2173	BOTELI VALVE GROUP CO. LTD. (Cast: Upto 56" (150#), 36" (300#), 24" (600#) & Forged: Upto 2" (800#))
56 . P2080	Zhejiang Jiehua Valve Co.,Ltd .
<b>GERMANY</b>	
57 . P2016	PEMTO VALVE
<b>INDIA</b>	
58 . P2263	INTEGRAL PROCESS CONTROLS INDIA PVT. LTD. (1.Gate(cast),CS, Upto24", Upto150#, 2.Gate(cast), CS, Upto16", Upto600#, 3.Globe(cast), CS, Upto10", Upto300#, 4.Gate/Globe/Check Valve(cast), CS/SS, Upto8", Upto300#, 5.Check (Swing), CS, Upto18",
<b>ITALY</b>	
59 . P0150	CESARE BONETTI SPA (Cast: Upto 42" (Upto 300#), 24" (600#) & Forged: Upto 1 ½" (800#))
60 . P0253	FASANI S.P.A.
61 . P2179	FRIULCO SPA (Upto 48" (150#), 32" (Upto 600#))
62 . P0476	GTC ITALIA, S.R.L.
63 . P2083	MANTOVANI SpA
64 . P0603	OMB S.P.A.
65 . P0628	PETROL VALVES S.R.L

## **JAPAN**

## 120301 : GATE/GLOBE/CHECK VALVES CS/SS/AS < 900 Lbs

CODE	NAME
66 . P0520	MATSURA H. P MACHINE WORKS CO.LTD.,
67 . P0587	NISHITANI & CO. LTD.
68 . P0575	SOJITZ CORPORATION
<b>NETHERLAND</b>	
69 . P2093	REDPOINT ALLOYS BV
<b>SPAIN</b>	
70 . P0083	BABCOCK BORSIG ESPANA, S.A.
71 . P2201	POYAM VALVES, (AMPO S. COOP.) (Size upto 60"(Rating upto 800#))
72 . P2015	WALTHAN & WEIR
<b>U.A.E.</b>	
73 . P0764	SUFA LIMITED
<b>U.K.</b>	
74 . P0097	BEL VALVES
<b>UAE</b>	
75 . P2273	NEWAY VALVE (SUZHOU) CO., LTD. (Cast: upto 88" (150#), Upto 48" (300#), Upto 40" (600#), Forge: Upto 2" (800#))

## 120302 : GATE/GLOBE/CHECK VALVES CS/SS/AS >=900 Lbs

CODE	NAME
<b>INDIA</b>	
1 . P0003	A V VALVES LIMITED (Cast: Upto 24" (900# & 1500#), 8" (2500#) & Forge: Upto 2" (Upto 2500#))
2 . P2052	ADVANCE VALVES (2"- 36" (900#), 2" - 24" (1500#), 2" -12" (2500#) Dual Plate Check Valves only.)
3 . P0072	ASSOCIATED TOOLINGS (I) PVT. LTD. (½" to 2" (Rating: 900# & 1500#))
4 . P0077	AUDCO INDIA LIMITED(L&T VALVES DIVN.)
5 . P0115	BHEL (VALVES DIVISION)
6 . P2248	FLOTEK INDUSTRIES (1. Gate [CAST]-CS/AS, Upto 6", ANSI Class -Upto 2500 # 2.Globe [CAST]-CS/AS, Upto 4", ANSI Class -Upto 1500 # 3.Check [Swing]-CS/AS, Upto 10", ANSI Class -Upto 2500 # 4.GATE/GLOBE/CHECK VALVES [Forged]-CS/AS/SS, Upto 0.75", ANSI
7 . P2172	FLOVEL VALVES PVT. LTD. (Dual Plate Check Valves only: Upto 24" (900#))
8 . P2277	FLOWJET VALVES PVT. LTD. (Gate [CAST], CS/SS/AS, Up to 8"- 1500#, Gate/Globe/Check Valve , CS/SS/AS, Up to 2"- 2500# [FORGED])
9 . P2254	G M VALVE PVT. LTD. (Item -FORGED- CS/SS/AS, Size- Upto 2", ANSI Class- Upto 2500 #)
10 . P2218	HAWA ENGINEERS LTD. (Gate Valves: Upto 20" (900#), Upto 10" (1500# & 2500#); Globe Valves: Upto 8" (900# & 1500#), Upto 1" (2500#); Check Valves: Upto 10" (900# ), Upto 6" (1500#), Upto 1" (2500#))
11 . P0404	INTERVALVE POONAWALLA LIMITED (Forged: Upto 2" (1500#))
12 . P2161	JC VALVES & CONTROLS INDIA PVT. LTD. (Cast: Upto 12" (upto 1500#), 10" (2500#) & Forged: Upto 2" (2500#))
13 . P0473	KSB PUMPS LIMITED (VALVES DIVN)
14 . P1101	LARSEN & TOUBRO LIMITED (1/2" to 2")
15 . P0487	LEADER VALVES LIMITED (Casting <= 12" - upto 2500#, Forging <= 2" - upto 2500#)
16 . P0533	METROPOLITAN INDUSTRIES (size=200mm, ratings=2500 lb)
17 . P2147	MICON ENGINEERS (HUBLI) PVT. LTD. (Forged: Upto 2" (1500#))

## 120302 : GATE/GLOBE/CHECK VALVES CS/SS/AS >=900 Lbs

CODE	NAME
18 . P2243	NEOSEAL ENGINEERING PRIVATE LIMITED (Upto 24", rating upto 2500#)
19 . P2279	NOVEL VALVES INDIA PVT. LTD. (1. Gate/Globe - CS , Up to10", 900 # 2. Gate/Globe - CS, Up to3", 1500 # & 3. Check [SWING]- CS, Upto 8", 900 #)
20 . P2164	NSSL LIMITED (Cast: Upto 36" (900#), 24"(upto 2500#) & Forged: Upto 2"(upto 2500#))
21 . P1207	NUTECH CONTROLS (Gate/Globe/Check valve (CS/AS) Up to 2", ANSI Class up to 2500#)
22 . P2041	OSWAL INDUSTRIES LTD. (Upto 12" (900# &1500#))
23 . P2249	SAKHI ENGINEERS PVT. LTD. (CS/AS/SS, upto 4" ANSI Class upto 1500#)
24 . P2204	SHALIMAR VALVES PVT. LTD. (Cast: Upto 20"(900#), Forged: ½" to 1 ½" (1500#))
25 . P1206	VALVE TECH INDUSTRIES (>=900 LBS (UPTO 8" 2500# FOR CS, UPTO 8" 1500# FOR SS/AS))
26 . P2285	VALVE TECH INDUSTRIES ((i) UP TO 24", 2500#, CS/AS/SS GATE/GLOBE (CAST) VALVE (ii) UP TO 28", 2500#, CS/AS/SS CHECK (CAST) VALVE (iii) UP TO 2", 2500#, SS GATE/GLOBE (FORGED) VALVE)
27 . P0093	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Cast: Upto 12" (Upto 2500#) & Forged: Upto 2"(1500#), 1"(2500#))
<b>CANADA</b>	
28 . P0857	VELAN INC. (Size upto 24" (Rating upto 2500#))
<b>CHINA</b>	
29 . P2173	BOTELI VALVE GROUP CO. LTD. (Cast: Upto 16" (upto 1500#) & 12" (2500#) & Forged: Upto 2" (1500# & 2500#))
30 . P2080	Zhejiang Jiehua Valve Co.,Ltd .
<b>INDIA</b>	
31 . P2263	INTEGRAL PROCESS CONTROLS INDIA PVT. LTD. (1. Gate(Cast), CS, Upto 16", Upto 900#, 2.Gate/Globe/Check Valve (Cast), CS/SS, Upto 4", Upto 1500#, 3.Gate/Globe/Check Valve (Cast), CS/SS, Upto 2", 800# to 2500#)
<b>ITALY</b>	
32 . P0103	BFE BONNEY FORGE VALVE LICENSEE

## 120302 : GATE/GLOBE/CHECK VALVES CS/SS/AS >=900 Lbs

CODE	NAME
33 . P0150	CESARE BONETTI SPA (Upto 24", (upto 2500#))
34 . P0253	FASANI S.P.A.
35 . P2179	FRIULCO SPA (Upto 32" (900#); 24" (1500#); 14" (2500#))
36 . P0476	GTC ITALIA, S.R.L.
37 . P0603	OMB S.P.A.
38 . P0628	PETROL VALVES S.R.L
39 . P2100	VALVITALIA SpA
<b>JAPAN</b>	
40 . P0520	MATSURA H. P MACHINE WORKS CO.LTD.,
41 . P0587	NISHITANI & CO. LTD.
<b>SPAIN</b>	
42 . P0083	BABCOCK BORSIG ESPANA, S.A.
43 . P2201	POYAM VALVES, (AMPO S. COOP.) (Size upto 30" (Rating upto 2500#))
<b>U.A.E.</b>	
44 . P0764	SUFA LIMITED
<b>U.K.</b>	
45 . P0097	BEL VALVES
<b>UAE</b>	
46 . P2273	NEWAY VALVE (SUZHOU) CO., LTD. (Cast: upto 24" (900# & 1500#), Upto 16" (2500#) & Forged Upto 2" (2500#))

## 120303 : BALL VALVES (SOFT SEATED)

CODE	NAME
<b>INDIA</b>	
1 . P0003	A V VALVES LIMITED (Up to 12" (Upto 600#))
2 . P2176	AIRA EURO AUTOMATION PVT. LTD. (Upto 6", Rating: 150# & 300#)
3 . P2056	AQUA VALVES PVT.LTD
4 . P2146	BRIGHTCH VALVES AND CONTROLS PVT. LTD. (4" x 150# for CS, AS & SS Material)
5 . P2117	CHEMTECH INDUSTRIAL VALVES PVT. LTD
6 . P2137	CRAWLEY & RAY (FOUNDERS & ENGINEERS) PVT. LTD (DN 25)
7 . P2163	DELVAL FLOW CONTROLS PRIVATE LIMITED (Upto12" ( Upto 900#))
8 . P0273	FLOCON SYSTEMS PVT. LTD. (CS upto 6" 150#)
9 . P2017	FLOW CONTROL
10 . P2073	FLOWCHEM INDUSTRIES ( upto 300# and upto 10")
11 . P2277	FLOWJET VALVES PVT. LTD. (Ball Valve(Cast), CS/SS, Up To 18"-150# & Ball Valve(Forged), CS, Up To 2" -800#)
12 . P2219	FLUIDTECH EQUIPMENT PVT. LTD. (Up to 4" (300#))
13 . P2114	FORWARD ALLOYS & CASTINGS (upto 900#)
14 . P2254	G M VALVE PVT. LTD. (1. Item- FORGED-CS, Size- Upto 2", ANSI Class- Upto 800 #, 2. Item - FORGED-- AS/SS, Size- Upto 1.25", ANSI Class- Upto 800 #)
15 . P2145	GURU INDUSTRIAL VALVES PVT. LTD. (Cast CS only: Upto 12"(Upto300#), 4" (Upto 900#) & Forged: Upto 2" (800#))
16 . P2218	HAWA ENGINEERS LTD. (Upto 16" (150# & 300#), Upto12" (600# & 900#))
17 . P0404	INTERVALVE POONAWALLA LIMITED (Forged: Upto 2" 800#, Cast: Upto 12" (Upto 300#))

## 120303 : BALL VALVES (SOFT SEATED)

CODE	NAME
18 . P2161	JC VALVES & CONTROLS INDIA PVT. LTD. (Upto 28" (upto 600#), 12" (900#, 1500#), 10" (2500#))
19 . P0473	KSB PUMPS LIMITED (VALVES DIVN) (CS upto 100DN,20 bar)
20 . P0487	LEADER VALVES LIMITED (Casting <= 6" - upto 600#, Forging <= 2" - upto 800#)
21 . P2228	MEVADA ENGINEERING WORKS PVT. LTD., MUMBAI (Upto 2" (800#), (Forged), Material: CS/AS/SS; Upto 14" (300#), Material: CS/AS/SS)
22 . P2147	MICON ENGINEERS (HUBLI) PVT. LTD. (Cast : Upto 6" (150# & 300#) & Forged: Upto 2" (800#))
23 . P0094	MICROFINISH VALVES PVT. LTD.
24 . P2243	NEOSEAL ENGINEERING PRIVATE LIMITED (Upto 12", rating upto 600# and Upto 8", rating upto 2500#)
25 . P2279	NOVEL VALVES INDIA PVT. LTD. (1. Ball Valve -CS, Up To 14"-900# 2. Ball Valve -CS, Up To 10"-900# & 3. Ball Valve (Forged) -SS Up To 2" -2500#)
26 . P2164	NSSL LIMITED (Upto 12" (150# & 300#))
27 . P1207	NUTECH CONTROLS (Ball valve(CS) Up to 10", ANSI Class up to 150#, Up to 2", ANSI Class up to 900#)
28 . P2041	OSWAL INDUSTRIES LTD. (Upto 24" (150#, 300# & 600#))
29 . P2249	SAKHI ENGINEERS PVT. LTD. (1. [Soft Seated] CS, upto 10", ANSI Class upto 300# 2.[Soft Seated] SS, upto 3" ,ANSI Class upto 150#)
30 . P1204	SAP Industries Limited (Up to 16", rating 600#)
31 . P2204	SHALIMAR VALVES PVT. LTD. (Upto 18" (600#) Material: CS/AS/SS)
32 . P1206	VALVE TECH INDUSTRIES (UPTO 24" 600#)
33 . P2144	VIBA FLUID CONTROL ((1) Ball Valves CS/SS, Size- Up to 18", 150# (2) Ball Valves CS, Size- Up to 6", 300#)
34 . P0865	VIRGO ENGINEERS LTD. (Upto16" (Upto 600#))

## 120303 : BALL VALVES (SOFT SEATED)

CODE	NAME
35 . P0093	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Cast: Upto 30" (150# & 300#); 20" NB (600#), 16" (900#), 12" (1500#) & Forged: Upto 2"(800#))
36 . P0264	XOMOX SANMAR LIMITED (FISHER XOMOX)

### **AUSTRIA**

37 . P0120 BHDT GMBH

### **CANADA**

38 . P0857 VELAN INC. (Size upto 16" (Rating upto 600#))

### **CHINA**

39 . P2173 BOTELI VALVE GROUP CO. LTD. (Upto 32" (150# & 300#), 30" (600#), 24" (900#))

40 . P2080 Zhejiang Jiehua Valve Co.,Ltd .

### **FRANCE**

41 . P0834 ETS TROUVAY & CAUVIN

### **GERMANY**

42 . P2186 PERRIN GmbH (Size upto 24" (Rating upto 2500#))

### **ITALY**

43 . P0150 CESARE BONETTI SPA (Cast: Upto 4" (150#) & Forged: Upto 1" (800#) Floating only)

44 . P2179 FRIULCO SPA (Upto 48" (150# & 300 #); 20" (Upto 1500#); 12" (2500#))

45 . P0476 GTC ITALIA, S.R.L.

46 . P2083 MANTOVANI SpA

47 . P0628 PETROL VALVES S.R.L

48 . P0631 PIBIVIESSE SRL (Upto 48", 600#)

### **SINGAPORE**



## 120303 : BALL VALVES (SOFT SEATED)

CODE	NAME
49 . P0568	METSO AUTOMATION

**SPAIN**

50 . P2201 POYAM VALVES, (AMPO S. COOP.) (Size upto 42" (Rating Upto 2500#))

**TAIWAN**

51 . P2007 HAITIMA CORPORATION

**UAE**

52 . P2273 NEWAY VALVE (SUZHOU) CO., LTD. (Upto 2" (1500#), Upto 12" (900#), Upto 48" (600#))

## 120304 : BALL VALVES (METAL SEATED)

CODE	NAME
<b>INDIA</b>	
1 . P2176	AIRA EURO AUTOMATION PVT. LTD. (Upto 6", Rating: 150# & 300#)
2 . P2146	BRIGHTCH VALVES AND CONTROLS PVT. LTD. (4" x 150# for CS, AS & SS Material)
3 . P2163	DELVAL FLOW CONTROLS PRIVATE LIMITED (Upto12" (Upto 900#))
4 . P2277	FLOWJET VALVES PVT. LTD. (Ball Valve(Cast), CS/SS, Up To 8" -300#)
5 . P2145	GURU INDUSTRIAL VALVES PVT. LTD. (Cast CS only: Upto 12"(Upto300#), 4" (Upto 900#) & Forged: Upto 2" (800#))
6 . P2218	HAWA ENGINEERS LTD. (Upto 16" (150# & 300#), Upto12" (600# & 900#))
7 . P0404	INTERVALVE POONAWALLA LIMITED (Upto 12" (150#))
8 . P2161	JC VALVES & CONTROLS INDIA PVT. LTD. (Upto 28" (upto 600#), 12" (upto 1500#), 10" (2500#))
9 . P2147	MICON ENGINEERS (HUBLI) PVT. LTD. (Cast : Upto 6" (150# & 300#) & Forged: Upto 2" (800#))
10 . P0094	MICROFINISH VALVES PVT. LTD.
11 . P2243	NEOSEAL ENGINEERING PRIVATE LIMITED (Upto 12", rating upto 600#)
12 . P2279	NOVEL VALVES INDIA PVT. LTD. (Ball Valve - 1. CS , Up To 10", 900# 2. CS, Up to 6", 1500#)
13 . P2164	NSSL LIMITED (Upto 12" (150# & 300#))
14 . P2041	OSWAL INDUSTRIES LTD. (Upto 24" (150#, 300#, & 600#))
15 . P1206	VALVE TECH INDUSTRIES (UPTO 16" 300#)
16 . P2285	VALVE TECH INDUSTRIES (UP TO 24", 300# CS BALL VALVE)
17 . P0865	VIRGO ENGINEERS LTD. (Upto16" (Upto 600#))

## 120304 : BALL VALVES (METAL SEATED)

CODE	NAME
18 . P0093	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Cast: Upto 30" (150# & 300#); 20" NB (600#), 16" (900#), 12" (1500#) & Forged: Upto 2"(800#))
<b>CANADA</b>	
19 . P0857	VELAN INC. (Size upto 16" (Rating upto 600#))
<b>CHINA</b>	
20 . P2173	BOTELI VALVE GROUP CO. LTD. (Upto 32" (150# & 300#), 30" (600#), 24" (900#))
<b>GERMANY</b>	
21 . P2186	PERRIN GmbH (Size upto 24" (Rating upto 2500#))
<b>ITALY</b>	
22 . P2054	ALFA VALVOLE Srl
23 . P0150	CESARE BONETTI SPA (Upto 24" (150#) & 4" (Upto 1500#) Trunnion Mounted only)
24 . P2179	FRIULCO SPA (Upto 48" (150# & 300#); 20" (Upto 1500#); 12" (2500#))
25 . P0594	GE POWER (NUOVO PIGNONE SPA)
26 . P0476	GTC ITALIA, S.R.L.
27 . P0628	PETROL VALVES S.R.L
28 . P0631	PIBIVIESSE SRL (Upto 48", 600#)
29 . P2100	VALVITALIA SpA
<b>NETHERLAND</b>	
30 . P2093	REDPOINT ALLOYS BV
<b>SINGAPORE</b>	
31 . P0568	METSO AUTOMATION

## 120304 : BALL VALVES (METAL SEATED)

CODE	NAME
32 . P0606	ORBIT VALVES PLC

**SPAIN**

33 . P2201 POYAM VALVES, (AMPO S. COOP.) (Size upto 42" (Rating Upto 2500#))

**UAE**

34 . P2273 NEWAY VALVE (SUZHOU) CO., LTD. (Upto 2" (1500#), Upto 12" (900#), Upto 48" (600#))

## 120305 : BUTTERFLY VALVES

CODE	NAME
<b>INDIA</b>	
1 . P0003	A V VALVES LIMITED (Upto 48" (150#))
2 . P2052	ADVANCE VALVES (2" - 120" (Upto 150#), 2" - 80" (Upto 900#))
3 . P2176	AIRA EURO AUTOMATION PVT. LTD. (Upto 48", Rating: Upto 300#)
4 . P0077	AUDCO INDIA LIMITED(L&T VALVES DIVN.)
5 . P2018	BDK PROCESS CONTROLS PVT. LTD. (upto 1600mm)
6 . P2117	CHEMTECH INDUSTRIAL VALVES PVT. LTD
7 . P2137	CRAWLEY & RAY (FOUNDERS & ENGINEERS) PVT. LTD (40mm - 1000mm)
8 . P2163	DELVAL FLOW CONTROLS PRIVATE LIMITED (Upto 24" (Upto 300#))
9 . P0273	FLOCON SYSTEMS PVT. LTD. (CS upto 12" 150#)
10 . P2248	FLOTEK INDUSTRIES (1. Triple Offset, Material - CS/AS, Upto 18", ANSI Class -Upto 300 # 2. Double Offset & Concentric-CS, Upto 36", ANSI Class -Upto 150 #)
11 . P2277	FLOWJET VALVES PVT. LTD. (Butterfly Valves, CS, Up to 42"-150#)
12 . P2219	FLUIDTECH EQUIPMENT PVT. LTD. (Up to 12" (300#))
13 . P0281	FOURESS ENGINEERING (I) LTD.
14 . P2218	HAWA ENGINEERS LTD. (2" to 48" (PN10/PN16/150#/300#))
15 . P2013	HAWA VALVES INDIA PVT. LTD. (CS upto 6", 150#)
16 . P2134	HI-TECH BUTTERFLY VALVES INDIA PVT. LTD. (<300#,<30"(Teflon/Rubber) ,<72"(Metal ))
17 . P0400	INSTRUMENTATION LTD. (PALAKKAD)

## 120305 : BUTTERFLY VALVES

CODE	NAME
18 . P0404	INTERVALVE POONAWALLA LIMITED (Upto 72" (150#) & Upto 16" (300#))
19 . P2161	JC VALVES & CONTROLS INDIA PVT. LTD. (Upto 20" (150#) & 10" (300#))
20 . P1101	LARSEN & TOUBRO LIMITED (1/2" to 24")
21 . P0487	LEADER VALVES LIMITED (size <=16" - 150#)
22 . P0519	MATHER & PLATT (INDIA) LTD. (A Subsidiary of WILO SE German (upto DN 1600,PN10 Double flange type)
23 . P0533	METROPOLITAN INDUSTRIES (size=2000mm)
24 . P2147	MICON ENGINEERS (HUBLI) PVT. LTD. (Upto 24" (PN10 & PN16))
25 . P2279	NOVEL VALVES INDIA PVT. LTD. (1. CS, Up to 48"150# & 2. AS, Up to 8" 150#)
26 . P2284	OMVAL CONTROLS PRIVATE LIMITED (CS, UP TO 24" UP TO 150#)
27 . P2249	SAKHI ENGINEERS PVT. LTD. (1. upto 6", ANSI Class upto 150#)
28 . P1204	SAP Industries Limited (Up to 32", rating PN10, Up to 18", rating 150#)
29 . P1206	VALVE TECH INDUSTRIES (UPTO 48" 300# & UPTO 24" 600#)
30 . P2014	VENUS PUMP & ENGINEERING WORKS (upto 600NB,150#)
31 . P0865	VIRGO ENGINEERS LTD. ((Triple Offset only): 3" to 24", Upto 600# (CS/SS))
32 . P0093	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Upto 56" (Upto 250#); 24" (300#))
33 . P0264	XOMOX SANMAR LIMITED (FISHER XOMOX)

### **JAPAN**

34 . P2200	TOMOE VALVE CO. LTD. (Upto 48" (150# & 300#), Upto 24" (600#, 900# & 1500#))
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## 120305 : BUTTERFLY VALVES

CODE	NAME
<b>AUSTRIA</b>	
35 . P0120	BHDT GMBH
<b>CANADA</b>	
36 . P0857	VELAN INC. (Size upto 48" (Rating upto 600#))
<b>CHINA</b>	
37 . P2173	BOTELI VALVE GROUP CO. LTD. (36" (150# & 300#))
38 . P2080	Zhejiang Jiehua Valve Co.,Ltd .
<b>FRANCE</b>	
39 . P2076	GRISS SAPAG INDUSTRAIL VALVES
<b>GERMANY</b>	
40 . P2051	ADAMS ARMATUREN
<b>ITALY</b>	
41 . P0476	GTC ITALIA, S.R.L.
<b>TAIWAN</b>	
42 . P2007	HAITIMA CORPORATION
<b>U.K.</b>	
43 . P0489	LEEDS VALVE LTD
<b>U.K</b>	
44 . P2101	WEIR VALVES & CONTROLS DIVISION.
<b>U.S.A.</b>	
45 . P2068	CURTIS WRIGHT FLOW CONTROL CORPOARATION
46 . P0679	EMERSON PROCESS MGT

## 120305 : BUTTERFLY VALVES

CODE	NAME
47 . P0488	LEAR SIEGLER MEAS. CTRLS. CORP.
48 . P0174	SPX VALVES & CONTROLS (COPES-VULCAN LTD)
49 . P0889	TYCO INTERNATIONAL INC.,U.S.A.
50 . P2102	XOMOS(CRANE CO)
<b>UAE</b>	
51 . P2273	NEWAY VALVE (SUZHOU) CO., LTD. (Upto 56" (600#))



## 120306 : BLOWDOWN VALVES

CODE	NAME
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**CANADA**

- 1 . P0857 VELAN INC. (Size upto 2" (Rating upto 1500#))

**GERMANY**

- 2 . P0307 GESTRA AG

**ITALY**

- 3 . P0150 CESARE BONETTI SPA (Upto 3" (upto 2500#))

**U.S.A.**

- 4 . P0889 TYCO INTERNATIONAL INC.,U.S.A.

## 120307 : SAMPLING VALVES/ NEEDLE VALVES

CODE	NAME
<b>INDIA</b>	
1 . P0072	ASSOCIATED TOOLINGS (I) PVT. LTD. (½" to 1-1/2" (Rating: 800#))
2 . P2117	CHEMTECH INDUSTRIAL VALVES PVT. LTD
3 . P0248	EXCELSIOR ENGG WORKS
4 . P2118	EXPERT ENGINEERING ENTERPRISES (Upto 12" - 150# & 300#)
5 . P2248	FLOTEK INDUSTRIES (Needle Valve- SS, Upto 0.5-0.75", ANSI Class -Upto 800-2500 #)
6 . P0487	LEADER VALVES LIMITED (size <= 1 1/2" - 800#)
7 . P0792	TECNOMATIC (INDIA) PVT. LTD.
8 . P0093	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Upto 50 mm size (Upto 2500#))
<b>UAE</b>	
9 . P2273	NEWAY VALVE (SUZHOU) CO., LTD. (Upto 1" (2500#))

## 120308 : PLUG VALVES (NON LUBRICATED)

CODE	NAME
<b>INDIA</b>	
1 . P0003	A V VALVES LIMITED (Upto 20" (150#) (CS & SS))
2 . P0077	AUDCO INDIA LIMITED(L&T VALVES DIVN.)
3 . P2177	AZ ARMATUREN GMBH (½" NB to 20" NB, 150#, 300#, 600# (Matl. CS, SS & AS))
4 . P2018	BDK PROCESS CONTROLS PVT. LTD.
5 . P2117	CHEMTECH INDUSTRIAL VALVES PVT. LTD
6 . P2229	CHEMTROLS SAMIL (INDIA) PVT. LTD. (Upto 12" - 150# & 300#)
7 . P2137	CRAWLEY & RAY (FOUNDERS & ENGINEERS) PVT. LTD (DN 200)
8 . P2219	FLUIDTECH EQUIPMENT PVT. LTD. (Up to 4" (300#))
9 . P2145	GURU INDUSTRIAL VALVES PVT. LTD. (Cast CS only: Upto 12"(Upto300#), 4" (Upto 900#) & Forged: Upto 2" (800#))
10 . P2218	HAWA ENGINEERS LTD. (½" to 8" (150#))
11 . P2161	JC VALVES & CONTROLS INDIA PVT. LTD. (Upto 12" (upto 300#))
12 . P1101	LARSEN & TOUBRO LIMITED ( 1/2" to 24")
13 . P0487	LEADER VALVES LIMITED (size <= 6" - upto 300#)
14 . P1204	SAP Industries Limited (Up to 12", rating 150#)
15 . P0093	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Upto 16"(150#), 12" (300#), 3" (600#))
16 . P0264	XOMOX SANMAR LIMITED (FISHER XOMOX)

### CHINA

**120308 : PLUG VALVES (NON LUBRICATED)**

CODE	NAME
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17 . P2080      Zhejiang Jiehua Valve Co.,Ltd .

***ITALY***

18 . P0612      O.M.S. SALERI DI SALERI P & FIGLI S.M.C.

***SPAIN***

19 . P2201      POYAM VALVES, (AMPO S. COOP.) (Upto 30" (Upto 900#) for Lift Plug valves only.)

## 120309 : PLUG VALVES (LUBRICATED)

CODE	NAME
<b>INDIA</b>	
1 . P0003	A V VALVES LIMITED (Upto 20" (150#) (CS & SS))
2 . P0077	AUDCO INDIA LIMITED(L&T VALVES DIVN.)
3 . P2018	BDK PROCESS CONTROLS PVT. LTD.
4 . P2139	ECONO VALVES PVT. LTD. (<=8"(150-300#), <=1-1/2" (<=800#))
5 . P2219	FLUIDTECH EQUIPMENT PVT. LTD. (Up to 4" (300#))
6 . P2145	GURU INDUSTRIAL VALVES PVT. LTD. (Cast CS only: Upto 12"(Upto300#), 4" (Upto 900#) & Forged: Upto 2" (800#))
7 . P2218	HAWA ENGINEERS LTD. (½" to 8" (150#))
8 . P2161	JC VALVES & CONTROLS INDIA PVT. LTD. (Upto 12" (upto 300#))
9 . P0093	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Upto 8" (125#))
<b>CHINA</b>	
10 . P2080	Zhejiang Jiehua Valve Co.,Ltd .
<b>ITALY</b>	
11 . P2108	DELTA VALVES EUROPE
12 . P0612	O.M.S. SALERI DI SALERI P & FIGLI S.M.C.
<b>SPAIN</b>	
13 . P0083	BABCOCK BORSIG ESPANA, S.A.

## 120311 : DIAPHRAGM VALVES / RUBBER LINED CHECK VALVES

CODE	NAME
<b>INDIA</b>	
1 . P0003	A V VALVES LIMITED (Upto 12" (125#))
2 . P0029	AKAY INDUSTRIES PVT LTD
3 . P2018	BDK PROCESS CONTROLS PVT. LTD. (upto 150#, 6 mm to 350mm)
4 . P2117	CHEMTECH INDUSTRIAL VALVES PVT. LTD
5 . P2137	CRAWLEY & RAY (FOUNDERS & ENGINEERS) PVT. LTD (25 NB to 200 NB)
6 . P2218	HAWA ENGINEERS LTD. (½" to 8" (PN10))
7 . P0093	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Upto 14" (PN16))

## 120312 : CAST IRON VALVES

CODE	NAME
<b>INDIA</b>	
1 . P0003	A V VALVES LIMITED (Upto 48" (125#))
2 . P0182	CRAWLEY & RAY (F&E) PVT. LTD. (Buttterfly)
3 . P2219	FLUIDTECH EQUIPMENT PVT. LTD. (Up to 24" (PN 1.0 & PN 1.6))
4 . P2074	GEETA ENGINEERING WORKS
5 . P0451	KIRLOSKAR BROTHERS LIMITED (sluice,gate,butterfly valves PN1 & PN1.6)
6 . P0487	LEADER VALVES LIMITED (size <= 24" upto PN16 rating)
7 . P2096	S & M INDUSTRIAL VALVES LIMITED (ONLY GATE & GLOBE VALVES,50mm -600mm,125#)
8 . P1204	SAP Industries Limited (Up to 12", rating 150#)
9 . P2014	VENUS PUMP & ENGINEERING WORKS (sluice<900mm,Diphragm,<300mm,stop<500mm)
10 . P0093	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Upto 12" (PN6))

## 120313 : PVC/CPVC VALVES

CODE	NAME
<b>INDIA</b>	
1 . P2058	ASTRAL POLYTECHNIK PVT. LTD. (SIZE 1/2"-6",BUTTERFLY VALVE UPTO 24")
2 . P2096	S & M INDUSTRIAL VALVES LIMITED (32mm - 80mm Size)



## 120401 : ASBESTOS/RUBBER GASKETS

CODE	NAME
<b>INDIA</b>	
1 . P0256	FERROLITE JOINTINGS (P) LTD. (Asbestos,CAF only)
2 . P0294	GASKETS (INDIA) PVT. LTD. (Asbestos,CAF only)
3 . P2112	GOODRICH GASKET PVT. LTD. (upto 24")
4 . P0350	HINDUSTAN ASBESTOS & ALLIED PRODUCTS
5 . P0354	HINDUSTAN COMPOSITES LIMITED
6 . P2079	HINDUSTAN FERREDO LTD.
7 . P0373	IGP ENGINEERS LIMITED
8 . P0501	MADRAS INDUSTRIAL PRODUCTS (upto 48")
9 . P0525	MECHANICAL PACKING INDUSTRIES LTD.,
10 . P2243	NEOSEAL ENGINEERING PRIVATE LIMITED (Upto 80", rating 150# (Only Rubber Gaskets))
11 . P0614	PACKINGS & JOINTINGS (P) LTD.
12 . P2088	PERFECT MARKETING (P) LTD,
13 . P2090	PRASHANT ENGG STORES
14 . P0663	REINZ TALBROS PRIVATE LIMITED
15 . P0745	SPIRASEAL GASKETS PVT. LTD. (CAF & Teflon)
16 . P2115	STARFLEX SEALING INDIA PVT. LTD.
17 . P2123	THE BENGAL MILL STORES SUPPLY CO.(TRADER)

**120401: ASBESTOS/RUBBER GASKETS**

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CODE	NAME
18. P2184	UNIQUE INDUSTRIAL PACKINGS PVT. LTD.

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## 120402 : SPIRALLY WOUND GASKETS

CODE	NAME
<b>INDIA</b>	
1 . P0294	GASKETS (INDIA) PVT. LTD.
2 . P2112	GOODRICH GASKET PVT. LTD. (up to 24")
3 . P0373	IGP ENGINEERS LIMITED (10 to 3550mm size, 150#-2500# for exch gskt)
4 . P0501	MADRAS INDUSTRIAL PRODUCTS (upto 52")
5 . P2243	NEOSEAL ENGINEERING PRIVATE LIMITED (Upto 84", rating upto 150# and upto 30" rating upto 600#)
6 . P0614	PACKINGS & JOINTINGS (P) LTD.
7 . P2088	PERFECT MARKETING (P) LTD,
8 . P2090	PRASHANT ENGG STORES
9 . P0745	SPIRASEAL GASKETS PVT. LTD. (SS upto 12" & 150#)
10 . P2115	STARFLEX SEALING INDIA PVT. LTD.
11 . P2123	THE BENGAL MILL STORES SUPPLY CO.(TRADER)
12 . P2184	UNIQUE INDUSTRIAL PACKINGS PVT. LTD. (Upto 42"(600#) & Upto 24" (2500#))
<b>CHINA</b>	
13 . P2080	Zhejiang Jiehua Valve Co.,Ltd .

## 120403 : LENS GASKETS & RING JOINT (METALLIC)

CODE	NAME
<b>INDIA</b>	
1 . P0294	GASKETS (INDIA) PVT. LTD.
2 . P2112	GOODRICH GASKET PVT. LTD. (0.5" to 24")
3 . P0373	IGP ENGINEERS LIMITED (150# - 2500#)
4 . P0501	MADRAS INDUSTRIAL PRODUCTS
5 . P0533	METROPOLITAN INDUSTRIES (3mm thickness , ratings=300 lb)
6 . P2243	NEOSEAL ENGINEERING PRIVATE LIMITED (Upto 30", rating upto 900# and Upto 20" rating upto 2500#)
7 . P0614	PACKINGS & JOINTINGS (P) LTD.
8 . P2090	PRASHANT ENGG STORES
9 . P0745	SPIRASEAL GASKETS PVT. LTD.
10 . P2115	STARFLEX SEALING INDIA PVT. LTD.
11 . P2184	UNIQUE INDUSTRIAL PACKINGS PVT. LTD. (Ring Joint Gaskets only, Upto 16" (1500#))
<b>AUSTRIA</b>	
12 . P0120	BHDT GMBH
<b>ITALY</b>	
13 . P2083	MANTOVANI SpA

## 120405 : EXPANSION JOINTS & BELLOWS

CODE	NAME
<b>INDIA</b>	
1 . P0177	CORI ENGINEERS PVT. LTD. (For Rubbbber)
2 . P0217	D.WREN & CO. (For Rubber & Fabric)
3 . P0269	FLEXATHERM EXPANLLOW PVT. LTD. (Circular: Upto 240", Rectangular: No bar for size, (Up to 600#))
4 . P0270	FLEXICAN BELLOWS & HOSES PVT. LTD.
5 . P0274	FLUIDYNE ENGINEERS (I) PVT. LTD. (Metallic Bellows upto 800 mm dia)
6 . P0443	KELD ELLENTOFT INDIA PVT. LTD. (For Fabric)
7 . P0498	LONESTAR INDUSTRIES
8 . P0530	MB METALLIC BELLOWS PVT. LTD.
9 . P2090	PRASHANT ENGG STORES
10 . P2259	RATNAFLEX ENGINEERING PRIVATE LIMITED (EXPANSION JOINTS / BELLOWS METALLIC - PIPING)
11 . P0752	STANDARD PRECISION BELLOWS
<b>GERMANY</b>	
12 . P2019	TUBOFLEX
<b>ITALY</b>	
13 . P0271	FLEXIDER S.P.A.

## 120406 : FASTENERS

CODE	NAME
<b>INDIA</b>	
1 . P0017	AEP COMPANY
2 . P0146	CAPITAL INDUSTRIES
3 . P2020	CONSOL ENGG. & FASTNERS INDUSTRIES
4 . P0221	EBY FASTNERS
5 . P0265	FIT TIGHT NUTS & BOLTS LTD.
6 . P0266	FIX FIT FASTENERS MFG. PVT. LTD.
7 . P2245	HEM INDUSTRIES (Upto 4")
8 . P2180	INDUSTRIAL ENGINEERING CORPORATION (Size upto 4" (M100))
9 . P2212	MEGA ENGINEERING PRIVATE LIMITED (½" to 3" Material: CS/AS/SS)
10 . P0532	METRO MECHANICAL PVT.LTD.
11 . P0559	NAGBHUSHANAM INDUSTRIES
12 . P0586	NIREKA ENGG. CO. PVT. LTD.
13 . P2021	PACIFIC FORGING & FASTENERS PVT. LTD. (M 10 to M125)
14 . P2088	PERFECT MARKETING (P) LTD,
15 . P2022	PIONEER NUTS & BOLTS PVT. LTD. (Up to 3.5")
16 . P0641	PRECISION AUTO ENGINEERS
17 . P0642	PRECISION ENGINEERING INDUSTRIES

## 120406 : FASTENERS

CODE	NAME
18 . P2257	PROCYON TECHNOLOGY (Upto 3.5")
19 . P0650	PTD FASTNERS PVT. LTD.
20 . P2110	SANGHVI METALS (TRADER)
21 . P0772	SUNDARAM FASTENERS LIMITED
22 . P2099	UDHERA FASTENERS

## 120501 : FIRE FIGHTING SYSTEM

CODE	NAME
<b>INDIA</b>	
1 . P2034	AGNICE FIRE PROTECTION LTD.
2 . P2062	BHARTIYA CACCIALANZA FIRE SYSTEMS LTD
3 . P0119	BLUE STAR LTD.
4 . P2027	DE'S TECHNICO
5 . P2220	DE'S TECHNICO PVT. LTD.
6 . P2033	FUTECH CONSULTANTS PVT. LTD.
7 . P2024	GENERAL MECHANICAL WORKS
8 . P2036	HD FIRE PROTECTION COMPANY
9 . P2271	INTEGRATED FIRE PROTECTION PVT. LTD.
10 . P2122	LAL ENTERPRISES
11 . P0519	MATHER & PLATT (INDIA) LTD. (A Subsidiary of WILO SE German
12 . P2197	MX SYSTEMS INTERNATIONAL PVT. LTD.
13 . P2026	NEWFIRE ENGINEERS SERVICES
14 . P2031	PRAGATI ENGG. (PVT.) LTD.
15 . P2091	PYROTEK INDUSTRIES (INDIA ) PVT. LTD.
16 . P2032	RADIANT FIRE PROTECTION ENGINEERS
17 . P2035	STEELAGE INDUSTRIES LTD.



## 120501 : FIRE FIGHTING SYSTEM

CODE	NAME
18 . P2030	TECHNOFAB ENGG.
19 . P2140	TRI-PARULEX FIRE PROTECTION SYSTEMS
20 . P2029	UNITECH MACHINES LTD.
21 . P2028	VIJAY FIRE PROTECTION SYSTEM LTD.

## 120503 : HOSE PIPES(METALLIC) & CAM LOCK COUPLING

CODE	NAME
<b>INDIA</b>	
1 . P2143	AEROFLEX INDUSTRIES LIMITED (Size 6mm to 250mm dia (SS Corrug. Flex.. Hose with Braid, Braid & Assembly)
2 . P2065	CHHATARIA RUBBER CHEMICALS INDUSTRIES
3 . P0217	D.WREN & CO.
4 . P0269	FLEXATHERM EXPANLLOW PVT. LTD. (1/2" to 6")
5 . P2023	GAYATRI INDUSTRIES
6 . P2192	GAYTRI INDUSTRIAL CORPORATION (Upto 6" ID)
7 . P2078	HELIFEX HYDRAULICS & ENGG CO. LTD.
8 . P0715	SENIOR INDIA PVT. LTD.

**120504 : HOSE PIPE (NON-METALLIC) & CAM LOCK COUPLING**

<b>CODE</b>	<b>NAME</b>
<b>INDIA</b>	
1 . P2065	CHHATARIA RUBBER CHEMICALS INDUSTRIES
2 . P0217	D.WREN & CO.
3 . P2023	GAYATRI INDUSTRIES
4 . P2192	GAYTRI INDUSTRIAL CORPORATION (Upto 8" ID)
5 . P2078	HELIFEX HYDRAULICS & ENGG CO. LTD.
6 . P2087	PADMINI INDUSTRIES LIMITED
7 . P2091	PYROTEK INDUSTRIES (INDIA ) PVT. LTD.
8 . P0715	SENIOR INDIA PVT. LTD.

## 120505 : FIRE WATER PUMPS

CODE	NAME
<b>INDIA</b>	
1 . P0102	BEST & CROMPTON ENGG. CO.
2 . P0321	GREAVES COTTON & CO. LTD.
3 . P3325	JAYANT ENGINEERING & MARKETING (P) LTD.
4 . P0451	KIRLOSKAR BROTHERS LIMITED
5 . P0519	MATHER & PLATT (INDIA) LTD. (A Subsidiary of WILO SE German

## 120506 : PORTABLE FIRE EXTINGUISHERS & FIRE FIGHTING CHEMICALS

CODE	NAME
<b>INDIA</b>	
1 . P2107	CEASEFIRE INDUSTRIES LTD
2 . P2271	INTEGRATED FIRE PROTECTION PVT. LTD.
3 . P2091	PYROTEK INDUSTRIES (INDIA ) PVT. LTD.
4 . P2029	UNITECH MACHINES LTD.
5 . P2104	ZENITH FIRE SEVICES INDIA PVT. LTD

## 120507 : SMOKE / GAS DETECTOR

CODE	NAME
<b>INDIA</b>	
1 . P2107	CEASEFIRE INDUSTRIES LTD
2 . P2091	PYROTEK INDUSTRIES (INDIA ) PVT. LTD.
3 . P2029	UNITECH MACHINES LTD.
4 . P2104	ZENITH FIRE SEVICES INDIA PVT. LTD

## 120508 : FIRE FIGHTING EQUIPMENTS

CODE	NAME
<b>INDIA</b>	
1 . P2220	DE'S TECHNICO PVT. LTD. (Deluge Valve and Sprinklers only.)
2 . P2141	HD FIRE PROTECT PVT. LTD.
3 . P2271	INTEGRATED FIRE PROTECTION PVT. LTD.
4 . P2091	PYROTEK INDUSTRIES (INDIA ) PVT. LTD.
5 . P2130	VENUS PUMP & ENGG. WORKS
6 . P2209	WINCO VALVES PVT. LTD. (Equipments for Fire Hydrant System)
7 . P2104	ZENITH FIRE SEVICES INDIA PVT. LTD

**120601 :MARINE LOADING ARM**

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CODE	NAME
<b>INDIA</b>	
1 . P0497	LLOYDS STEELS INDUSTRIES LIMITED (8" to 20")

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## 120602 : TRUCK/WAGON LOADING ARM

CODE	NAME
<b>INDIA</b>	
1 .	LLOYDS STEELS INDUSTRIES LIMITED (2" to 4")
2 . P2232	WOODFIELD SYSTEMS INTERNALNATIONAL PVT.LTD. (Upto size: Core-4" / Jacket:-6")

	<b>MASTER VENDORS LIST FOR PROJECTS</b>	04-00MM-0011	18
		DOCUMENT NO	REV

**MASTER VENDORS LIST**  
**FOR**  
**PROJECTS**  
**MECHANICAL ITEMS (MACHINERY)**

## INDEX MECHANICAL (MACHINERY) ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE NO.
<b>1301</b>	<b>CENTRIFUGAL PUMPS (HORIZONTAL)</b>	
130101	PUMPS FOR HP BFW SERVICE (ABOVE 60 KG/CM2 DISCH. PR.)	3
130102	PUMPS FOR SEMI LEAN SOLUTION	4
130103	PUMPS FOR HP REACTOR FEED (AMMONIA & CARBAMATE)	6
130104	PUMPS FOR UREA MELT	7
130105	PUMPS FOR CHEMICALS/ACID/ALKALI/BFW/CONDENSATE USE	8
130106	COOLING WATER PUMPS (HORIZONTAL)	10
130107	PUMPS FOR SLURRY SERVICE	11
130108	RUBBER LINED PUMPS	12
130109	POLY PROPYLENE PUMPS/FRP PUMPS	13
130110	PUMPS FOR UTILITY SERVICES	14
130111	DIAPHRAGM PUMPS	15
130112	BARREL PUMPS	16
<b>1302</b>	<b>CENTRIFUGAL PUMPS (VERTICAL)</b>	
130201	PUMPS FOR VERY LOW NPSH REQUIREMENTS (AMM./NAPHTHA )	17
130203	PUMPS FOR COOLING WATER SERVICE (VERTICAL)	19
130204	DEEP TUBEWELL PUMPS	20
130205	VERTICAL CAN PUMPS	21
130206	CENTRIFUGAL MONOBLOCK PUMP SET	22
130207	POT/CAN MOUNTED AND INTANK SUBMERGED MOTOR CRYOGENIC	23
130208	SUMP PUMPS	24
<b>1303</b>	<b>RECIPROCATING / ROTARY PUMPS</b>	
130301	PUMPS FOR REACTOR FEED(AMMONIA & CARBAMATE)	25
130302	PUMPS FOR CHEMICAL DOSING / METERING	26
130303	PUMPS FOR MISC. SERVICE	28
130304	ROTARY PUMPS /SCREW PUMPS	29
<b>1304</b>	<b>CENTRIFUGAL COMPRESSORS</b>	
130401	COMPRESSOR FOR HP SERVICE (SYN.GAS,CO2,NG ETC.)	30
130402	COMPRESSOR FOR MP SERVICE (PROCESS AIR,REF.,CO2,N2,NG)	31
130403	BOOSTER COMPRESSOR FOR CO2 & N2	32
130404	COMPRESSOR FOR INSTRUMENT AIR SERVICE	34

## INDEX CUSTOM CLEARANCE & TRANSPORTATION ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE NO.
<b>1305</b>	<b>RECIPROCATING COMPRESSOR/SCREW COMPRESSOR/VACCUM</b>	
130501	RECIPROCATING COMPRESSOR	36
130502	PASSIVATION AIR COMPRESSOR FOR HP STRIPPER	38
130504	SCREW COMPRESSOR	39
130505	VACCUM PUMPS AND COMPRESSORS	40
130506	DIAPHRAGM COMPRESSOR	41
130507	ROTARY COMPRESSOR	42
<b>1306</b>	<b>TURBINE / BLOWERS</b>	
130601	STEAM TURBINE UPTO 3 MW	43
130602	STEAM TURBINE ABOVE 3 MW	45
130603	GAS TURBINE	47
130604	HEAT RECOVERY STEAM GENERATION FOR GAS TURBINE	48
130605	FANS & BLOWERS	49
<b>1307</b>	<b>MISCELLANEOUS EQUIPMENTS</b>	
130701	AGITATORS/ MIXERS	50
130702	FILTERS & SEPARATORS	51
130703	PROCESS EJECTORS	53
130704	COUPLINGS	54
130705	ARC VALVES	55
130706	AXIAL FLOW PUMPS	56
130707	MECHANICAL SEALS FOR ROTATING EQUIPMENTS	57
<b>1309</b>	<b>AIR CONDITIONING</b>	
130901	AIR CONDITIONING SYSTEM	58
130902	POLLUTION CONTROL EQUIPMENT	59
130903	REFRIGERATION SYSTEMS	60

## 130101 : PUMPS FOR HP BFW SERVICE (ABOVE 60 KG/CM2 DISCH. PR.)

CODE	NAME
<b>INDIA</b>	
1 . P1179	KIRLOSKAR EBARA PUMPS LIMITED (Above 60 Kg/cm2 Disch. Pr.)
2 . P0111	BHARAT PUMPS & COMPRESSORS LTD.
3 . P3002	FLOWSERVE INDIA CONTROLS PVT. LTD.
4 . P0472	KSB PUMPS LIMITED (upto 190Kg/cm2 Differential pr.)
5 . P1302	RUHRPUMPEN INDIA PRIVATE LIMITED
6 . P0767	SULZER PUMPS INDIA LIMITED (upto 960 mlc, 80 m3/Hr)
<b>GERMANY</b>	
7 . P0470	KSB AG
<b>JAPAN</b>	
8 . P0220	EBARA CORPORATION
9 . P0724	SHIN NIPPON MACHINERY CO. LTD.
<b>U.K.</b>	
10 . P0395	FLOWSERVE (IDP)

## 130102 : PUMPS FOR SEMI LEAN SOLUTION

CODE	NAME
<b>INDIA</b>	
1 . P1179	KIRLOSKAR EBARA PUMPS LIMITED
2 . P3002	FLOWSERVE INDIA CONTROLS PVT. LTD.
3 . P3388	ITT CORPORATION INDIA PVT. LTD.
4 . P0472	KSB PUMPS LIMITED
5 . P1302	RUHRPUMPEN INDIA PRIVATE LIMITED
<b>AUSTRIA</b>	
6 . P0651	PUMPEN FABRIK ERNST VOGEL
<b>FRANCE</b>	
7 . P0471	KSB GUINARD
<b>GERMANY</b>	
8 . P0470	KSB AG
<b>ITALY</b>	
9 . P3001	FLOW SERVE
10 . P0594	GE POWER (NUOVO PIGNONE SPA)
11 . P0636	WEIR GABBIONETA SRL (FORMERLY POMPE GABBIONETA SPA)
<b>JAPAN</b>	
12 . P0220	EBARA CORPORATION
13 . P0539	MITSUBISHI CORPORATION
14 . P0724	SHIN NIPPON MACHINERY CO. LTD.

## 130102 : PUMPS FOR SEMI LEAN SOLUTION

CODE	NAME
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15 . P0817      TORISHIMA PUMP MFG. CO. LTD.

### **SINGAPORE**

16 . P0315      GOULD PUMPS INC.

### **SWITZERLAND**

17 . P0768      SULZER PUMPS LTD.

**130103 : PUMPS FOR HP REACTOR FEED (AMMONIA & CARBAMATE)**

<b>CODE</b>	<b>NAME</b>
<b>INDIA</b>	
1 . P1179	KIRLOSKAR EBARA PUMPS LIMITED
2 . P3002	FLOWSERVE INDIA CONTROLS PVT. LTD.
3 . P0472	KSB PUMPS LIMITED (Under guarrantee & support form KSB Germany)
<b>JAPAN</b>	
4 . P0220	EBARA CORPORATION
5 . P0580	NIKKISO-SUNDSTRAND CO. LTD.



## 130104 : PUMPS FOR UREA MELT

CODE	NAME
<b>INDIA</b>	
1 . P3002	FLOWSERVE INDIA CONTROLS PVT. LTD.
2 . P1302	RUHRPUMPEN INDIA PRIVATE LIMITED ((SOLUTION OF UREA 64%))
<b>AUSTRIA</b>	
3 . P0651	PUMPEN FABRIK ERNST VOGEL
<b>GERMANY</b>	
4 . P0286	FRIATEC-RHEINHUTTE GMBH & CO.
<b>ITALY</b>	
5 . P0636	WEIR GABBIONETA SRL (FORMERLY POMPE GABBIONETA SPA)
<b>JAPAN</b>	
6 . P0057	ARAI PUMP MFG.CO. LTD.
7 . P0724	SHIN NIPPON MACHINERY CO. LTD.

## 130105 : PUMPS FOR CHEMICALS/ACID/ALKALI/BFW/CONDENSATE USE

CODE	NAME
<b>INDIA</b>	
1 . P1179	KIRLOSKAR EBARA PUMPS LIMITED
2 . P3301	A.R.WILFLEY INDIA PVT. LTD.
3 . P0029	AKAY INDUSTRIES PVT LTD
4 . P0095	BEACON WEIR LTD.
5 . P0111	BHARAT PUMPS & COMPRESSORS LTD.
6 . P3002	FLOWERVE INDIA CONTROLS PVT. LTD.
7 . P3388	ITT CORPORATION INDIA PVT. LTD.
8 . P0451	KIRLOSKAR BROTHERS LIMITED
9 . P0452	KIRLOSKAR EBARA PUMPS LIMITED,
10 . P0455	KISHORE PUMPS PVT.LTD.
11 . P0472	KSB PUMPS LIMITED
12 . P3339	MICROFINISH PUMPS PVT. LTD.
13 . P1302	RUHRPUMPEN INDIA PRIVATE LIMITED
14 . P1144	SAM TURBO INDUSTRY PRIVATE LTD. (Capacity - 900 m3/hr. Head - 60 mtr)
15 . P0767	SULZER PUMPS INDIA LIMITED (Single stage only)
<b>AUSTRIA</b>	
16 . P0651	PUMPEN FABRIK ERNST VOGEL
<b>BELGIUM</b>	

## 130105 : PUMPS FOR CHEMICALS/ACID/ALKALI/BFW/CONDENSATE USE

CODE	NAME
17 . P0241	ENSIVAL S.A.
<b>ITALY</b>	
18 . P0594	GE POWER (NUOVO PIGNONE SPA)
19 . P0636	WEIR GABBIONETA SRL (FORMERLY POMPE GABBIONETA SPA)
<b>JAPAN</b>	
20 . P0057	ARAI PUMP MFG.CO. LTD.
21 . P0697	SANWA HYDROTECH CORPORATION
<b>SINGAPORE</b>	
22 . P0315	GOULD PUMPS INC.
<b>U.K.</b>	
23 . P0395	FLOWSERVE (IDP)
24 . P0481	LA BOUR PUMP CO. LTD.

## 130106 : COOLING WATER PUMPS (HORIZONTAL)

CODE	NAME
<b>INDIA</b>	
1 . P3301	A.R.WILFLEY INDIA PVT. LTD.
2 . P0095	BEACON WEIR LTD.
3 . P0111	BHARAT PUMPS & COMPRESSORS LTD.
4 . P3316	FLOWMORE LIMITED (FORMERLY FLOWMORE PVT. LTD.)
5 . P3002	FLOWSERVE INDIA CONTROLS PVT. LTD.
6 . P0430	JYOTI LIMITED
7 . P0451	KIRLOSKAR BROTHERS LIMITED
8 . P0519	MATHER & PLATT (INDIA) LTD. (A Subsidiary of WILO SE German
9 . P1302	RUHRPUMPEN INDIA PRIVATE LIMITED
10 . P1144	SAM TURBO INDUSTRY PRIVATE LTD. (Capacity - 3600 m3/hr. Head - 35 mtr)
11 . P0869	VOLTAS LTD. (PUMPS & PROJECTS BUSINESS DIV)
<b>GERMANY</b>	
12 . P0470	KSB AG
<b>JAPAN</b>	
13 . P0540	MITSUBISHI HEAVY INDUSTRIES LTD.
14 . P0724	SHIN NIPPON MACHINERY CO. LTD.
15 . P0817	TORISHIMA PUMP MFG. CO. LTD.
<b>U.K.</b>	

**130106: COOLING WATER PUMPS (HORIZONTAL)**

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CODE	NAME
16. P0395	FLOWSERVE (IDP)

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## 130107 : PUMPS FOR SLURRY SERVICE

CODE	NAME
<b>INDIA</b>	
1 . P3301	A.R.WILFLEY INDIA PVT. LTD.
2 . P0029	AKAY INDUSTRIES PVT LTD
3 . P0095	BEACON WEIR LTD.
4 . P0102	BEST & CROMPTON ENGG. CO.
5 . P0111	BHARAT PUMPS & COMPRESSORS LTD.
6 . P1301	EGGER PUMPS INDIA PVT.LTD.
7 . P3316	FLOWMORE LIMITED (FORMERLY FLOWMORE PVT. LTD.)
8 . P0320	GREAVES LTD.
9 . P0455	KISHORE PUMPS PVT.LTD.
10 . P0472	KSB PUMPS LIMITED
11 . P3339	MICROFINISH PUMPS PVT. LTD.
12 . P1144	SAM TURBO INDUSTRY PRIVATE LTD. (Capacity - 1350 m3/hr. Head - 40 mtr)
13 . P0762	SU MOTORS PVT. LTD
14 . P0767	SULZER PUMPS INDIA LIMITED

## 130108 : RUBBER LINED PUMPS

CODE	NAME
<b>INDIA</b>	
1 . P0029	AKAY INDUSTRIES PVT LTD
2 . P0111	BHARAT PUMPS & COMPRESSORS LTD.
3 . P0353	HINDUSTAN DOOR-OLIVER LTD.
4 . P0403	INTERNATIONAL COMBUSTION INDIA (P)LTD.
5 . P0451	KIRLOSKAR BROTHERS LIMITED
6 . P0452	KIRLOSKAR EBARA PUMPS LIMITED,
7 . P0455	KISHORE PUMPS PVT.LTD.
8 . P0472	KSB PUMPS LIMITED
<b>BELGIUM</b>	
9 . P0241	ENSIVAL S.A.
<b>ITALY</b>	
10 . P0636	WEIR GABBIONETA SRL (FORMERLY POMPE GABBIONETA SPA)
<b>JAPAN</b>	
11 . P0220	EBARA CORPORATION
12 . P0724	SHIN NIPPON MACHINERY CO. LTD.
13 . P0817	TORISHIMA PUMP MFG. CO. LTD.
<b>U.K.</b>	
14 . P0395	FLOWSERVE (IDP)

## 130109 : POLY PROPYLENE PUMPS/FRP PUMPS

CODE	NAME
<b>INDIA</b>	
1 . P3301	A.R.WILFLEY INDIA PVT. LTD.
2 . P0086	BAKUBHAI AMBALAL
3 . P3339	MICROFINISH PUMPS PVT. LTD.



## 130110 : PUMPS FOR UTILITY SERVICES

CODE	NAME
<b>INDIA</b>	
1 . P1179	KIRLOSKAR EBARA PUMPS LIMITED
2 . P0029	AKAY INDUSTRIES PVT LTD
3 . P0095	BEACON WEIR LTD.
4 . P0102	BEST & CROMPTON ENGG. CO.
5 . P3316	FLOWMORE LIMITED (FORMERLY FLOWMORE PVT. LTD.)
6 . P3002	FLOWSERVE INDIA CONTROLS PVT. LTD.
7 .	FLOWSERVE INDIA CONTROLS PVT. LTD.
8 . P0451	KIRLOSKAR BROTHERS LIMITED
9 . P0452	KIRLOSKAR EBARA PUMPS LIMITED,
10 . P0455	KISHORE PUMPS PVT.LTD.
11 . P3339	MICROFINISH PUMPS PVT. LTD.
12 . P1302	RUHRPUMPEN INDIA PRIVATE LIMITED
13 . P1144	SAM TURBO INDUSTRY PRIVATE LTD. (Capacity - 1200 m3/hr. Head - 90 mtr)
14 . P0762	SU MOTORS PVT. LTD
15 . P0767	SULZER PUMPS INDIA LIMITED
16 . P0093	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.)

## 130111 : DIAPHRAGM PUMPS

CODE	NAME
<b>INDIA</b>	
1 . P3065	HI-LIFE MANUFACTURING CO. (2.5-4.5 m3/hr)
2 . P1160	S R METERING PUMPS & SYSTEMS (36-10080 LPH)

## 130112 : BARREL PUMPS

CODE	NAME
<b>INDIA</b>	
1 . P1179	KIRLOSKAR EBARA PUMPS LIMITED
2 . P3002	FLOWSERVE INDIA CONTROLS PVT. LTD.
3 . P3065	HI-LIFE MANUFACTURING CO. (122 cc/cycle)
4 . P1302	RUHRPUMPEN INDIA PRIVATE LIMITED

## 130201 : PUMPS FOR VERY LOW NPSH REQUIREMENTS (AMM./NAPTHA )

CODE	NAME
<b>INDIA</b>	
1 . P1179	KIRLOSKAR EBARA PUMPS LIMITED
2 . P0111	BHARAT PUMPS & COMPRESSORS LTD.
3 . P3002	FLOWERVE INDIA CONTROLS PVT. LTD.
4 . P3388	ITT CORPORATION INDIA PVT. LTD.
5 . P0472	KSB PUMPS LIMITED
6 . P1302	RUHRPUMPEN INDIA PRIVATE LIMITED
7 . P0767	SULZER PUMPS INDIA LIMITED
<b>FRANCE</b>	
8 . P0471	KSB GUINARD
<b>GERMANY</b>	
9 . P0470	KSB AG
<b>ITALY</b>	
10 . P0594	GE POWER (NUOVO PIGNONE SPA)
11 . P0636	WEIR GABBIONETA SRL (FORMERLY POMPE GABBIONETA SPA)
<b>JAPAN</b>	
12 . P0057	ARAI PUMP MFG.CO. LTD. (only Horizontal Pumps)
13 . P0220	EBARA CORPORATION
14 . P0580	NIKKISO-SUNDSTRAND CO. LTD.
15 . P0697	SANWA HYDROTECH CORPORATION (only Horizontal Pumps)

# 130201 : PUMPS FOR VERY LOW NPSH REQUIREMENTS (AMM./NAPTHA )

CODE	NAME
<b>SINGAPORE</b>	
16 . P0315	GOULD PUMPS INC.
<b>U.K.</b>	
17 . P0340	HAYWARD TYLER LTD.
<b>U.S.A.</b>	
18 . P0138	BYRON JACKSON PUMP

## 130203 : PUMPS FOR COOLING WATER SERVICE (VERTICAL)

CODE	NAME
<b>INDIA</b>	
1 . P0095	BEACON WEIR LTD.
2 . P0111	BHARAT PUMPS & COMPRESSORS LTD.
3 . P3316	FLOWMORE LIMITED (FORMERLY FLOWMORE PVT. LTD.)
4 . P3002	FLOWSERVE INDIA CONTROLS PVT. LTD.
5 . P0430	JYOTI LIMITED
6 . P0451	KIRLOSKAR BROTHERS LIMITED
7 . P0519	MATHER & PLATT (INDIA) LTD. (A Subsidiary of WILO SE German
8 . P1302	RUHRPUMPEN INDIA PRIVATE LIMITED
9 . P0869	VOLTAS LTD. (PUMPS & PROJECTS BUSINESS DIV)
<b>GERMANY</b>	
10 . P0470	KSB AG
<b>JAPAN</b>	
11 . P0540	MITSUBISHI HEAVY INDUSTRIES LTD.
12 . P0724	SHIN NIPPON MACHINERY CO. LTD.
13 . P0817	TORISHIMA PUMP MFG. CO. LTD.
<b>U.K.</b>	
14 . P0395	FLOWSERVE (IDP)

## 130204 : DEEP TUBEWELL PUMPS

CODE	NAME
<b>INDIA</b>	
1 . P0111	BHARAT PUMPS & COMPRESSORS LTD.
2 . P3316	FLOWMORE LIMITED (FORMERLY FLOWMORE PVT. LTD.)
3 . P0430	JYOTI LIMITED
4 . P0451	KIRLOSKAR BROTHERS LIMITED
5 . P0472	KSB PUMPS LIMITED
6 . P0519	MATHER & PLATT (INDIA) LTD. (A Subsidiary of WILO SE German
7 . P0642	PRECISION ENGINEERING INDUSTRIES
8 . P0869	VOLTAS LTD. (PUMPS & PROJECTS BUSINESS DIV)
<b>FRANCE</b>	
9 . P0471	KSB GUINARD
<b>GERMANY</b>	
10 . P0470	KSB AG
<b>ITALY</b>	
11 . P0636	WEIR GABBIONETA SRL (FORMERLY POMPE GABBIONETA SPA)

## 130205 : VERTICAL CAN PUMPS

CODE	NAME
<b>INDIA</b>	
1 . P1179	KIRLOSKAR EBARA PUMPS LIMITED
2 . P3002	FLOWSERVE INDIA CONTROLS PVT. LTD.
3 . P0472	KSB PUMPS LIMITED
4 . P1302	RUHRPUMPEN INDIA PRIVATE LIMITED
5 . P0767	SULZER PUMPS INDIA LIMITED



## 130206 : CENTRIFUGAL MONOBLOCK PUMP SET

CODE	NAME
<b>INDIA</b>	
1 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
2 . P0430	JYOTI LIMITED
3 . P0451	KIRLOSKAR BROTHERS LIMITED
4 . P0519	MATHER & PLATT (INDIA) LTD. (A Subsidiary of WILO SE German
5 . P0642	PRECISION ENGINEERING INDUSTRIES (small pumps upto 2HP)
6 . P3004	UJALA



## 130207: POT/CAN MOUNTED AND INTANK SUBMERGED MOTOR CRYOGENIC PUMPS

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CODE	NAME
<i>INDIA</i>	
1 . P3303	AGROTECH CORP (J.C.CARTER) (up to 1300 m3/hr ,2100m HEAD)

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## 130208 : SUMP PUMPS

CODE	NAME
<b>INDIA</b>	
1 . P0029	AKAY INDUSTRIES PVT LTD
2 . P0095	BEACON WEIR LTD.
3 . P3002	FLOWSERVE INDIA CONTROLS PVT. LTD.
4 . P0455	KISHORE PUMPS PVT.LTD.
5 . P1302	RUHRPUMPEN INDIA PRIVATE LIMITED
6 . P1144	SAM TURBO INDUSTRY PRIVATE LTD. (Capacity - 550 m3/hr. Head - 35 mtr)

## 130301 : PUMPS FOR REACTOR FEED(AMMONIA & CARBAMATE)

CODE	NAME
<b>INDIA</b>	
1 . P0111	BHARAT PUMPS & COMPRESSORS LTD.
2 . P1156	GOMA ENGINEERING PVT. LTD. (Range: 0-1500 kg/cm <sup>2</sup> Horizontal Triplex Reciprocating Pluger/Piston Pumps (API-674), Capacity: 150 m <sup>3</sup> /hr. Max HP: 700 HP)
<b>GERMANY</b>	
3 . P0847	URACA PUMPENFABRIK GMBH & CO. KG
4 . P0882	WORTHINGTON PUMPS GMBH
<b>ITALY</b>	
5 . P0626	PERONI POMPE SPA (capacity=50m <sup>3</sup> /hr, pr=240kg/cm <sup>2</sup> )

## 130302 : PUMPS FOR CHEMICAL DOSING / METERING

CODE	NAME
<b>INDIA</b>	
1 . P3309	BRAN & LEUBE INDIA
2 . P0521	MATZ PUMPS PRIVATE LIMITED
3 . P3340	MILTON ROY INDIA (P) LTD.
4 . P3070	POSITIVE METERING PUMPS (I) PVT. LTD. (Plunger Pump : 300 LPH Diaphragm Pumps : 3000 LPH)
5 .	POSITIVE METERING PUMPS (I) PVT. LTD. (UP TO 0-6000 LPH)
6 . P1160	S R METERING PUMPS & SYSTEMS (0.3-12462 LPH)
7 . P0721	SHAPO TOOLS
8 . P0779	SWELORE ENGINEERING PVT.LTD.
9 . P0852	V K PUMPS INDUSTRIES PVT. LTD.
10 . P3067	VARICON SYSTEMS (Motor Driven / Pneumatic)
<b>FRANCE</b>	
11 . P0537	DOSAPRO MILLTON ROY
<b>GERMANY</b>	
12 . P0492	LEWA HERBERT OTT GMBH & CO.
<b>ITALY</b>	
13 . P0626	PERONI POMPE SPA (Metering Pump: Capacity 1.13 m3/hr., Pr. 5.59 kg/cm2)
<b>JAPAN</b>	
14 . P0578	NIIGATA WORTHNGTON PUPMS
15 . P0579	NIKKISO CO. LTD.



## 130302: PUMPS FOR CHEMICAL DOSING / METERING

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CODE	NAME
<hr/>	
<i>U.K.</i>	
16. P0125	BRAN & LUEBBE LTD.

## 130303 : PUMPS FOR MISC. SERVICE

CODE	NAME
<b>INDIA</b>	
1 . P3301	A.R.WILFLEY INDIA PVT. LTD.
2 . P0111	BHARAT PUMPS & COMPRESSORS LTD.
3 . P1156	GOMA ENGINEERING PVT. LTD. (Range: 0-1500 kg/cm <sup>2</sup> Capacity: 150 m <sup>3</sup> /hr.Max HP: 700 HP)
4 . P0472	KSB PUMPS LIMITED
5 . P0767	SULZER PUMPS INDIA LIMITED
6 . P3056	UT PUMPS & SYSTEMS LTD (HP Triplex Plunger Pumps capacity 215 LPM, Pr 250 Bar)
7 . P0852	V K PUMPS INDUSTRIES PVT. LTD. (For Non-critical use)
<b>GERMANY</b>	
8 . P0492	LEWA HERBERT OTT GMBH & CO.
9 . P0847	URACA PUMPENFABRIK GMBH & CO. KG
<b>ITALY</b>	
10 . P0210	DOSAPRO MILTON ROY
11 . P0626	PERONI POMPE SPA (capacity=95m <sup>3</sup> /hr, pr=306kg/cm <sup>2</sup> )
<b>JAPAN</b>	
12 . P0578	NIIGATA WORTHINGTON PUMPS
13 . P0579	NIKKISO CO. LTD.
<b>U.K.</b>	
14 . P0125	BRAN & LUEBBE LTD.

## 130304 : ROTARY PUMPS /SCREW PUMPS

CODE	NAME
<b>INDIA</b>	
1 . P0026	AIRAUTO INDUSTRIES
2 . P0199	DELTA CORPORATION
3 . P3070	POSITIVE METERING PUMPS (I) PVT. LTD. (UP TO 10000 LPH)
4 . P0683	ROTO PUMPS LTD.
5 . P3056	UT PUMPS & SYSTEMS LTD (Single Screw : cap.5 m <sup>3</sup> /h pr 0.6 Bar,Twin screw :cap. 25m <sup>3</sup> /h pr 25 Bar,Triple screw : cap.53.4 m <sup>3</sup> /h, pr.10 Bar)



## 130401 : COMPRESSOR FOR HP SERVICE (SYN.GAS,CO<sub>2</sub>,NG ETC.)

CODE	NAME
<b>INDIA</b>	
1 . P0108	BHARAT HEAVY ELECTRICALS LTD.
<b>GERMANY</b>	
2 . P0499	BORSIG GmbH
3 . P0122	MAN TURBOMASCHINEN AG GHH BORSIG
4 . P0735	SIEMENS AG, GERMANY
<b>ITALY</b>	
5 . P0594	GE POWER (NUOVO PIGNONE SPA)
<b>JAPAN</b>	
6 . P0357	HITACHI LTD.
7 . P0410	ISHIKAWAJIMA HARIMA HEAVY INDS.CO LTD (IHI)
8 . P0437	KAWASAKI HEAVY INDUSTRIES LTD.
9 . P0540	MITSUBISHI HEAVY INDUSTRIES LTD.
<b>SINGAPORE</b>	
10 . P0215	DRESSER - RAND CO.

## 130402 : COMPRESSOR FOR MP SERVICE (PROCESS AIR,REF.,CO2,N2,NG)

CODE	NAME
<b>GERMANY</b>	
1 . P1159	FIMA MASCHINENBAU GMBH (Max Flow: 964 m3/Hr, Per Stage Pr. Ratio: Upto 2.3)
<b>INDIA</b>	
2 . P0108	BHARAT HEAVY ELECTRICALS LTD.
3 . P3071	CAMERON COMPRESSION SYSTEM (API 617: 60,000 CFM @ 80 bar; API 672:950,000 CFM @ 80 bar)
<b>GERMANY</b>	
4 . P0074	ATLAS COPCO ENERGAS GMBH
5 . P0309	GHH BORSIG TURBOMASCHINEN GMBH
6 . P0508	SIEMENS AG PGI
<b>ITALY</b>	
7 . P0594	GE POWER (NUOVO PIGNONE SPA)
<b>JAPAN</b>	
8 . P0357	HITACHI LTD.
9 . P0458	KOBE STEEL LIMITED
10 . P0540	mitsubishi heavy industries ltd.
<b>SINGAPORE</b>	
11 . P0215	DRESSER - RAND CO.

## 130403 : BOOSTER COMPRESSOR FOR CO2 & N2

CODE	NAME
<b>GERMANY</b>	
1 . P1159	FIMA MASCHINENBAU GMBH (Max Flow: 964 m3/Hr, Per Stage Pr. Ratio: Upto 2.3)
<b>INDIA</b>	
2 . P0108	BHARAT HEAVY ELECTRICALS LTD.
3 . P3071	CAMERON COMPRESSION SYSTEM (API 617: 60,000 CFM @ 80 bar; API 672:950,000 CFM @ 80 bar)
4 . P0766	SULZER INDIA PRIVATE LTD.
<b>GERMANY</b>	
5 . P0074	ATLAS COPCO ENERGAS GMBH
6 . P0309	GHH BORSIG TURBOMASCHINEN GMBH
7 . P3336	MANNESMAN DEMAG AG.
8 . P0508	SIEMENS AG PGI
<b>JAPAN</b>	
9 . P0410	ISHIKAWAJIMA HARIMA HEAVY INDS.CO LTD (IHI)
10 . P0437	KAWASAKI HEAVY INDUSTRIES LTD.
11 . P0458	KOBE STEEL LIMITED
12 . P0540	MITSUBISHI HEAVY INDUSTRIES LTD.
13 . P0541	mitsui ENGINEERING & SHIPBUILDING CO.LTD
<b>SINGAPORE</b>	
14 . P0215	DRESSER - RAND CO.
<b>SWITZERLAND</b>	

## 130403 : BOOSTER COMPRESSOR FOR CO2 &amp; N2

CODE	NAME
15 . P0765	BURCKHARDT COMPRESSION AG
16 . P3377	SULZER TURBO LIMITED

## 130404 : COMPRESSOR FOR INSTRUMENT AIR SERVICE

CODE	NAME
<b>GERMANY</b>	
1 . P1159	FIMA MASCHINENBAU GMBH (Max Flow: 964 m3/Hr, Per Stage Pr. Ratio: Upto 2.3)
<b>INDIA</b>	
2 . P3057	INGERSOLL RAND INDIA LTD.
<b>GERMANY</b>	
3 . P0074	ATLAS COPCO ENERGAS GMBH
4 . P0309	GHH BORSIG TURBOMASCHINEN GMBH
5 . P0495	LINDE AG WERKSGRUPPE
6 . P3336	MANNESMAN DEMAG AG.
7 . P0508	SIEMENS AG PGI
<b>ITALY</b>	
8 . P0594	GE POWER (NUOVO PIGNONE SPA)
<b>JAPAN</b>	
9 . P0220	EBARA CORPORATION
10 . P0357	HITACHI LTD.
11 . P0437	KAWASAKI HEAVY INDUSTRIES LTD.
12 . P0458	KOBE STEEL LIMITED
13 . P0540	MITSUBISHI HEAVY INDUSTRIES LTD.
14 . P0541	MITSUI ENGINEERING & SHIPBUILDING CO.LTD
<b>SINGAPORE</b>	

**130404 : COMPRESSOR FOR INSTRUMENT AIR SERVICE**

CODE	NAME
15 . P0215	DRESSER - RAND CO.

**SWITZERLAND**

16 . P3377      SULZER TURBO LIMITED

**U.S.A.**

17 . P0233      ELLIOT OVERSEAS CORPORATION.

## 130501 : RECIPROCATING COMPRESSOR

CODE	NAME
1 . P1194	ANEST IWATA MOTHERSON PVT. LTD. (UP TO 15 HP (for air services only))
<b>GERMANY</b>	
2 . P1169	NEUMAN & ESSER GmbH & Co. KG
<b>INDIA</b>	
3 . P3007	ATLAS COPCO INDIA LIMITED (for air service only)
4 . P0111	BHARAT PUMPS & COMPRESSORS LTD.
5 . P3387	BURCKHARDT COMPRESSION (INDIA) PVT. LTD. (Capacity upto 15520 m3/hr. Pressure upto 401 Bar abs (CNG application also))
6 . P3071	CAMERON COMPRESSION SYSTEM (API 618: 6000 KW @ 450 Bar)
7 . P3006	DRESSER RAND INDIA PVT. LTD.
8 . P1153	ELGI SAUER COMPRESSORS LTD. (Capacity up to: 172 m3/hr, Pressure up to: 280 bar)
9 . P3057	INGERSOLL RAND INDIA LTD. (for air & N2)
10 . P0478	KIRLOSKAR PNEUMATIC CO. LTD (For Air service only)
<b>KOREA</b>	
11 . P5001	KWANGSHIN MACHINE INDUSTRY CO., LTD. (Upto 3000 HP)
<b>FRANCE</b>	
12 . P0137	HOWDEN (FORMERLY BURTON CORBLIN)
<b>GERMANY</b>	
13 . P0495	LINDE AG WERKSGRUPPE
<b>ITALY</b>	
14 . P0594	GE POWER (NUOVO PIGNONE SPA)

## 130501 : RECIPROCATING COMPRESSOR

CODE	NAME
<b>JAPAN</b>	
15 . P0410	ISHIKAWAJIMA HARIMA HEAVY INDS.CO LTD (IHI)
16 . P0458	KOBE STEEL LIMITED
17 . P0541	mitsui ENGINEERING & SHIPBUILDING CO.LTD
<b>SWITZERLAND</b>	
18 . P0765	BURCKHARDT COMPRESSION AG
<b>THE NETHERLANDS</b>	
19 . P0810	THOMASSEN TURBINE SYSTEMS B.V.



## 130502 : PASSIVATION AIR COMPRESSOR FOR HP STRIPPER

CODE	NAME
<b>INDIA</b>	
1 . P3387	BURCKHARDT COMPRESSION (INDIA) PVT. LTD. (Capacity: 100 NM3/hr; Pressure upto 160 kg/cm 2g)
<b>FRANCE</b>	
2 . P0137	HOWDEN (FORMERLY BURTON CORBLIN)

## 130504 : SCREW COMPRESSOR

CODE	NAME
<b>GERMANY</b>	
1 . P1189	AERZENER MASCHINENFABRIK GMBH. (FOR PROCESS GAS - CAPACITY : 23000 Nm3/hr)
<b>INDIA</b>	
2 . P1211	ELGI EQUIPMENTS LIMITED (FOR INSTRUMENT AIR)
<b>DENMARK</b>	
3 . P0075	ATLAS COPCO KOMPRESSORTEKNIK A/S
<b>GERMANY</b>	
4 . P0499	BORSIG GmbH
5 . P0122	MAN TURBOMASCHINEN AG GHH BORSIG
<b>JAPAN</b>	
6 . P0458	KOBE STEEL LIMITED
<b>SWITZERLAND</b>	
7 . P3377	SULZER TURBO LIMITED
<b>U.K.</b>	
8 . P0368	HOWDEN SIROCCO LIMITED

## 130505 : VACCUM PUMPS AND COMPRESSORS

CODE	NAME
1 . P1194	ANEST IWATA MOTHERSON PVT. LTD. (UP TO 10 HP)
<b>INDIA</b>	
2 . P1158	ACME AIR EQUIPMENTS CO. PVT.LTD. (81 CMH to 2030 CMH)
3 . P3316	FLOWMORE LIMITED (FORMERLY FLOWMORE PVT. LTD.)
4 . P0438	KAY INTERNATIONAL LIMITED
5 . P3063	MAZDA LIMITED
6 . P3351	PREMIER PUMPS PVT LTD. (LIQUID RING VACUUM PUMPS & COMPRESSORS)
7 . P3009	SLM MANEKLAL
8 . P3371	USHA COMPRESSORS PVT. LTD. (Manufacturer Standard)

**130506: DIAPHRAGM COMPRESSOR**

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CODE	NAME
<i>FRANCE</i>	
1 . P0137	HOWDEN (FORMERLY BURTON CORBLIN)

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## 130507 : ROTARY COMPRESSOR

CODE	NAME
<b>INDIA</b>	
1 . P1158	ACME AIR EQUIPMENTS CO. PVT.LTD. (13 CMH to 18789 CMH Roots Blower (Twin lobe, tri-lobe Rotary compressor)
2 . P3371	USHA COMPRESSORS PVT. LTD.
<b>FRANCE</b>	
3 . P0137	HOWDEN (FORMERLY BURTON CORBLIN)

## 130601 : STEAM TURBINE UPTO 3 MW

CODE	NAME
<b>INDIA</b>	
1 . P1179	KIRLOSKAR EBARA PUMPS LIMITED
<b>CHINA</b>	
2 . P3392	HANGZHOU STEAM TURBINE CO. LTD.
<b>INDIA</b>	
3 . P0065	ASEA BROWN BOVERI LIMITED,
4 . P0108	BHARAT HEAVY ELECTRICALS LTD.
5 . P0452	KIRLOSKAR EBARA PUMPS LIMITED, (Upto 1562 KW (API 611 & API 612) for YR series Turbine)
6 . P0832	TRIVENI ENGINEERING WORKS LIMITED
<b>GERMANY</b>	
7 . P3302	ABB TURBINEN NUMBERG GmbH
8 . P0012	ALSTOM POWER TURBINEN GMBH
9 . P3304	ALTHOM POWER
10 . P0309	GHH BORSIG TURBOMASCHINEN GMBH
11 . P0734	SIEMENS AKTIENGESELLSCHAFT
12 . P0836	TUTHILL NADROWSKI TURBINEN GMBH
<b>ITALY</b>	
13 . P0594	GE POWER (NUOVO PIGNONE SPA)
<b>JAPAN</b>	
14 . P0220	EBARA CORPORATION

**130601 : STEAM TURBINE UPTO 3 MW**

<b>CODE</b>	<b>NAME</b>
15 . P0437	KAWASAKI HEAVY INDUSTRIES LTD.
16 . P0540	MITSUBISHI HEAVY INDUSTRIES LTD.
17 . P0541	MTSUI ENGINEERING & SHIPBUILDING CO.LTD
18 . P0724	SHIN NIPPON MACHINERY CO. LTD.
<b>U.S.A.</b>	
19 . P0797	DRESSER RAND CO
20 . P0233	ELLIOT OVERSEAS CORPORATION.
21 . P0825	TRANSMERICA DELAVAL INC.
22 . P0837	TUTHILL ENERGY SYSTEMS

## 130602 : STEAM TURBINE ABOVE 3 MW

CODE	NAME
<b>CHINA</b>	
1 . P3392	HANGZHOU STEAM TURBINE CO. LTD.
<b>INDIA</b>	
2 . P0108	BHARAT HEAVY ELECTRICALS LTD.
3 . P1190	TRIVENI TURBINE LIMITED (UP TO 25 MW FOR NON - API APPLICATIONS)
<b>GERMANY</b>	
4 . P3302	ABB TURBINEN NUMBERG GmbH
5 . P0012	ALSTOM POWER TURBINEN GMBH
6 . P0309	GHH BORSIG TURBOMASCHINEN GMBH
7 . P0734	SIEMENS AKTIENGESELLSCHAFT
<b>ITALY</b>	
8 . P0594	GE POWER (NUOVO PIGNONE SPA)
<b>JAPAN</b>	
9 . P0220	EBARA CORPORATION
10 . P0287	FUJI ELECTRIC SYSTEMS CO. LTD.
11 . P0437	KAWASAKI HEAVY INDUSTRIES LTD.
12 . P0540	MITSUBISHI HEAVY INDUSTRIES LTD.
13 . P0541	MITSUI ENGINEERING & SHIPBUILDING CO.LTD
<b>SWEDEN</b>	
14 . P0064	ASEA BROWN BOVERI
<b>U.S.A.</b>	



## 130602 : STEAM TURBINE ABOVE 3 MW

CODE	NAME
15 . P0797	DRESSER RAND CO
16 . P0233	ELLIOT OVERSEAS CORPORATION.
17 . P0825	TRANSMERICA DELAVAL INC.
18 . P0837	TUTHILL ENERGY SYSTEMS

## 130603 : GAS TURBINE

CODE	NAME
<b>INDIA</b>	
1 . P0065	ASEA BROWN BOVERI LIMITED,
2 . P0108	BHARAT HEAVY ELECTRICALS LTD.
<b>FRANCE</b>	
3 . P0035	ALSTHOM FLUIDES SAPAG
<b>GERMANY</b>	
4 . P0309	GHH BORSIG TURBOMASCHINEN GMBH
<b>ITALY</b>	
5 . P0594	GE POWER (NUOVO PIGNONE SPA)
<b>JAPAN</b>	
6 . P0357	HITACHI LTD.
<b>SINGAPORE</b>	
7 . P0676	ROLLS-ROYCE ENERGY SYSTEMS INC.
<b>THE NETHERLANDS</b>	
8 . P0810	THOMASSEN TURBINE SYSTEMS B.V.
<b>U.K.</b>	
9 . P0428	JOHN BROWN ENGG. LTD.
<b>U.S.A.</b>	
10 . P3311	COOPER ROLLS INCORPORATED.
11 . P0797	DRESSER RAND CO
12 . P0303	GENERAL ELECTRIC CO.

## 130604 : HEAT RECOVERY STEAM GENERATION FOR GAS TURBINE

CODE	NAME
<b>INDIA</b>	
1 . P0108	BHARAT HEAVY ELECTRICALS LTD.
2 . P1104	LARSEN & TOUBRO LIMITED
<b>ITALY</b>	
3 . P1151	STF S.P.A. (Heat Recovery Steam Generation behind Gas Turbine from 1 MW upto 380 MW GT)
<b>JAPAN</b>	
4 . P0437	KAWASAKI HEAVY INDUSTRIES LTD.
5 . P0542	mitsui & COMPANY LTD.
6 . P0541	MITSUI ENGINEERING & SHIPBUILDING CO.LTD
<b>THE NETHERLANDS</b>	
7 . P0759	NEM HENGLO
8 . P3361	STORK KETALS
9 . P0810	THOMASSEN TURBINE SYSTEMS B.V.

## 130605 : FANS & BLOWERS

CODE	NAME
<b>GERMANY</b>	
1 . P1159	FIMA MASCHINENBAU GMBH (Max Flow: 900 m3/Hr, Per Stage Pr. Ratio: Upto 1.5)
2 . P1189	AERZENER MASCHINENFABRIK GMBH. (ROOT BLOWER - CAPACITY : 9200 m3/hr)
<b>INDIA</b>	
3 . P0267	ABB FLAKT INDIA LTD.
4 . P0020	AEROVENT PROJECTS PVT.LTD
5 . P0024	AIR CONDITIONING CORPN LTD
6 . P0025	AIR CONTROL & CHEMICAL ENGG. CO.LTD
7 . P0108	BHARAT HEAVY ELECTRICALS LTD.
8 . P3385	BOLDROCCHI INDIA PRIVATE LIMITED (FD/ID Fans / Blowers, Capacity 0.84 m3/s to 423.9 m3/s, Pr. 0.16 kPa to 64.6 kPa, Power 2 KW to 2000 KW)
9 . P3390	DRAFT-AIR INDIA PVT. LTD. (Upto 550 kW/737 HP)
10 . P1182	M/S CB DOCTOR VENTILATORS PVT. LTD. (2,30,000 M3/hr)
11 . P1139	MAXFLOW FANS MANUFACTURING (P) LTD. (Upto 6,16,000 M3/hr)
12 .	MAXFLOW FANS MANUFACTURING (P) LTD.
13 . P1039	SONAL ENGG. PLASTIC FABRICATOR (FOR FRP/PP/CPVC/BLOWERS/FANS ONLY)
14 . P1142	SWAM PNEUMATICS PVT. LTD. (Capacity -From 1485 m3/hr. to 48000 m3/hr. Pressure - From 0.7 barg to 3500 mmwc)
15 . P0804	THERMAX BABCOCK & WILCOX LIMITED
16 . P8028	TLT ENGINEERING INDIA PVT LTD
<b>U.S.A.</b>	

**130605: FANS & BLOWERS**

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CODE	NAME
17. P3321	ILLONOIS BLOWERS INC

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## 130701 : AGITATORS/ MIXERS

CODE	NAME
<b>INDIA</b>	
1 . P0291	GANSONS LTD.
2 . P3012	HYTEC GRANT INSTRUMENTS
3 . P3013	MARS DYE CHEM PVT. LTD.
4 . P1212	MILTONROY INDIA PRIVATE LIMITED
5 . P3383	RATHI LIGHTNIN MIXERS PRIVATE LIMITED
6 . P0666	REMI PROCESS PLANT & MACHINERY LIMITED
7 . P3011	SAFE MAX AGITATOR
8 . P0751	STANDARD ENGINEERS

## 130702 : FILTERS & SEPARATORS

CODE	NAME
<b>INDIA</b>	
1 . P3389	COPERION IDEAL PVT. LTD.
2 . P3384	FIL SEP EQUIPMENTS PVT. LTD.
3 . P3014	FILTRATION ENGINEERS PVT. LTD.
4 . P0291	GANSONS LTD.
5 . P0318	GRAND PRIX ENGINEERING PVT. LTD. (Cartridge Filters upto 1500#,40" size)
6 . P0338	HAYER STANDARD INDIA PVT.LTD. (only Disc Filters)
7 . P1184	M/S MULTITEX FILTRATION ENGINEERS LTD (UP TO 56" & 600# nozzle size & rating.)
8 . P0549	MULTITEX FILTRATION ENGINEERS LTD
9 . P0610	OTOKLIN PLANTS AND EQUIP LTD.
10 . P1173	PETROMAR ENGINEERED SOLUTIONS PVT.LTD.
11 . P0773	SUPERFLO FILTERS PVT. LTD.
12 . P0839	ULTRAFILTER (INDIA) PVT. LTD.,
<b>SINGAPORE</b>	
13 . P1135	PEERLESS MFG. COMPANY
<b>CANADA</b>	
14 . P3374	WATSON PROCESS SYSTEM (FOR VANE TYPE SEPARATORS)
<b>JAPAN</b>	
15 . P3341	MURA CHEMICALS EQPT.CO. LTD. (FOR VANE TYPE SEPARATORS)
<b>STEINWIESEN</b>	

## 130702 : FILTERS &amp; SEPARATORS

CODE	NAME
16 . P3353	RAUSCHERI VERFARENSTECHNIK GmbH

**U.S.A.**

17 . P3346      NORTHEAST CONTROLS EQPT.CO. LTD. (FOR VANE TYPE SEPARATORS)



## 130703 : PROCESS EJECTORS

CODE	NAME
<b>INDIA</b>	
1 . P1113	NEW FIELD INDUSTRIAL EQUIPMENT PVT. LTD.
2 . P0879	WIEGAND INDIA PVT. LTD.
<b>GERMANY</b>	
3 . P0298	GEA JET PUMPS GMBH
4 . P0463	KOERTING HANNOVER AG
<b>U.S.A</b>	
5 . P0316	GRAHAM CORPORATION
<b>U.S.A.</b>	
6 . P0446	KETEMA INC. SCHUTTE & KOERTING DIVISION

## 130704 : COUPLINGS

CODE	NAME
<b>INDIA</b>	
1 . P1172	CUBIC TRANSMISSION PVT. LTD. (Flexible Disc Coupling: 2kW- 60 MW; Flexible Gear Coupling: Upto 6600kW @100 RPM)
2 . P3017	ELECON ENGG. CO. LTD. (for flexible coupling)
3 . P3018	FENNER (INDIA) LTD. (for flexible coupling)
4 . P3058	HI-CLIFF (for gear coupling)
5 . P3059	RATHI TRANSPower PVT. LTD.
6 . P3060	RATHI TURBOFLEX PVT. LTD. (41.77 MW-6300 RPM MAX)

## 130705 : ARC VALVES

CODE	NAME
<b>GERMANY</b>	
1 . P3053	HOLTER REGELARMETUREN GMBH & CO. KG (HORA)
2 . P3051	SCHROEDAHL
3 . P3050	SCHROEDER
4 . P3052	YARWAY CORPORATION (Formerly TYCO ENGG. & CONSTN. PVT. LTD.)

## 130706 : AXIAL FLOW PUMPS

CODE	NAME
<b>INDIA</b>	
1 . P3316	FLOWMORE LIMITED (FORMERLY FLOWMORE PVT. LTD.)
2 . P3061	KESTNER

**130707 : MECHANICAL SEALS FOR ROTATING EQUIPMENTS**

CODE	NAME
<b>INDIA</b>	
1 . P1188	EAGLE BURGMANN INDIA PVT.LTD.
2 . P1181	LEAK-PROOF ENGINEERING (I) PVT. LTD.
3 . P1199	SEAL MATIC INDIA PRIVATE LIMITED (Mech Seals up to 185 MM Dia.)

**130901 : AIR CONDITIONING SYSTEM**

<b>CODE</b>	<b>NAME</b>
<b>INDIA</b>	
1 . P1202	ADVANCE VENTILATION PRIVATE LIMITED
2 . P0024	AIR CONDITIONING CORPN LTD
3 . P1209	ANEMO PROJECTS PRIVATE LIMITED
4 . P0119	BLUE STAR LTD.
5 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
6 . P1187	KIRLOSKAR PNEUMATIC CO. LTD. (VAPOUR ABSORPTION MACHINE - UP TO 600 TR)
7 . P3015	SUVIDHA ENGINEERS
8 . P0869	VOLTAS LTD. (PUMPS & PROJECTS BUSINESS DIV)



130902: POLLUTION CONTROL EQUIPMENT

CODE	NAME
<i>INDIA</i>	
1 . P0024	AIR CONDITIONING CORPN LTD

## 130903 : REFRIGERATION SYSTEMS

CODE	NAME
<b>INDIA</b>	
1 . P1187	KIRLOSKAR PNEUMATIC CO. LTD. (UP TO 162,000 KG/HR)
2 . P3391	SYSTEMS & COMPONENTS (INDIA) PVT. LTD. (30 TR-750 TR)



	<b>MASTER VENDORS LIST FOR PROJECTS</b>	04-00MM-0011	18
		DOCUMENT NO	REV

**MASTER VENDORS LIST**  
**FOR**  
**PROJECTS**  
**MECHANICAL ITEMS (REFORMER)**

## INDEX MECHANICAL (REFORMER) ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE NO.
<b>1401</b>	<b>PRIMARY REFORMER PACKAGE AND ASSOCIATED ITEMS</b>	
140101	COMPLETE REFORMER PACKAGE	2
140102	COMPLETE REFORMER PACKAGE EXCEPT FREE ISSUE OF MATLS.	3
140103	FIRE HEATER PACKAGE	4
140104	CATALYST TUBES /REFORMER TUBES	5
140105	BURNERS	6
140107	REFRATORIES (BRICKS)	7
140108	REFRATORIES (CERAMIC FIBRES)	8
140109	HOT COLLECTOR & OUTLET PIGTAIL	10
140110	INLET PIGTAIL & INLET DISTRIBUTOR	11
140111	W.H. RECOVERY COILS & TUBE MATL.FOR W.H.R. & FIRED HEATERS	12
140113	COMBUSTION AIR PRE-HEATER	13
140114	ID/FD FAN SET	14
140115	STATIC CASTINGS (TUBE SHEET / FITTINGS)	15
140116	FINNED TUBES / STUDDERED TUBES	16

## 140101 : COMPLETE REFORMER PACKAGE

CODE	NAME
<b>INDIA</b>	
1 . P0110	B H P V
2 . P1103	LARSEN & TOUBRO LIMITED
<b>FRANCE</b>	
3 . P0345	HEURTEY PETROCHEM ENGG.
<b>GERMANY</b>	
4 . P0162	CLAUDIUS PETERS AG
<b>HOLLAND</b>	
5 . P0010	ABB LUMMUS HEAT TRANSFER B.V.
6 . P0475	TECHNIP BENELUX BV
<b>ITALY</b>	
7 . P0465	KRICHNER ITALIA S.P.A.
<b>JAPAN</b>	
8 . P0157	CHIYODA CORPORATION
9 . P0437	KAWASAKI HEAVY INDUSTRIES LTD.
10 . P0540	MITSUBISHI HEAVY INDUSTRIES LTD.
<b>U.K.</b>	
11 . P0124	BOUSTEAD INTERNATIONAL HEATERS LIMITED
12 . P0280	FOSTER WHEELER POWER PRODUCTS LTD

## 140102 : COMPLETE REFORMER PACKAGE EXCEPT FREE ISSUE OF MATLS.

CODE	NAME
<b>INDIA</b>	
1 . P0110	B H P V
2 . P1103	LARSEN & TOUBRO LIMITED
<b>FRANCE</b>	
3 . P0345	HEURTEY PETROCHEM ENGG.
<b>GERMANY</b>	
4 . P0162	CLAUDIUS PETERS AG
<b>HOLLAND</b>	
5 . P0010	ABB LUMMUS HEAT TRANSFER B.V.
6 . P0475	TECHNIP BENELUX BV
<b>ITALY</b>	
7 . P0465	KRICHNER ITALIA S.P.A.
<b>JAPAN</b>	
8 . P0157	CHIYODA CORPORATION
9 . P0437	KAWASAKI HEAVY INDUSTRIES LTD.
10 . P0540	MITSUBISHI HEAVY INDUSTRIES LTD.
<b>U.K.</b>	
11 . P0124	BOUSTEAD INTERNATIONAL HEATERS LIMITED
12 . P0280	FOSTER WHEELER POWER PRODUCTS LTD

## 140103 : FIRE HEATER PACKAGE

CODE	NAME
<b>INDIA</b>	
1 . P0110	B H P V
2 . P0450	KINETICS TECHNOLOGY INDIA LTD.
3 . P1103	LARSEN & TOUBRO LIMITED
4 . P2191	PETROFAB (A Div. of PETRON ENGINEERING CONSTRUCTION LTD.
<b>ITALY</b>	
5 . P2205	KIRCHNER ITALIA S.p.A. JNK
<b>KOREA</b>	
6 . P2190	HEATERS CO., LTD. HEURTEY
<b>FRANCE</b>	
7 . P0345	PETROCHEM ENGG.
<b>ITALY</b>	
8 . P0465	KRICHER ITALIA S.P.A.
<b>JAPAN</b>	
9 . P0157	CHIYODA CORPORATION
<b>U.K.</b>	
10 . P0124	BOUSTEAD INTERNATIONAL HEATERS LIMITED
11 . P0280	FOSTER WHEELER POWER PRODUCTS LTD

## 140104 : CATALYST TUBES /REFORMER TUBES

CODE	NAME
<b>INDIA</b>	
1 . P4001	CENTRA CERO S.A.
2 . P0589	NITIN CASTINGS LIMITED
3 . P0840	UNI ABEX ALLOY PRODUCTS LIMITED
<b>UK</b>	
4 . P2171	CRONITE SCOMARK ENGG. LTD. (Subject to approval by Process Licensor)
<b>CHINA</b>	
5 . P2158	YANTAI MANOIR HEAT RESISTANT ALLOYS CO. LTD. , P.R.OF CHINA (Material for Centrifugally-Cast Tubes and Static Casting Fittings - Manaurite XM, 900 & 900B with Complete assembly.(Sub. to approval by Process Licensor))
<b>FRANCE</b>	
6 . P0511	MANOIR INDUSTRIES
<b>GERMANY</b>	
7 . P0637	POSE-MARRE EDELSTAHLWERK GMBH
8 . P0707	SCHMIDT & CLEMENS GMBH & CO
<b>JAPAN</b>	
9 . P0412	ITOCHU CORPORATION (REP.KUBOTA CORPN.)
10 . P0458	KOBE STEEL LIMITED
<b>SPAIN</b>	
11 . P2151	T.T.I. - TUBACEX TUBOS INOXIDABLES, S.A. (Upto 250.0 mm OD)
<b>U.K.</b>	
12 . P0209	DONCASTERS-PARALLOY
<b>U.S.A.</b>	
13 . P0014	ABEX CORPORATION

## 140105 : BURNERS

CODE	NAME
<b>USA</b>	
1 . P2236	ZEECO. INC
<b>INDIA</b>	
2 . P0027	AIROIL FLAREGAS (INDIA) PVT.LIMITED,
<b>ITALY</b>	
3 . P2237	I.C.E. Srl (INTERNATIONAL COMBUSTION EQUIPMENT Srl)
<b>USA</b>	
4 . P2203	CALLIDUS TECHNOLOGIES, LLC
<b>JAPAN</b>	
5 . P0584	NIPPON NATIONAL AIR OIL
<b>U.K.</b>	
6 . P7034	CALIDUS
7 . P0333	HAMWORTHY COMBUSTION ENGINEERING LTD.
8 . P0429	JOHN ZINK COMPANY LIMITED
<b>U.S.A.</b>	
9 . P0895	ZINK JOHN CO.

## 140107 : REFRACTORIES (BRICKS)

CODE	NAME
<b>INDIA</b>	
1 . P0069	CALDERYS INDIA REFRACTORIES LIMITED
2 . P2221	GLOBE CARBON INDUSTRIES
3 . P4008	REFRACTORIES SHAPES PVT LTD (3400 MT/Annum)
<b>GERMANY</b>	
4 . P0205	DIDIER WERKE AG
<b>HOLLAND</b>	
5 . P0401	INSULCON B.V.
<b>ITALY</b>	
6 . P0160	CIRIA S.P.A.
<b>JAPAN</b>	
7 . P0634	PLIBRICO JAPAN CO. LTD.
<b>SINGAPORE</b>	
8 . P0336	HARBISON-WALKER REFRACTORIES COMPANY
<b>U.K.</b>	
9 . P0551	M.H. DETRICK CO. LTD.,
10 . P0799	THE CARBORUNDUM CO. LTD.
11 . P0803	THERMAL CERAMIC LTD.



## 140108 : REFRACTORIES (CERAMIC FIBRES)

CODE	NAME
<b>INDIA</b>	
1 . P2231	UNIFRAX INDIA LIMITED
<b>FRANCE</b>	
2 . P4006	SAVOIE REFRACTORIES
<b>GERMANY</b>	
3 . P0205	DIDIER WERKE AG
<b>HOLLAND</b>	
4 . P4005	INSULATION BV
<b>ITALY</b>	
5 . P0160	CIRIA S.P.A.
<b>JAPAN</b>	
6 . P4003	ISOLITE INSULATING PRODUCT
7 . P0634	PLIBRICO JAPAN CO. LTD.
8 . P4004	NICHIAS CORPN.
<b>SINGAPORE</b>	
9 . P0336	HARBISON-WALKER REFRACTORIES COMPANY
<b>U.K.</b>	
10 . P7008	CARBORANDUM RESISTANT MATERIAL
11 . P0551	M.H. DETRICK CO. LTD.,
12 . P4002	THERMAL CERAMICS LTD.
<b>U.S.A.</b>	
13 . P7010	AP GREEN REFRACTORIES

**140108: REFRACTORIES (CERAMIC FIBRES)**

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<b>CODE</b>	<b>NAME</b>
14. P4007	CHRISTY REFRACTORIES COMPANY

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## 140109 : HOT COLLECTOR & OUTLET PIGTAIL

CODE	NAME
<b>BELGIUM</b>	
1 . P0876	WELDERS N.V.
<b>FRANCE</b>	
2 . P0511	MANOIR INDUSTRIES
<b>GERMANY</b>	
3 . P0637	POSE-MARRE EDELSTAHLWERK GMBH
4 . P0707	SCHMIDT & CLEMENS GMBH & CO
<b>ITALY</b>	
5 . P0191	DALMINE SPA
<b>JAPAN</b>	
6 . P0412	ITOCHU CORPORATION (REP.KUBOTA CORPN.)
7 . P0458	KOBE STEEL LIMITED
<b>SWEDEN</b>	
8 . P0004	AB SANDVIK STEEL
<b>U.S.A.</b>	
9 . P0014	ABEX CORPORATION

## 140110 : INLET PIGTAIL & INLET DISTRIBUTOR

CODE	NAME
<b>INDIA</b>	
1 . P0589	NITIN CASTINGS LIMITED
<b>BELGIUM</b>	
2 . P0876	WELDERS N.V.
<b>FRANCE</b>	
3 . P0511	MANOIR INDUSTRIES
<b>GERMANY</b>	
4 . P0637	POSE-MARRE EDELSTAHLWERK GMBH
5 . P0707	SCHMIDT & CLEMENS GMBH & CO
<b>ITALY</b>	
6 . P0191	DALMINE SPA
<b>JAPAN</b>	
7 . P0412	ITOCHU CORPORATION (REP.KUBOTA CORPN.)
8 . P0458	KOBE STEEL LIMITED
<b>SWEDEN</b>	
9 . P0004	AB SANDVIK STEEL
<b>U.S.A.</b>	
10 . P0014	ABEX CORPORATION

## 140111 : W.H. RECOVERY COILS & TUBE MATL.FOR W.H.R. & FIRED HEATERS

CODE	NAME
<b>INDIA</b>	
1 . P0110	B H P V
2 . P1101	LARSEN & TOUBRO LIMITED
3 . P0840	UNI ABEX ALLOY PRODUCTS LIMITED (For cracker coils)
<b>SPAIN</b>	
4 . P2213	DELFIN TUBES, S.A. (Convection Section Coil Assessblies & Accessories)
<b>GERMANY</b>	
5 . P0713	SELAS-LINDE GMBH
<b>ITALY</b>	
6 . P0191	DALMINE SPA
<b>JAPAN</b>	
7 . P0157	CHIYODA CORPORATION
8 . P0412	ITOCHU CORPORATION (REP.KUBOTA CORPN.)
9 . P0458	KOBE STEEL LIMITED
<b>KOREA</b>	
10 . P0370	HYUNDAI CORPORATION
<b>SPAIN</b>	
11 . P2151	T.T.I. - TUBACEX TUBOS INOXIDABLES, S.A. (Upto 250.0 mm OD)
<b>U.K.</b>	
12 . P0124	BOUSTEAD INTERNATIONAL HEATERS LIMITED

## 140113 : COMBUSTION AIR PRE-HEATER

CODE	NAME
<b>INDIA</b>	
1 . P2217	KAMAL ENGINEERING CORPORATION (A DIV.OF KEC INDUSTRIES LTD.)
2 . P0431	KAMAL ENGINEERING CORPORATION,
3 . P1109	KELVION INDIA PRIVATE LIMITED (FORMERLY GEA ECOFLEX INDIA PV
<b>BELGIUM</b>	
4 . P0139	BY-CAST NV
<b>FRANCE</b>	
5 . P0332	HAMON INDUSTRIE THERMIQUE
<b>ITALY</b>	
6 . P0191	DALMINE SPA

## 140114 : ID/FD FAN SET

CODE	NAME
<b>INDIA</b>	
1 . P8028	TLT ENGINEERING INDIA PVT LTD (up to 100m3/sec,750KW, Blower upto 400 Deg.C)
<b>GERMANY</b>	
2 . P0309	GHH BORSIG TURBOMASCHINEN GMBH
3 . P0508	SIEMENS AG PGI
<b>ITALY</b>	
4 . P0196	DE CARDENAS S.R.L.
<b>JAPAN</b>	
5 . P0208	DMW STAINLESS SAS
6 . P0220	EBARA CORPORATION
7 . P0437	KAWASAKI HEAVY INDUSTRIES LTD.
<b>U.S.A.</b>	
8 . P0394	INGERSOLL DRESSER PUMP CO.
9 . P0896	ZURN INDUSRIES

**140115: STATIC CASTINGS (TUBE SHEET / FITTINGS)**

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CODE	NAME
<i>UK</i>	
1 . P2171	CRONITE SCOMARK ENGG. LTD. (Subject to approval by Process Licensor)

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## 140116 : FINNED TUBES / STUDDED TUBES

CODE	NAME
<b>INDIA</b>	
1 . P2208	AKSHAR PRECISION TUBES PVT. LTD. (Finned Tubes:upto 6" , Studded Tubes: upto 8")
<b>SPAIN</b>	
2 . P2213	DELFIN TUBES, S.A. (Upto 10")

	<b>MASTER VENDORS LIST FOR PROJECTS</b>	04-00MM-0011	18
		DOCUMENT NO	REV

**MASTER VENDORS LIST**  
**FOR**  
**PROJECTS**  
**MECHANICAL ITEMS (MATERIAL HANDLING)**

## INDEX MECHANICAL (MATERIAL HANDLING) ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE NO.
<b>1501</b>	<b>MATERIAL HANDLING PACKAGES</b>	
150101	UREA HANDLING SYSTEM	3
150102	RAW MATL / COAL HANDLING SYSTEM	4
150103	ASH HANDLING SYSTEM	5
150104	PNEUMATIC HANDLING SYSTEM	6
150105	AUTOMATIC BAGGING & PACKING	7
150106	PALLETIZER	8
<b>1502</b>	<b>CONVEYORS &amp; RELATED EQPTS/ITEMS</b>	
150201	BELT CONVEYOR	9
150202	SCREW CONVEYOR	11
150203	PIPE CONVEYORS	12
150204	CONVEYOR BELTING	13
150205	BUCKET ELEVATOR	14
150206	CONTINUOUS BELT WEIGHER	15
150207	BELT CONVEYOR COMPONENTS(IDLERS & PULLEYS)	16
150208	EXTERNAL BELT CLEANER	17
150209	SKIRT BOARD SEALING SYSTEM	18
150210	PRILLING BUCKETS FOR UREA, AN & ANP	19
<b>1503</b>	<b>BAGGING &amp; LOADING / DESPATCH EQPTS.</b>	
150301	WEIGHING CUM TIPPING MACHINE (BAGGING M/C)	20
150302	BAG STITCHING MACHINE	21
150303	BIG BAG FILLING MACHINE	22
150304	WAGON LOADERS & TRUCK LOADERS	23
150305	FILLED BAG DIVERTOR	24
150306	BULK LOADING / UNLOADING SYSTEM & SPOUT	25
<b>1504</b>	<b>OTHER MATERIAL HANDLING EQUIPMENTS</b>	
150401	CRUSHERS & VIBRATING SCREENS	26
150402	E.O.T. CRANES	27
150403	H.O.T CRANES	28
150404	ELECTRIC HOISTS	29
150405	CHAIN PULLEY BLOCKS/CHAIN HOISTS	30

## INDEX CUSTOM CLEARANCE & TRANSPORTATION ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE NO.
150406	RAIL/ROAD WEIGH BRIDGE	31
150407	JIB CRANE	32
150408	DUST EXTRACTION SYSTEM	33
<b>1508</b>	<b>LPG CHAIN CONVEYOR SYSTEM &amp; INLINE EQUIPMENTS</b>	
150801	LPG CHAIN CONVEYOR SYSTEM & INLINE EQUIPMENTS	34
150802	LPG CAROUSAL	35
150803	LPG AIR COMPRESSOR	36
150804	DG SET FOR LPG BOTTLING PLANT	37
150805	WEIGHBRIDGE (WEIGHING MACHINE)	38

## 150101 : UREA HANDLING SYSTEM

CODE	NAME
<b>INDIA</b>	
1 . P3017	ELECON ENGG. CO. LTD.
2 . P3018	FENNER (INDIA) LTD.
3 . P3027	INDIANA CONVEYORS PVT. LTD.
4 . P3019	TECHNIMONT ICB
5 . P3020	TRF LTD

## 150102 : RAW MATL / COAL HANDLING SYSTEM

CODE	NAME
<b>INDIA</b>	
1 . P3017	ELECON ENGG. CO. LTD. (>Rs.5 Crores)
2 . P3018	FENNER (INDIA) LTD. (>Rs.5 Crores)
3 . P3027	INDIANA CONVEYORS PVT. LTD.
4 . P3023	MACNALLY BHARAT ENGG. CO. LTD. (>Rs.5 Crores)
5 . P3022	MASYC PROJECTS PVT. LTD. (< Rs 10 Crores)
6 . P3024	SHREE CONVEYOR SYSTEMS PVT. LTD. (<Rs 5 Crores)
7 . P3025	SIMPLICITY PROJECTS (<Rs 5 Crores)
8 . P3020	TRF LTD (>Rs.5 Crores)

## 150103 : ASH HANDLING SYSTEM

CODE	NAME
<b>INDIA</b>	
1 . P3312	DESEIN (INDURE)
2 . P3334	MACAWBER BEEKAY PVT.LTD
3 . P2260	SOLID MATERIAL CONVEYING SYSTEMS (Upto 26.5 TPH)
4 . P3369	UNITED CONVEYOR CORPORATION

## 150104 : PNEUMATIC HANDLING SYSTEM

CODE	NAME
<b>INDIA</b>	
1 . P1158	ACME AIR EQUIPMENTS CO. PVT.LTD.
2 . P3389	COPERION IDEAL PVT. LTD. (From 500 kg/hr to 120,000 kg/hr)
3 . P3334	MACAWBER BEEKAY PVT.LTD
4 . P3021	SCORPIO ENGG. PVT. LTD.
5 . P2260	SOLID MATERIAL CONVEYING SYSTEMS (Upto 26.5 TPH)



## 150105 : AUTOMATIC BAGGING & PACKING

CODE	NAME
<b>INDIA</b>	
1 . P2282	ARODO INDIA PRIVATE LIMITED (UPTO 1000 BAGS/HR (BAG WEIGHT-50KG))
2 . P3035	CHRONOS RICHARDSON
3 . P0225	EEL INDIA LTD.
<b>ITALY</b>	
4 . P2225	CONCETTI S.P.A. (Up to 2400 bags/hr.)
<b>GERMANY</b>	
5 . P3308	BINDER CO AG
6 . P3038	LIBRAWERK
7 . P3039	VOLLENDRA-WERK
<b>JAPAN</b>	
8 . P3041	NEWLONG MACHINE CO.
<b>U.K.</b>	
9 . P3036	CLYDE RICHARD SIMON LTD

## 150106 : PALLETIZER

CODE	NAME
<b>INDIA</b>	
1 . P2282	ARODO INDIA PRIVATE LIMITED (UPTO 1000 BAGS/HR (HEIGHT-2100MM))
2 . P3035	CHRONOS RICHARDSON
<b>ITALY</b>	
3 . P2225	CONCETTI S.P.A. (Up to 2800 bags/hr.)

## 150201 : BELT CONVEYOR

CODE	NAME
<b>INDIA</b>	
1 . P3026	ADVANCE DYNAMICS (< Rs.3 Crores)
2 . P2222	BTL EPC LIMITED (FORMERLY BENGAL TOOLS LIMITED)
3 . P0164	COBIT ENGINEERING PVT. LTD.
4 . P2267	CONTINENTAL CONVEYORS PRIVATE LIMITED (500mm width to 2200mm width only)
5 . P0225	EEL INDIA LTD. (< 5 Crores)
6 . P3017	ELECON ENGG. CO. LTD.
7 . P3018	FENNER (INDIA) LTD.
8 . P3031	HYQUIP SYSTEMS PVT. LTD. (< Rs.3 Crores)
9 . P3027	INDIANA CONVEYORS PVT. LTD.
10 . P3028	KONEL PROJECTS
11 . P2234	MACMET ENGINEERING LIMITED
12 . P3023	MACNALLY BHARAT ENGG. CO. LTD.
13 . P3030	MAHINDRA ENGG. & CHEMICALS (< Rs.3 Crores)
14 . P3022	MASYC PROJECTS PVT. LTD.
15 . P3029	NAVEEN PROJECTS (< Rs.10 Crores)
16 . P3021	SCORPIO ENGG. PVT. LTD. (Upto 500TPH)
17 . P3024	SHREE CONVEYOR SYSTEMS PVT. LTD. (< Rs.5 Crores)

## 150201 : BELT CONVEYOR

CODE	NAME
18 . P3025	SIMPLICITY PROJECTS (< Rs.5 Crores)
19 . P3062	STALLION ENGG. SYSTEMS PVT. LTD. (< Rs 20 Lakhs)
20 . P3032	TEC PRO SYSTEMS LTD. (< Rs.5 Crores)
21 . P3020	TRF LTD

## 150202 : SCREW CONVEYOR

CODE	NAME
<b>INDIA</b>	
1 . P2222	BTL EPC LIMITED (FORMERLY BENGAL TOOLS LIMITED)
2 . P0164	COBIT ENGINEERING PVT. LTD.
3 . P3069	DOMACLS ENGG. (P) LTD.
4 . P3017	ELECON ENGG. CO. LTD.
5 . P3027	INDIANA CONVEYORS PVT. LTD.
6 . P3028	KONEL PROJECTS
7 . P3022	MASYC PROJECTS PVT. LTD.
8 . P3024	SHREE CONVEYOR SYSTEMS PVT. LTD.
9 . P3032	TEC PRO SYSTEMS LTD.

## 150203 : PIPE CONVEYORS

CODE	NAME
<b>INDIA</b>	
1 . P2222	BTL EPC LIMITED (FORMERLY BENGAL TOOLS LIMITED)
2 . P2234	MACMET ENGINEERING LIMITED
3 . P3022	MASYC PROJECTS PVT. LTD.
4 . P3029	NAVEEN PROJECTS
5 . P3024	SHREE CONVEYOR SYSTEMS PVT. LTD.

**150204 : CONVEYOR BELTING**

<b>CODE</b>	<b>NAME</b>
<b>INDIA</b>	
1 . P3049	ANDREW YULE & CO.
2 . P3378	ANIL RUBBER MILLS PVT. LIMITED
3 . P3047	MRF LIMITED
4 . P3046	ORIENTAL RUBBER INDUSTRIES LTD.
5 . P2148	PENTAGON RUBBER PVT. LTD., (Conveyor Belting of Grade N-17, M-24, HR, SHR & FR as per IS 1891/1994. Width <= 1600 mm and thk. 5-30mm.)
6 . P3048	SEMPERTRANS INDIA PRIVATE LIMITED
7 . P3370	UNIVERSAL CONVEYOR BELTING LTD

## 150205 : BUCKET ELEVATOR

CODE	NAME
<b>INDIA</b>	
1 . P3049	ANDREW YULE & CO.
2 . P3064	BHP ENGINEERS
3 . P2222	BTL EPC LIMITED (FORMERLY BENGAL TOOLS LIMITED)
4 . P0164	COBIT ENGINEERING PVT. LTD.
5 . P3069	DOMACLS ENGG. (P) LTD.
6 . P0225	EEL INDIA LTD. (upto 225 TPH)
7 . P3017	ELECON ENGG. CO. LTD.
8 . P3027	INDIANA CONVEYORS PVT. LTD.
9 . P3030	MAHINDRA ENGG. & CHEMICALS
10 . P3024	SHREE CONVEYOR SYSTEMS PVT. LTD.
11 . P3033	SOLCON ENGINEERS PVT. LTD. (upto 100TPH & 30M High)
12 . P3032	TEC PRO SYSTEMS LTD.
13 . P3020	TRF LTD



## 150206 : CONTINOUS BELT WEIGHER

CODE	NAME
<b>INDIA</b>	
1 . P3314	ENCARDIO-RITE ELECTRONICS PVT.LTD.
2 . P3326	JENSON & NICHOLSON
3 . P0639	POWER ENGG CO
4 . P3362	TEGA INDIA LIMITED
5 . P3365	TRANSWEIGH (INDIA) LIMITED
6 . P3375	WEITEX INDIA LIMITED.

## 150207 : BELT CONVEYOR COMPONENTS(IDLERS & PULLEYS)

CODE	NAME
<b>INDIA</b>	
1 . P2226	GLOBAL CONVEYOR SYSTEMS PVT. LTD. (HPPE (High Performance Poly Etheylene) Idlers & Ceramic Pulleys)
2 . P3026	ADVANCE DYNAMICS
3 . P2222	BTL EPC LIMITED (FORMERLY BENGAL TOOLS LIMITED)
4 . P0164	COBIT ENGINEERING PVT. LTD.
5 . P3017	ELECON ENGG. CO. LTD.
6 . P3018	FENNER (INDIA) LTD.
7 . P0373	IGP ENGINEERS LIMITED
8 . P3027	INDIANA CONVEYORS PVT. LTD.
9 . P2234	MACMET ENGINEERING LIMITED
10 . P3022	MASYC PROJECTS PVT. LTD.
11 . P3029	NAVEEN PROJECTS
12 . P3024	SHREE CONVEYOR SYSTEMS PVT. LTD.
13 . P3062	STALLION ENGG. SYSTEMS PVT. LTD. (idlers & pulley)
14 . P3032	TEC PRO SYSTEMS LTD.

## 150208 : EXTERNAL BELT CLEANER

CODE	NAME
<b>INDIA</b>	
1 . P3319	HOSCH EQUIPMENT (I) LIMITED.
2 . P3328	KAVERI ULTRA -POLYMERS LTD.
<b>ITALY</b>	
3 . P0791	TECHNOMATIC SPA

## 150209 : SKIRT BOARD SEALING SYSTEM

CODE	NAME
<b>INDIA</b>	
1 . P3328	KAVERI ULTRA -POLYMERS LTD.
2 . P3362	TEGA INDIA LIMITED
<b>ITALY</b>	
3 . P0791	TECHNOMATIC SPA

**150210: PRILLING BUCKETS FOR UREA, AN &ANP**

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CODE	NAME
<b>INDIA</b>	
1 . P3068	SIMCO PRILLING EQUIPMENTS

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## 150301 : WEIGHING CUM TIPPING MACHINE (BAGGING M/C)

CODE	NAME
<b>INDIA</b>	
1 . P3035	CHRONOS RICHARDSON
2 .	CHRONOS RICHARDSON
3 . P0225	EEL INDIA LTD. (upto 600 Bags/Hr)
4 . P3034	JASUBHAI RICHARD SIMON
5 . P2283	TECHNO WEIGH SYSTEMS PVT. LTD. (UP TO 900 BAG / HR)
<b>AUSTRIA</b>	
6 . P3040	WAGNER BIRO BINDER AG
<b>GERMANY</b>	
7 . P3038	LIBRAWERK
8 . P3039	VOLLENDRA-WERK
<b>JAPAN</b>	
9 . P3041	NEWLONG MACHINE CO.
<b>U.K.</b>	
10 . P3037	CHRONOS RICHARDSON
11 . P3036	CLYDE RICHARD SIMON LTD

## 150302 : BAG STITCHING MACHINE

CODE	NAME
<b>INDIA</b>	
1 . P3035	CHRONOS RICHARDSON ((Sealing & Stitching M/c))
2 . P3354	REED MEDWAY PACKAGING CO. LIMITED
3 . P2247	SUMECH ENGINEERS PRIVATE LIMITED (upto 1200 bags/hr.)
4 . P2283	TECHNO WEIGH SYSTEMS PVT. LTD. (UP TO 900 BAG / HR)
<b>GERMANY</b>	
5 . P3368	UNION SPECIAL GmbH
<b>JAPAN</b>	
6 . P3345	NEWLONG MACHINE CO
<b>SINGAPORE</b>	
7 . P3315	FISCHBEN PACKAGING (SINGAPORE) PTE LTD.
<b>UAE</b>	
8 . P3344	NEW LONG FZE

**150303 : BIG BAG FILLING MACHINE**

<b>CODE</b>	<b>NAME</b>
<b>INDIA</b>	
1 . P0225	EEL INDIA LTD. (upto 2.0 Te)
2 . P3022	MASYC PROJECTS PVT. LTD.
3 . P3021	SCORPIO ENGG. PVT. LTD. (Upto 2.0 Te)
4 . P2283	TECHNO WEIGH SYSTEMS PVT. LTD. (UP TO 10 BAG / HR)



## 150304 : WAGON LOADERS & TRUCK LOADERS

CODE	NAME
<b>INDIA</b>	
1 . P3042	BLUE STAR LIMITED (BINDER)
2 . P0225	EEL INDIA LTD. (upto 1200 Bags/Hr)
3 . P0638	POWER BUILD LTD
<b>FRANCE</b>	
4 . P3045	BABIELA
<b>GERMANY</b>	
5 . P3043	BEUMER
6 . P3308	BINDER CO AG
7 . P3044	MACHINEN FABRIK MOLLERS GMBH

## 150305 : FILLED BAG DIVERTOR

CODE	NAME
<b>INDIA</b>	
1 . P3022	MASYC PROJECTS PVT. LTD.
2 . P3024	SHREE CONVEYOR SYSTEMS PVT. LTD.
3 . P2283	TECHNO WEIGH SYSTEMS PVT. LTD. (UP TO 900 BAG / HR)

**150306 : BULK LOADING / UNLOADING SYSTEM & SPOUT**

CODE	NAME
<b>INDIA</b>	
1 . P3072	DCL BULK TECHNOLOGIES PVT.LTD.
2 . P2283	TECHNO WEIGH SYSTEMS PVT. LTD. (3T/ HR)

**150401 : CRUSHERS & VIBRATING SCREENS**

CODE	NAME
<b>INDIA</b>	
1 . P3069	DOMACLS ENGG. (P) LTD.
2 . P3017	ELECON ENGG. CO. LTD.
3 . P3323	INTERNATIONAL COMBUSTION
4 . P3329	KINERGY
5 . P3022	MASYC PROJECTS PVT. LTD.
6 . P3342	McNALLY BHARAT ENGG. CO
7 . P3358	SAYAJI IRON & ENGINEERING CO. LTD.
8 . P3366	TRF LIMITED.
9 . P3372	USHA MILL PVT.LIMITED

## 150402 : E.O.T. CRANES

CODE	NAME
<b>INDIA</b>	
1 . P3382	AVON CRANES
2 . P2241	SAFEX ENERGY PVT. LTD.
3 . P3066	SAMCO ENGINEERING PVT. LTD (upto 30 tonnes capacity)
4 . P3363	THE ACME MANUFACTURING CO.LTD.
5 . P3376	WMI CRANES

## 150403 : H.O.T CRANES

CODE	NAME
<b>INDIA</b>	
1 . P3305	ANUPAM INDUSTRIES LIMITED.
2 . P3310	CONSOLIDATED HOISTS PVT.LTD.
3 . P3318	GRIP ENGINEERS PVT. LTD.
4 . P0344	HERCULES HOISTS LTD.
5 . P3332	LIFTING EQPT.& ACCESSORIES LTD.
6 . P3337	MEEKA MACHINERY CO.
7 . P3355	REVA ENGG. INDUSTRIES LIMITED
8 . P3367	UNICON TECHNOLOGY INTERNATIONAL (P) LTD.
9 . P3373	W.H.BRADY & CO LTD.

## 150404 : ELECTRIC HOISTS

CODE	NAME
<b>INDIA</b>	
1 . P3017	ELECON ENGG. CO. LTD.
2 . P0320	GREAVES LTD.
3 . P0344	HERCULES HOISTS LTD.
4 . P0361	HOIST-O-MECH.LTD.
5 . P0365	HOPES METAL INDUSTRIES(I) LTD.
6 . P2241	SAFEX ENERGY PVT. LTD.
7 . P3066	SAMCO ENGINEERING PVT. LTD (upto 20 tonnes capacity)
8 . P0704	SAYAJI IRON & ENGG.CO(P)LIMITED
9 . P0855	VAUGHAN BURN CRANE CO.LIMITED
10 . P0885	W.H. BRADY & CO. LIMITED

## 150405 : CHAIN PULLEY BLOCKS/CHAIN HOISTS

CODE	NAME
<b>INDIA</b>	
1 . P0091	BATLIBOI & CO. LTD.
2 . P0344	HERCULES HOISTS LTD.
3 . P3332	LIFTING EQPT.& ACCESSORIES LTD.
4 . P3333	LIGHT LIFT INDUSTRIES.
5 . P3335	MANGLA HOIST & HYDRAULICS LTD.
6 . P3355	REVA ENGG. INDUSTRIES LIMITED
7 . P2241	SAFEX ENERGY PVT. LTD.
8 . P3364	TRACTEL TIRFOR INDIA PVT.LIMITED
9 . P3373	W.H.BRADY & CO LTD.



## 150406 : RAIL/ROAD WEIGH BRIDGE

CODE	NAME
<b>INDIA</b>	
1 . P3306	ASHBEE SYSTEMS (P) LIMITED.
2 . P3379	ATCO PRODUCTS LIMITED.
3 . P3307	AVERY INDIA LTD.
4 . P3317	GLOBAL WEIGHING INDIA
5 . P3320	HYDERABAD TULAMEN LTD.
6 . P3322	INTEGRATED PROCESS AUTOMATION
7 . P3326	JENSON & NICHOLSON
8 . P3327	JYOTI WEIGHING SYSTEM LTD.
9 . P3338	METTLER- TOLLEDO INDIA PVT.LTD.
10 . P3349	PENTA ELECTRONICS SYSTEM
11 . P3357	SANMAR WEIGHING SYSTEM LTD.

## 150407 : JIB CRANE

CODE	NAME
<b>INDIA</b>	
1 . P2241	SAFEX ENERGY PVT. LTD.
2 . P3066	SAMCO ENGINEERING PVT. LTD (upto 5 tonnes capacity)

**150408 : DUST EXTRACTION SYSTEM**

CODE	NAME
<b>INDIA</b>	
1 . P2281	C K AIRTECH INDIA PRIVATE LIMITED (a CENTRIFUGAL BLOWERS:1000 TO 2,00,000 CMH b BAG FILTERS: 1000 TO 1,50,000 CMH c CYCLONES: 1000 TO 1,50,000 CMH d SCRUBBERS: 1000 TO 2,00,000 CMH)
2 . P3072	DCL BULK TECHNOLOGIES PVT.LTD. (DRY (BAG FILTER) TYPE)

**150801 : LPG CHAIN CONVEYOR SYSTEM & INLINE EQUIPMENTS**

<b>CODE</b>	<b>NAME</b>
<b>INDIA</b>	
1 . P3331	LAYCOCK ENGINEERS
2 . P3380	MENON & PATEL
3 . P3347	PAM SYSTEM
4 . P3352	RAGHVENDRA AUTOMATION PVT. LTD.
5 . P3356	S.S.FABS
6 . P3360	SPECTRUM MECHANICAL ENGINEERS PVT. LTD.

## 150802 : LPG CAROUSAL

CODE	NAME
<b>INDIA</b>	
1 . P3380	MENON & PATEL
2 . P3347	PAM SYSTEM
<b>DENMARK</b>	
3 . P3330	KOSAN CRISPLANT
<b>FRANCE</b>	
4 . P3359	SIRAGA SA

## 150803 : LPG AIR COMPRESSOR

CODE	NAME
<b>INDIA</b>	
1 . P3313	ELGI EQUIPMENTS LTD.
2 . P3057	INGERSOLL RAND INDIA LTD.
3 . P0478	KIRLOSKAR PNEUMATIC CO. LTD


## 150804 : DG SET FOR LPG BOTTLING PLANT

CODE	NAME
<b>INDIA</b>	
1 . P0188	CUMMINS INDIA LIMITED
2 . P3381	GOEL POWER CONTROLS
3 . P0321	GREAVES COTTON & CO. LTD.
4 . P8008	JAKSON ENGINEERS LTD
5 . P0451	KIRLOSKAR BROTHERS LIMITED
6 . P3348	PARRY & CO
7 . P3350	POWERICA LIMITED

## 150805 : WEIGHBRIDGE (WEIGHING MACHINE)

CODE	NAME
<b>INDIA</b>	
1 . P3307	AVERY INDIA LTD.
2 . P3324	JAY INSTRUMENTS & SYSTEMS LIMITED. (JISL)
3 . P3326	JENSON & NICHOLSON
4 . P3343	NARVE TULAMEN /HYDERABAD TULAMAN
5 . P0623	PHILIPS INDIA LTD.
6 . P3357	SANMAR WEIGHING SYSTEM LTD.



	<b>MASTER VENDORS LIST FOR PROJECTS</b>	04-00MM-0011	18
		DOCUMENT NO	REV

**MASTER VENDORS LIST**  
**FOR**  
**PROJECTS**  
**INSTRUMENT ITEMS**

## INDEX INSTRUMENTATION ENGINEERING ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE NO.
<b>3101</b>	<b>ANALYSERS</b>	
310101	GAS ANALYSERS(IR,Thermal Conductivity, Paramagnetic)	6
310102	pH , CONDUCTIVITY& ORP ANALYSER	7
310103	TRACE ANALYSER / ION SELECTIVE	8
310104	SOx / NOx ANALYSER	9
310105	MASS SPECTROMETER	10
310106	GAS CHROMATOGRAPH	11
310107	FLUE GAS ANALYSER (ZrO2 Type)	12
310108	H2S / TOTAL SULPHUR ANALYSERS	13
310109	SYSTEM HOUSE ANALYSERS	14
310110	DENSITY ANALYSERS	15
310111	MOISTURE ANALYSERS	16
310113	GAS & FIRE DETECTION SYSTEM	17
310114	AIR QUALITY MONITORING SYSTEM	18
310115	SAMPLE HANDLING SYSTEM	19
<b>3102</b>	<b>FLOW INSTRUMENTS</b>	
310201	FLOW ELEMENT:ORIFICE/VENTURI/ FLOW NOZZLE	20
310202	PITOT TUBE / ANNUBAR	22
310203	ROTAMETERS	23
310204	MASS FLOW METER (CORIOLIS TYPE)	24
310205	TURBINE FLOW METER	25
310206	VORTEX METER	26
310207	PD METER	27
310208	MAGNETIC FLOW METER	28
310209	INSERTION TYPE FLOW METER	29
310210	ULTRASONIC FLOW METER	30
310211	ORIFICE METER	31
310212	METERING SKID	32
<b>3103</b>	<b>PRESSURE INSTRUMENTS</b>	
310301	PRESSURE GAUGES	33
310302	VOL. SEAL PR. GAUGES	35
310303	LOCAL D/P INDICATORS	36
310304	PRESSURE & D/P TRANSMITTERS	37

## INDEX CUSTOM CLEARANCE & TRANSPORTATION ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE NO.
310305	VOL. SEAL PR./DP TRANSMITTER	38
310310	PRESSURE & D/P SWITCHES INCLUDING VOL. SEAL	39
310311	VOL. SEAL PRESSURE.&DP SWITCHES (UREA SERVICE)	40
<b>3104</b>	<b>LEVEL INSTRUMENTS</b>	
310401	TRANSPARENT/ REFLEX / BICOLOR MAG.LEVEL GAUGES	41
310402	LEVEL SWITCHES (FLOAT & DISPLACER TYPE)	43
310403	DISPLACER TYPE LEVEL TRANSMITTERS	44
310404	NUCLEONIC LEVEL TRANSMITTER	45
310405	CAPACITANCE TYPE LEVEL TRANSMITTER	46
310406	TANK LEVEL INSTRUMENTS	47
310408	RESITIVE ELECTRODE TYPE LEVEL INSTRUMENT	48
310409	SPECIAL LEVEL SWITCHES (VIBRATION FORK/RF ADMITTANCE)	49
310410	ULTRASONIC LEVEL TRANSMITTER	50
310411	TANK FARM MANAGEMENT	51
310412	GUIDED WAVE RADAR	52
310413	NUCLEONIC DENSITY METER	53
<b>3105</b>	<b>TEMPERTURE INSTRUMENTS</b>	
310501	TEMPERATURE ELEMENTS (THERMOCOUPLE, RTD)	54
310502	BIMETALLIC THERMOMETER	56
310503	DIAL THERMOMETER (Hg in Steel/Glass)	58
310504	RADIATION PYROMETER	59
310505	TEMPERATURE TRANSMITTER	60
310506	TEMPERATURE SWITCHES	61
310507	SPECIAL TEMPERATURE ELEMENTS	63
<b>3106</b>	<b>CONTROL VALVES</b>	
310601	GATE/PLUG VALVES	62
310602	GLOBE / ANGLE VALVES	64
310603	BALL VALVES	66
310604	BUTTERFLY VALVES	68
310605	SAUNDERS (PINCH) VALVES	70
310606	SOLENOID VALVES	71
310607	PRDS & SPRAY NOZZLE, VENT VALVES upto 2500#	72
310611	ELECTRIC ACTUATOR	73
310613	AIR FILTER REGULATOR	74

## INDEX CUSTOM CLEARANCE & TRANSPORTATION ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE NO.
310614	LIMIT/PROXIMITY SWITCHES	75
310615	VALVE ACTUATOR (PNEUMATIC / ROTARY)	76
310616	SELF ACTUATED PRESSURE CONTROL VALVES	77
310617	SLAM SHUT OFF VALVE	78
310618	ELECTROPNEUMATIC POSITIONER	79
310619	TURBINE BYPASS VALVES	80
310620	DESUPERHEATERS	81
310621	PRESSURE REDUCING STATION	82
310622	PRESSURE REGULATOR	83
<b>3107</b>	<b>SAFETY DEVICES</b>	
310701	SAFETY VALVES & THERMAL RELIEF VALVES upto 2500#	84
310703	VACUUM BREAKERS	86
310704	RUPTURE DISCS	87
310705	PILOT RELIEF VALVES	88
310706	LOW PRESSURE RELIEF VALVES	89
310708	FLAME ARRESTOR	90
<b>3108</b>	<b>CONTROL SYSTEM &amp; ACCESSORIES</b>	
310801	CONTROL PANEL	91
310802	PANEL ACCESS. ( Relay,Switch,Lamp,Terminal,Push Button)	92
310803	PROGRAMABLE LOGIC CONTROLLER	94
310804	DISTRIBUTED CONTROL SYSTEM	96
310805	MULTIPLEXER / REMOTE I/O	97
310806	RECEIVER INSTRUMENTS (INDICATOR,CONTROLLER,RECORDER)	98
310807	ALARM ANNUNCIATOR	99
310808	BARRIER/ISOLATOR/TRIP AMPLIFIER	100
310809	TEMPERATURE SCANNER	101
310810	CCTV / ACCESS SYSTEM	102
310815	MISCELLANEOUS ITEMS (RTU / SCADA ETC)	103
310816	ENERGY METER	104
310821	SURGE PROTECTION DEVICES	105
310824	WIRING DUCTS	106
310825	DIN RAIL	107
310826	INTERFACE MODULE	108
310827	CABLE CONNECTOR	109

## INDEX CUSTOM CLEARANCE & TRANSPORTATION ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE NO.
310828	ADVANCE PROCESS CONTROL SYSTEM	110
310829	VIDEO WALL DLP CUBE AND VIDEO WALL CONTROLLER	113
<b>3109</b>	<b>PUMP &amp; COMPRESSOR INSTRUMENTS</b>	
310901	MACHINE MONITORING SYSTEM	111
310902	SPEED INDICATOR	112
310903	ANTI SURGE CONTROLLER	113
<b>3110</b>	<b>BURNER INSTRUMENTATION</b>	
311001	BURNER MANAGEMENT SYSTEM	114
311002	FURNACE CAMERA, HEATER, THERMAL IMAGER	115
<b>3111</b>	<b>TERMINAL AUTOMATION</b>	
311101	TERMINAL AUTOMATION SYSTEM	116
<b>3115</b>	<b>OTHER INSTRUMENTS</b>	
311501	I/P CONVERTER	117
<b>3116</b>	<b>ERECTION MATERIALS</b>	
311601	INSTRUMENT POWER & CONTROL CABLES	118
311602	EXTENSION & COMPENSATING CABLES	119
311603	SPECIAL CABLES (FOUNDATION FIELD BUS CABLES)	120
311606	CABLE TRAYS & ACCESSORIES (AL./GI)	121
311607	MULTI TRANSIT INLET SYSTEM	122
311608	JUNCTION BOX & CABLE GLAND	123
311615	CS SEAMLESS PIPES	124
311616	SS SEAMLESS PIPES	126
311617	SS TUBES	127
311618	PIPE FITTINGS	128
311619	COMPRESSION FITTINGS	130
311620	INSTRUMENT MINIATURE VALVES	131
311621	PURGE ROTAMETER	133
311622	AIR HEADER/ADPOT	134
311623	CONDENSATE POT	135
311624	VALVE MANIFOLDS	136
311626	CALIBRATION EQUIPMENT & SERVICES	137

## INDEX CUSTOM CLEARANCE & TRANSPORTATION ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE NO.
311627	ENCLOSURES	138
311628	MONOFLANGES	139
311629	CLOSE COUPLE HOOK-UPS (CCHU)	140
311631	INSTRUMENTATION VALVES (NEEDLE VALVE & CHECK VALVES	141
<b>3117</b>	<b>INSTRUMENT CONTRACTOR</b>	
311701	INSTRUMENT CONTRACTOR FOR INST. CONSTRUCTION/ERECTION	142
<b>3118</b>	<b>TRACING</b>	
3118	TRACING	
311801	ELECTRICAL HEAT TRACING	143

## 310101 : GAS ANALYSERS(IR,Thermal Conductivity, Paramagnetic)

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
2 . P0153	CHEMTROLS INDUSTRIES LTD.
3 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
4 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD. (TDL type)
5 . P0891	YOKOGAWA INDIA LIMITED ((IR/UV, Thermal, UV, TDLS, Gas Density))
<b>GERMANY</b>	
6 . P0506	MAIHAK AKTIENGESELLSCHAFT
7 . P0735	SIEMENS AG, GERMANY
<b>SINGAPORE</b>	
8 . P0262	EMERSON PROCESS MGT SINGAPORE LTD
<b>U.S.A.</b>	
9 . P0043	AMETEK, INC.
10 . P0552	M.S.A. INTERNATIONAL

## 310102 : pH , CONDUCTIVITY& ORP ANALYSER

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
2 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
3 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD. (Liquid Analysers)
4 . P0277	FORBES POLYMETRON PVT. LTD.
5 . P0891	YOKOGAWA INDIA LIMITED ((pH, conductivity, turbidity, chlorine))
<b>FRANCE</b>	
6 . P0893	ZELLWEGER SA
<b>JAPAN</b>	
7 . P0892	YOKOGAWA ELECTRIC CORPORATION
<b>SINGAPORE</b>	
8 . P0262	EMERSON PROCESS MGT SINGAPORE LTD
9 . P0283	FOXBORO FAR EAST PTE LTD
<b>U.S.A.</b>	
10 . P0328	HACH COMPANY



## 310103 : TRACE ANALYSER / ION SELECTIVE

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
2 . P0277	FORBES POLYMETRON PVT. LTD.
<b>FRANCE</b>	
3 . P0893	ZELLWEGER SA
<b>U.K.</b>	
4 . P0125	BRAN & LUEBBE LTD.
<b>U.S.A.</b>	
5 . P0328	HACH COMPANY

## 310104 : SO<sub>x</sub> / NO<sub>x</sub> ANALYSER

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
2 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
3 . P0891	YOKOGAWA INDIA LIMITED ((CEMS, O <sub>2</sub> -Zirconia))
<b>GERMANY</b>	
4 . P0732	SICK AG
5 . P0735	SIEMENS AG, GERMANY
<b>JAPAN</b>	
6 . P0367	HORIBA LTD.
7 . P0892	YOKOGAWA ELECTRIC CORPORATION
<b>SINGAPORE</b>	
8 . P0262	EMERSON PROCESS MGT SINGAPORE LTD
<b>U.S.A.</b>	
9 . P0488	LEAR SIEGLER MEAS. CTRLS. CORP.
10 . P0552	M.S.A. INTERNATIONAL
11 . P0808	THERMO ENVIRONMENT INSTRUMENTS INC.

## 310105 : MASS SPECTROMETER

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
<b>U.K.</b>	
2 . P0858	VG GAS ANALYSIS SYSTEMS
<b>U.S.A.</b>	
3 . P0607	ORBITAL SCIENCE CORPORATION

## 310106 : GAS CHROMATOGRAPH

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
2 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
3 . P0891	YOKOGAWA INDIA LIMITED
<b>SINGAPORE</b>	
4 . P0054	APPLIED AUTOMATION INC
5 . P0283	FOXBORO FAR EAST PTE LTD

## 310107 : FLUE GAS ANALYSER (ZrO<sub>2</sub> Type)

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
2 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
3 . P0891	YOKOGAWA INDIA LIMITED
<b>IRELAND</b>	
4 . P0616	GE PANAMETRICS
<b>U.S.A.</b>	
5 . P0043	AMETEK, INC.

310108 : H<sub>2</sub>S / TOTAL SULPHUR ANALYSERS

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
<b>U.K.</b>	
2 . P0090	BARTON INSTRUMENT SYSTEMS LIMITED

## 310109 : SYSTEM HOUSE ANALYSERS

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
2 . P3431	ADAGE AUTOMATION PVT. LIMITED
3 . P3457	ANALYSER INSTRUMENT CO. PVT. LTD.
4 . P3492	AXIS SOLUTIONS PVT.LTD.
5 . P0153	CHEMTROLS INDUSTRIES LTD.
6 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
7 . P0891	YOKOGAWA INDIA LIMITED
<b>ITALY</b>	
8 . P0402	INTECH

## 310110 : DENSITY ANALYSERS

CODE	NAME
<b>INDIA</b>	
1 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD. (coriolis type)
<b>GERMANY</b>	
2 . P0121	BOPP & REUTHER MESSTECHNIK GMBH (coriolis type)
<b>U.K.</b>	
3 . P0741	SOLARTRON MOBREY



## 310111 : MOISTURE ANALYSERS

CODE	NAME
<b>IRELAND</b>	
1 . P0616	GE PANAMETRICS
<b>U.S.A.</b>	
2 . P0043	AMETEK, INC.

## 310113 : GAS & FIRE DETECTION SYSTEM

CODE	NAME
<b>INDIA</b>	
1 . P0050	ANDREW YULE & COMPANY LTD. (FIRE)
2 . P0787	HONEYWELL AUTOMATION INDIA LIMITED (GAS)
3 . P0415	J B BODA AND BROTHERS PVT. LTD. (GAS, Make-International Sensor Technology)
4 . P3101	POLLUTION PROTECTION SYSTEM MUMBAI PVT LTD (GAS)
5 . P3473	UNIPHOS ENVIROTRONIC PVT.LTD. (FOR GAS DETECTION SYSTEM ONLY)
<b>RUSSIA</b>	
6 . P3498	JSC "ELECTRONSTANDART-PRIBOR" (-)
<b>THAILAND</b>	
7 . P0794	TELEDYNE FLUID SYSTEMS (GAS)
<b>U.K.</b>	
8 . P0306	GENERAL MONITORS (GAS)



## 310114: AIR QUALITY MONITORING SYSTEM

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CODE	NAME
<i>INDIA</i>	
1 . P0153	CHEMTROLS INDUSTRIES LTD.

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## 310115: SAMPLE HANDLING SYSTEM

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CODE	NAME
<i>INDIA</i>	
1 . P3457	ANALYSER INSTRUMENT CO. PVT. LTD.

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## 310201 : FLOW ELEMENT:ORIFICE/VENTURI/ FLOW NOZZLE

CODE	NAME
<b>INDIA</b>	
1 . P3481	DYNAFLUID VALVES AND FLOW CONTROLS PVT.LTD
2 . P3482	MINCO (INDIA) PVT. LTD
3 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED (Only Orifice)
4 . P0153	CHEMTROLS INDUSTRIES LTD.
5 . P3476	COMFIT & VALVES PVT.LTD. (ONLY ORIFICE)
6 . P3199	EUREKA INDUSTRIAL EQUIPMENTS PRIVATE LIMITED (Upto 12" size & upto 600 #)
7 . P3510	EUREKA INDUSTRIAL EQUIPMENTS PVT. LTD.
8 . P3433	FLOWTECH INSTRUMENTS SERVICES (Orifice Plate /Venturi)
9 . P0304	GENERAL INSTRUMENTS CONSORTIUM,
10 . P3490	HYDROPNEUMATICS PVT.LTD
11 . P0400	INSTRUMENTATION LTD. (PALAKKAD)
12 . P0534	MICRO PRECISION PRODUCTS PRIVATE LTD.
13 . P3520	MINCO (INDIA) FLOW ELEMENTS PVT. LTD.
14 . P3453	MINCO (INDIA) FLOW ELEMENTS PVT.LTD. (All range)
15 . P3416	UNICONTROLS INSTRUMENTS PVT. LTD.
<b>GERMANY</b>	
16 . P0121	BOPP & REUTHER MESSTECHNIK GMBH
<b>ITALY</b>	

## 310201 : FLOW ELEMENT:ORIFICE/VENTURI/ FLOW NOZZLE

CODE	NAME
17 . P0791	TECHNOMATIC SPA
<b>U.K.</b>	
18 . P0408	ISA CONTROLS LIMITED
<b>U.S.A.</b>	
19 . P0193	DANIEL MEASUREMENT & CONTROL

## 310202 : PITOT TUBE / ANNUBAR

CODE	NAME
<b>INDIA</b>	
1 . P3481	DYNAFLUID VALVES AND FLOW CONTROLS PVT.LTD
2 . P3482	MINCO (INDIA) PVT. LTD
3 . P0151	ABB INDIA LIMITED
4 . P0171	CONTROL ENGINEERS
5 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
6 . P3510	EUREKA INDUSTRIAL EQUIPMENTS PVT. LTD.
7 . P0534	MICRO PRECISION PRODUCTS PRIVATE LTD.
8 . P3520	MINCO (INDIA) FLOW ELEMENTS PVT. LTD.
9 . P3416	UNICONTROLS INSTRUMENTS PVT. LTD.
<b>ITALY</b>	
10 . P0791	TECHNOMATIC SPA
<b>U.K.</b>	
11 . P0408	ISA CONTROLS LIMITED
<b>U.S.A.</b>	
12 . P0193	DANIEL MEASUREMENT & CONTROL

## 310203 : ROTAMETERS

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
2 . P0153	CHEMTROLS INDUSTRIES LTD.
3 . P3199	EUREKA INDUSTRIAL EQUIPMENTS PRIVATE LIMITED
4 . P3510	EUREKA INDUSTRIAL EQUIPMENTS PVT. LTD.
5 . P3433	FLOWTECH INSTRUMENTS SERVICES
6 . P0398	INSTRUMENTATION ENGINEERS PVT. LTD.
7 . P0468	KROHNE MARSHALL PVT. LTD.
8 . P0633	PLACKA INSTRUMENTS & CONTROLS PVT. LTD. (Purge Rotameter only)
9 . P0680	ROTA INSTRUMENTATION
10 . P0891	YOKOGAWA INDIA LIMITED
<b>GERMANY</b>	
11 . P0467	KROHNE
12 . P0681	ROTA YOKOGAWA GMBH & CO. KG
<b>JAPAN</b>	
13 . P0888	AZBIL CORPORATION (Formerly YAMATAKE CORPORATION)
14 . P0816	TOKYO KEISO CO. LTD.
<b>U.S.A.</b>	
15 . P0679	EMERSON PROCESS MGT



## 310204 : MASS FLOW METER (CORIOLIS TYPE)

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
2 . P0153	CHEMTROLS INDUSTRIES LTD.
3 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
4 . P3417	SIEMENS LTD.
5 . P0891	YOKOGAWA INDIA LIMITED
<b>GERMANY</b>	
6 . P0121	BOPP & REUTHER MESSTECHNIK GMBH
7 . P0238	ENDRESS + HAUSER GMBH & CO.,
8 . P0467	KROHNE
<b>U.S.A.</b>	
9 . P0706	SCHLUMBERGER RESOURCE MANAGEMENT LTD.

## 310205 : TURBINE FLOW METER

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
2 . P0153	CHEMTROLS INDUSTRIES LTD.
3 . P0275	FMC SANMAR LTD.
4 . P3462	ROCKWIN FLOWMETER INDIA PVT.LTD.
<b>GERMANY</b>	
5 . P0121	BOPP & REUTHER MESSTECHNIK GMBH
<b>HOLLAND</b>	
6 . P0397	INSTROMET INTERNATIONAL N.V
<b>JAPAN</b>	
7 . P0888	AZBIL CORPORATION (Formerly YAMATAKE CORPORATION)
8 . P0412	ITOCHU CORPORATION (REP.KUBOTA CORPN.)
<b>SINGAPORE</b>	
9 . P0611	OVAL ASEA PACIFIC PTE LTD
<b>U.K.</b>	
10 . P0090	BARTON INSTRUMENT SYSTEMS LIMITED
11 . P0192	EMERSON PROCESS MGT
<b>U.S.A.</b>	
12 . P0679	EMERSON PROCESS MGT
13 . P0675	ROCKWELL INTERNATIONAL CORPN.

## 310206 : VORTEX METER

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
2 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
3 . P0468	KROHNE MARSHALL PVT. LTD.
4 . P3417	SIEMENS LTD.
5 . P0891	YOKOGAWA INDIA LIMITED
<b>GERMANY</b>	
6 . P0121	BOPP & REUTHER MESSTECHNIK GMBH
7 . P0238	ENDRESS + HAUSER GMBH & CO.,
8 . P0467	KROHNE
<b>JAPAN</b>	
9 . P0412	ITOCHU CORPORATION (REP.KUBOTA CORPN.)
<b>U.S.A.</b>	
10 . P0706	SCHLUMBERGER RESOURCE MANAGEMENT LTD.

## 310207 : PD METER

CODE	NAME
<b>INDIA</b>	
1 . P0153	CHEMTROLS INDUSTRIES LTD.
2 . P3102	ROCKWIN FLOW METERS (I) PVT. LTD.
3 . P3462	ROCKWIN FLOWMETER INDIA PVT.LTD.
<b>GERMANY</b>	
4 . P0121	BOPP & REUTHER MESSTECHNIK GMBH
<b>SINGAPORE</b>	
5 . P0611	OVAL ASEA PACIFIC PTE LTD
<b>U.S.A.</b>	
6 . P0679	EMERSON PROCESS MGT
7 . P0706	SCHLUMBERGER RESOURCE MANAGEMENT LTD.

## 310208 : MAGNETIC FLOW METER

CODE	NAME
<b>INDIA</b>	
1 . P3479	ADEPT FLUIDYNE PVT.LTD
2 . P0151	ABB INDIA LIMITED
3 . P0153	CHEMTROLS INDUSTRIES LTD.
4 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
5 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD.
6 . P3510	EUREKA INDUSTRIAL EQUIPMENTS PVT. LTD.
7 . P0468	KROHNE MARSHALL PVT. LTD.
8 . P3459	SBEM PVT. LTD.
9 . P3417	SIEMENS LTD.
10 . P0891	YOKOGAWA INDIA LIMITED
<b>GERMANY</b>	
11 . P0121	BOPP & REUTHER MESSTECHNIK GMBH
12 . P0467	KROHNE
<b>JAPAN</b>	
13 . P0888	AZBIL CORPORATION (Formerly YAMATAKE CORPORATION)



## 310209: INSERTION TYPE FLOWMETER

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CODE	NAME
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<i>INDIA</i>	
1 . P3417	SIEMENS LTD.

## 310210 : ULTRASONIC FLOW METER

CODE	NAME
<b>INDIA</b>	
1 . P3479	ADEPT FLUIDYNE PVT.LTD ((Insertion Type only))
2 . P0153	CHEMTROLS INDUSTRIES LTD.
3 . P3465	EIP ENVIRO LEVEL CONTROLS PRIVATE LIMITED
4 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD.
5 . P3417	SIEMENS LTD.
6 . P0891	YOKOGAWA INDIA LIMITED



## 310211 :ORIFICE METER

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CODE	NAME
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<i>INDIA</i>	
1 . P0153	CHEMTROLS INDUSTRIES LTD.





## 310212: METERING SKID

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CODE	NAME
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<i>INDIA</i>	
1 .	CHEMTROLS INDUSTRIES LTD. ((For Liquid & Gas))

## 310301 : PRESSURE GAUGES

CODE	NAME
1 . P3185	(standard normal type)
<b>INDIA</b>	
2 . P3477	NESSTECH INSTRUMENTS PRIVATE LIMITED
3 . P3483	WIKA INSTRUMENTS INDIA PVT.LTD
4 . P0081	A N INSTRUMENTS PVT. LTD.
5 . P3103	BAUMER TECHNOLOGIES INDIA PVT. LTD.(FORMERLY WAAREE INSTRUM
6 . P3496	FORBES MARSHALL (HYD) PRIVATE LIMITED (Up to 0.6 to 600Kg/cm2)
7 . P3466	GAUGES BOURDON INDIA PVT. LTD (Mfg. unit of GIC)
8 . P0304	GENERAL INSTRUMENTS CONSORTIUM,
9 . P0371	H.GURU INDUSTRIES
10 . P3470	ITEC MEASURES PRIVATE LIMITED
11 . P0512	MANOMETER (INDIA) PVT. LTD.
12 . P3469	MICRO PROCESS CONTROLS
13 . P3517	MILLENNIUM INSTRUMENTS LIMITED
14 . P0622	PEEJEE ENGG. WORKS
15 . P3456	PRECISION MASS PRODUCTS PVT. LTD.
16 . P0646	PREMIUM INST. & CONTROLS LTD.

## 310301 : PRESSURE GAUGES

CODE	NAME
17 . P3454	THERMAL INSTRUMENT INDIA PVT.LTD.
18 . P0874	WALCHANDNAGAR INDUSTRIES LTD.
<b>GERMANY</b>	
19 . P0212	DRESSER EUROPE S.A.
20 . P0880	WIKA ALEXENDER WIEGAND GMBH & CO.
<b>ITALY</b>	
21 . P0746	SPRIANO SPA
<b>JAPAN</b>	
22 . P0558	NAGANO KEIKI SEISAKUSHO
<b>SWITZERLAND</b>	
23 . P0690	RUEGER SA
<b>U.K.</b>	
24 . P0136	BUDENBERG GAUGE CO. LTD.

## 310302 : VOL. SEAL PR. GAUGES

CODE	NAME
<b>INDIA</b>	
1 . P3483	WIKA INSTRUMENTS INDIA PVT.LTD
2 . P0081	A N INSTRUMENTS PVT. LTD. (=<600# Except Urea Service)
3 . P3496	FORBES MARSHALL (HYD) PRIVATE LIMITED ((Diaphragm Seal Pressure Gauge) (0.06 to 40 Kg/cm <sup>2</sup> ; Low Pressure Gauge range (100mm WC to 6000mmWC)
4 . P3470	ITEC MEASURES PRIVATE LIMITED
5 . P3469	MICRO PROCESS CONTROLS
6 . P3517	MILLENNIUM INSTRUMENTS LIMITED
7 . P3456	PRECISION MASS PRODUCTS PVT. LTD.
8 . P3454	THERMAL INSTRUMENT INDIA PVT.LTD.
<b>GERMANY</b>	
9 . P0212	DRESSER EUROPE S.A.
10 . P0880	WIKA ALEXENDER WIEGAND GMBH & CO.
<b>ITALY</b>	
11 . P0746	SPRIANO SPA
<b>JAPAN</b>	
12 . P0558	NAGANO KEIKI SEISAKUSHO
<b>SWITZERLAND</b>	
13 . P0690	RUEGER SA
<b>U.K.</b>	
14 . P0136	BUDENBERG GAUGE CO. LTD.

## 310303 : LOCAL D/P INDICATORS

CODE	NAME
<b>INDIA</b>	
1 . P3466	GAUGES BOURDON INDIA PVT. LTD (Mfg. unit of GIC)
2 . P3469	MICRO PROCESS CONTROLS
3 . P3517	MILLENNIUM INSTRUMENTS LIMITED
4 . P3456	PRECISION MASS PRODUCTS PVT. LTD.
5 . P0781	SWITZER INSTRUMENT CO.,
<b>U.K.</b>	
6 . P0090	BARTON INSTRUMENT SYSTEMS LIMITED
7 . P0198	DELTA CONTROLS LTD.

## 310304 : PRESSURE & D/P TRANSMITTERS

CODE	NAME
<b>GERMANY</b>	
1 . P3430	VEGA GRIESHABER KG
<b>INDIA</b>	
2 . P0151	ABB INDIA LIMITED
3 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
4 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD.
5 . P0787	HONEYWELL AUTOMATION INDIA LIMITED
6 . P3417	SIEMENS LTD.
7 . P0891	YOKOGAWA INDIA LIMITED
<b>GERMANY</b>	
8 . P0735	SIEMENS AG, GERMANY
<b>JAPAN</b>	
9 . P0888	AZBIL CORPORATION (Formerly YAMATAKE CORPORATION)
10 . P0892	YOKOGAWA ELECTRIC CORPORATION
<b>SINGAPORE</b>	
11 . P0262	EMERSON PROCESS MGT SINGAPORE LTD
12 . P0740	SMAR SINGAPORE PTE. LTD.
<b>U.S.A.</b>	
13 . P0363	HONEYWELL INC.,
14 . P0544	MOORE PRODUCTS COMPANY

## 310305 : VOL. SEAL PR./DP TRANSMITTER

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
2 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
3 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD.
4 . P0787	HONEYWELL AUTOMATION INDIA LIMITED
5 . P3417	SIEMENS LTD.
6 . P0891	YOKOGAWA INDIA LIMITED
<b>JAPAN</b>	
7 . P0888	AZBIL CORPORATION (Formerly YAMATAKE CORPORATION)
8 . P0287	FUJI ELECTRIC SYSTEMS CO. LTD. (Except Urea Service)
9 . P0892	YOKOGAWA ELECTRIC CORPORATION
<b>SINGAPORE</b>	
10 . P0262	EMERSON PROCESS MGT SINGAPORE LTD
<b>U.S.A.</b>	
11 . P0544	MOORE PRODUCTS COMPANY

## 310310 : PRESSURE & D/P SWITCHES INCLUDING VOL. SEAL

CODE	NAME
<b>INDIA</b>	
1 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD.
2 . P0379	INDFOS INDUSTRIES LTD. (except vol.seal)
3 . P3405	KAUSTUBHA UDYOG
4 . P3469	MICRO PROCESS CONTROLS
5 . P3456	PRECISION MASS PRODUCTS PVT. LTD.
6 . P0781	SWITZER INSTRUMENT CO., (except vol.seal)
<b>JAPAN</b>	
7 . P0888	AZBIL CORPORATION (Formerly YAMATAKE CORPORATION)
8 . P0558	NAGANO KEIKI SEISAKUSHO
<b>U.K.</b>	
9 . P0198	DELTA CONTROLS LTD.
<b>U.S.A.</b>	
10 . P0743	SOR INC.
11 . P0899	UNITED ELECTRIC CONTROLS CO.



## 310311 : VOL. SEAL PRESSURE.&amp;DP SWITCHES (UREA SERVICE)

CODE	NAME
<b>INDIA</b>	
1 . P3477	NESSTECH INSTRUMENTS PRIVATE LIMITED
2 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD.
3 . P3456	PRECISION MASS PRODUCTS PVT. LTD.
<b>ITALY</b>	
4 . P0746	SPRIANO SPA
<b>U.K.</b>	
5 . P0198	DELTA CONTROLS LTD.
<b>U.S.A.</b>	
6 . P0743	SOR INC.

## 310401 : TRANSPARENT/ REFLEX / BICOLOR MAG.LEVEL GAUGES

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
2 . P3414	BLISS ANAND PRIVATE LIMITED
3 . P3181	CHEMTROLS SAMIL (INDIA) PVT LTD.
4 . P3433	FLOWTECH INSTRUMENTS SERVICES
5 . P3466	GAUGES BOURDON INDIA PVT. LTD (Mfg. unit of GIC)
6 . P3400	NISAN SCIENTIFIC PROCESS EQUIPMENTS PVT. LTD. (Transparent/ Reflex type Level Gauge : Upto 600#; Tubular Type Level Gauges : Upto 150#)
7 . P3186	PUNE TECHTROL PVT.LTD. (<=300# rating only)
8 . P0792	TECNOMATIC (INDIA) PVT. LTD.
9 . P3491	V.AUTOMAT & INSTRUMENTS (P) LTD
10 . P0871	V.AUTOMAT & INSTRUMENTS (P) LTD. (upto 300#)
<b>AUSTRIA</b>	
11 . P0672	RICHARD KLINGER AG
<b>ITALY</b>	
12 . P0150	CESARE BONETTI SPA
13 . P0791	TECHNOMATIC SPA
<b>JAPAN</b>	
14 . P0577	NIHON KLINGAGE CO. LTD.
<b>U.S.A.</b>	
15 . P0161	CLARK-RELIANCE CORP.

**310401 : TRANSPARENT/ REFLEX / BICOLOR MAG.LEVEL GAUGES**

<b>CODE</b>	<b>NAME</b>
16 . P0425	JERGUSON GAUGE & VALVE CO.
17 . P0889	TYCO INTERNATIONAL INC.,U.S.A.

## 310402 : LEVEL SWITCHES (FLOAT & DISPLACER TYPE)

CODE	NAME
<b>GERMANY</b>	
1 . P3430	VEGA GRIESHABER KG ((Tuning fork, Capacitance, Radar))
<b>INDIA</b>	
2 . P0151	ABB INDIA LIMITED
3 . P3414	BLISS ANAND PRIVATE LIMITED
4 . P3181	CHEMTROLS SAMIL (INDIA) PVT LTD.
5 . P3466	GAUGES BOURDON INDIA PVT. LTD (Mfg. unit of GIC)
6 . P3186	PUNE TECHTROL PVT.LTD.
7 . P3459	SBEM PVT. LTD.
8 . P3417	SIEMENS LTD. ((Ultrasonic, Vibrating Fork, Capacitance, Paddle))
9 . P3491	V.AUTOMAT & INSTRUMENTS (P) LTD
10 . P0871	V.AUTOMAT & INSTRUMENTS (P) LTD. (upto 300# , Non-critical service)
<b>BELGIUM</b>	
11 . P0502	MAGNETROL INTERNATIONAL N.V.
<b>U.K.</b>	
12 . P0408	ISA CONTROLS LIMITED
13 . P0441	KDG MOBREY LTD.
<b>U.S.A.</b>	
14 . P0743	SOR INC.

## 310403 : DISPLACER TYPE LEVEL TRANSMITTERS

CODE	NAME
<b>INDIA</b>	
1 . P0153	CHEMTROLS INDUSTRIES LTD.
2 . P3183	DRESSER VALVE INDIA PVT LTD (Rating <= 600#)
3 . P3491	V.AUTOMAT & INSTRUMENTS (P) LTD
<b>BELGIUM</b>	
4 . P0502	MAGNETROL INTERNATIONAL N.V. (LVDT)
<b>FRANCE</b>	
5 . P0518	DRESSER MASONEILAN
<b>GERMANY</b>	
6 . P0282	FOXBORO ECKARDT GmbH
<b>ITALY</b>	
7 . P0618	PARCOL SPA (Pneumatic Transmission only)

## 310404 : NUCLEONIC LEVEL TRANSMITTER

CODE	NAME
<b>GERMANY</b>	
1 . P3430	VEGA GRIESHABER KG
<b>INDIA</b>	
2 . P3465	EIP ENVIRO LEVEL CONTROLS PRIVATE LIMITED
<b>GERMANY</b>	
3 . P0101	BERTHOLD TECHNOLOGIES GMBH & CO.KG
4 . P0238	ENDRESS + HAUSER GMBH & CO.,
<b>U.S.A.</b>	
5 . P0439	KAY RAY

## 310405 : CAPACITANCE TYPE LEVEL TRANSMITTER

CODE	NAME
<b>GERMANY</b>	
1 . P3430	VEGA GRIESHABER KG
<b>INDIA</b>	
2 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD.
3 . P3417	SIEMENS LTD.
<b>BELGIUM</b>	
4 . P0502	MAGNETROL INTERNATIONAL N.V.
<b>GERMANY</b>	
5 . P0238	ENDRESS + HAUSER GMBH & CO.,
6 . P0467	KROHNE
<b>U.K.</b>	
7 . P0441	KDG MOBREY LTD.

## 310406 : TANK LEVEL INSTRUMENTS

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
2 . P3465	EIP ENVIRO LEVEL CONTROLS PRIVATE LIMITED
3 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
4 . P3186	PUNE TECHTROL PVT.LTD.
5 . P3459	SBEM PVT. LTD.
6 . P3417	SIEMENS LTD. ((Radar Level Transmitter, Guded Wave Radar))
<b>GERMANY</b>	
7 . P0238	ENDRESS + HAUSER GMBH & CO., (Non-contact & servo)
8 . P0467	KROHNE (Non-contact type)
<b>JAPAN</b>	
9 . P0816	TOKYO KEISO CO. LTD.
<b>SINGAPORE</b>	
10 . P0240	ENRAF SINGAPORE PTE. LTD.
<b>U.S.A.</b>	
11 . P0480	L & J TECHNOLOGIES



**310408 : RESITIVE ELECTRODE TYPE LEVEL INSTRUMENT**

CODE	NAME
<b>U.S.A.</b>	
1 . P0161	CLARK-RELIANCE CORP.
2 . P0706	SCHLUMBERGER RESOURCE MANAGEMENT LTD.

## 310409 : SPECIAL LEVEL SWITCHES (VIBRATION FORK/RF ADMITTANCE)

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
2 . P3465	EIP ENVIRO LEVEL CONTROLS PRIVATE LIMITED
3 . P3404	PROTOCONTROL INSTRUMENTS (I) PVT. LTD. (For Non Critical application)
<b>GERMANY</b>	
4 . P0238	ENDRESS + HAUSER GMBH & CO.,
<b>U.S.A.</b>	
5 . P0743	SOR INC.

## 310410 : ULTRASONIC LEVEL TRANSMITTER

CODE	NAME
<b>GERMANY</b>	
1 . P3430	VEGA GRIESHABER KG
<b>INDIA</b>	
2 . P3465	EIP ENVIRO LEVEL CONTROLS PRIVATE LIMITED
3 . P3417	SIEMENS LTD.



# 310411 :TANK FARM MANAGEMENT

CODE	NAME
<i>INDIA</i>	
1 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD. (Servo, Radar)

## 310412 : GUIDED WAVE RADAR

CODE	NAME
<b>GERMANY</b>	
1 . P3430	VEGA GRIESHABER KG
<b>INDIA</b>	
2 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD.

## 310413 : NUCLEONIC DENSITY METER

CODE	NAME
<b>GERMANY</b>	
1 . P3430	VEGA GRIESHABER KG
<b>INDIA</b>	
2 . P3465	EIP ENVIRO LEVEL CONTROLS PRIVATE LIMITED

## 310501 : TEMPERATURE ELEMENTS (THERMOCOUPLE, RTD)

CODE	NAME
<b>INDIA</b>	
1 . P3477	NESSTECH INSTRUMENTS PRIVATE LIMITED
2 . P3483	WIKA INSTRUMENTS INDIA PVT.LTD
3 . P0151	ABB INDIA LIMITED
4 . P3184	ALTOP INDUSTRIES LTD. (only normal type (MI))
5 . P0201	DETRIV INSTRUMENTATION & ELECTRONICS LTD (Only Normal Type)
6 . P0227	ELECTRICAL & ELECTRONICS CORPORATION,
7 . P0232	ELEIND ENGINEERING PVT. LTD. (Only Normal Type)
8 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD.
9 . P3439	EXOTHERM INSTRUMENTS
10 . P3466	GAUGES BOURDON INDIA PVT. LTD (Mfg. unit of GIC)
11 . P0304	GENERAL INSTRUMENTS CONSORTIUM,
12 . P3436	GOA INSTRUMENTS INDUSTRIES PVT. LTD.
13 . P0390	INDUSTRIAL INSTRUMENTATION, (Only Normal Type)
14 . P3470	ITEC MEASURES PRIVATE LIMITED
15 . P3469	MICRO PROCESS CONTROLS
16 . P3517	MILLENNIUM INSTRUMENTS LIMITED
17 . P3456	PRECISION MASS PRODUCTS PVT. LTD.

## 310501 : TEMPERATURE ELEMENTS (THERMOCOUPLE, RTD)

CODE	NAME
18 . P3402	PYRO ELECTRIC INSTRUMENTS GOA PVT. LTD. (A.Thermocouple Assemblies with / without Thermowells; B. RTD Assemblies with / without Thermowells.)
19 . P3507	TECHNO INSTRUMENTS
20 . P3420	TEMPSENS INSTRUMENTS (I) PVT. LTD.
21 . P3454	THERMAL INSTRUMENT INDIA PVT.LTD. (All Ranges)
22 . P3416	UNICONTROLS INSTRUMENTS PVT. LTD.
<b>GERMANY</b>	
23 . P0716	SENSYCON ( M/S DEGUSSA AG )
24 . P0884	W.C. HERAEUS GMBH
<b>HOLLAND</b>	
25 . P0807	THERMO ELECTRIC CO. LTD.
<b>JAPAN</b>	
26 . P0888	AZBIL CORPORATION (Formerly YAMATAKE CORPORATION)
27 . P0600	OKAZAKI MANUFACTURING CO.



## 310502 : BIMETALLIC THERMOMETER

CODE	NAME
1 . P3185	
<b>INDIA</b>	
2 . P3477	NESSTECH INSTRUMENTS PRIVATE LIMITED
3 . P0081	A N INSTRUMENTS PVT. LTD.
4 . P3103	BAUMER TECHNOLOGIES INDIA PVT. LTD.(FORMERLY WAAREE INSTRUM
5 . P3496	FORBES MARSHALL (HYD) PRIVATE LIMITED ((-50 'C to -400'C))
6 . P3466	GAUGES BOURDON INDIA PVT. LTD (Mfg. unit of GIC)
7 . P0304	GENERAL INSTRUMENTS CONSORTIUM,
8 . P3436	GOA INSTRUMENTS INDUSTRIES PVT. LTD.
9 . P0371	H.GURU INDUSTRIES
10 . P3470	ITEC MEASURES PRIVATE LIMITED
11 . P0468	KROHNE MARSHALL PVT. LTD.
12 . P3517	MILLENNIUM INSTRUMENTS LIMITED
13 . P3456	PRECISION MASS PRODUCTS PVT. LTD.
14 . P3454	THERMAL INSTRUMENT INDIA PVT.LTD.
<b>ITALY</b>	
15 . P0791	TECHNOMATIC SPA
<b>JAPAN</b>	

## 310502 : BIMETALLIC THERMOMETER

CODE	NAME
16 . P0558	NAGANO KEIKI SEISAKUSHO

### **SWITZERLAND**

17 . P0690 RUEGER SA

### **U.S.A.**

18 . P0827 TREND INSTRUMENT INC.

## 310503 : DIAL THERMOMETER (Hg in Steel/Glass)

CODE	NAME
1 . P3185	
<b>INDIA</b>	
2 . P3477	NESSTECH INSTRUMENTS PRIVATE LIMITED
3 . P3483	WIKA INSTRUMENTS INDIA PVT.LTD
4 . P0081	A N INSTRUMENTS PVT. LTD.
5 . P3103	BAUMER TECHNOLOGIES INDIA PVT. LTD.(FORMERLY WAAREE INSTRUM
6 . P3496	FORBES MARSHALL (HYD) PRIVATE LIMITED (HG in Steel / Glass); (-50 'C to 600'C))
7 . P3466	GAUGES BOURDON INDIA PVT. LTD (Mfg. unit of GIC)
8 . P0304	GENERAL INSTRUMENTS CONSORTIUM,
9 . P3436	GOA INSTRUMENTS INDUSTRIES PVT. LTD. (Liquid filled, Gas filled, Mercury in steel)
10 . P0371	H.GURU INDUSTRIES
11 . P3470	ITEC MEASURES PRIVATE LIMITED
12 . P3469	MICRO PROCESS CONTROLS
13 . P3517	MILLENNIUM INSTRUMENTS LIMITED
14 . P0622	PEEJEE ENGG. WORKS
15 . P3456	PRECISION MASS PRODUCTS PVT. LTD.
16 . P3454	THERMAL INSTRUMENT INDIA PVT.LTD.

**310503: DIAL THERMOMETER (Hg in Steel/Glass)**

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CODE	NAME
17. P0874	WALCHANDNAGAR INDUSTRIES LTD.

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## 310504 : RADIATION PYROMETER

CODE	NAME
<b>INDIA</b>	
1 . P3420	TEMPSENS INSTRUMENTS (I) PVT. LTD.
<b>GERMANY</b>	
2 . P0735	SIEMENS AG, GERMANY
<b>ITALY</b>	
3 . P0189	C.C.R. TECHNICO
<b>JAPAN</b>	
4 . P0155	CHINO CORPN.
<b>U.K.</b>	
5 . P0482	LAND INFRARED
<b>U.S.A.</b>	
6 . P0873	WAHL INSTRUMENTS

## 310505 : TEMPERATURE TRANSMITTER

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
2 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD.
3 . P3417	SIEMENS LTD.
4 . P0891	YOKOGAWA INDIA LIMITED
<b>JAPAN</b>	
5 . P3415	M. SYSTEM CO., LTD., (Model No. B6U-B; Model No. 27HU-B)



## 310506: TEMPERATURE SWITCHES

CODE	NAME
<i>INDIA</i>	
1 . P3436	GOA INSTRUMENTS INDUSTRIES PVT. LTD.



## 310507: SPECIAL TEMPERATURE ELEMENTS

CODE	NAME
<i>INDIA</i>	
1.P3513	THERMAL INSTRUMENT INDIA PVT. LTD.



## 310601 : GATE/PLUG VALVES

CODE	NAME
<b>INDIA</b>	
1 . P0077	AUDCO INDIA LIMITED(L&T VALVES DIVN.)
2 . P0115	BHEL (VALVES DIVISION)
3 . P3181	CHEMTROLS SAMIL (INDIA) PVT LTD. (For Plug Valves only)
4 . P3424	FLOWSERVE INDIA CONTROL PVT. LTD. (Plug Valve upto 12" 300#, up to 6" 600#)
5 . P0473	KSB PUMPS LIMITED (VALVES DIVN)
6 . P3441	NU TECH CONTROLS (MOV Gate : ½" to 8" - 2500#; 10" to 14" - 300#)
7 . P3105	SAMSON CONTROLS PVT. LTD. (Upto 34" - 300 #)
8 . P3460	VALVE-TECH INDUSTRIES ((MOV - 8" Upto 2500#) Non Critical)
9 . P3448	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (GATE VALVE : Upto 14" 150#; 2"-12" upto 600#; 2"-12" 900# to 1500#; PLUG VALVE:Upto 16" 150#;2"-12" upto 300#;2"-3" upto 600#)
<b>india</b>	
10 . P3461	VALTECH INDUSTRIES (Upto 28" - 150#)
<b>CANADA</b>	
11 . P0857	VELAN INC. (Size : ¼" to 24" (Rating upto 2500 #), Size : 26" to 30" (Rating upto 600#))
<b>FRANCE</b>	
12 . P0507	MALBRANQUE S.A.
<b>ITALY</b>	
13 . P0150	CESARE BONETTI SPA
14 . P0253	FASANI S.P.A.
15 . P0628	PETROL VALVES S.R.L

## 310601 : GATE/PLUG VALVES

CODE	NAME
<b>JAPAN</b>	
16 . P0520	MATSURA H. P MACHINE WORKS CO.LTD.,
<b>U.K.</b>	
17 . P0097	BEL VALVES

## 310602 : GLOBE / ANGLE VALVES

CODE	NAME
<b>INDIA</b>	
1 . P3449	AST S.P.A (Up to 8" 900#, Urea Grade Also)
2 . P0153	CHEMTROLS INDUSTRIES LTD. ((For Water and Steam))
3 . P3425	CIRCOR FLOW TECHNOLOGIES INDIA PVT. LTD. (Globe 2" to 16" 300#, Angle 12" 2500#)
4 . P3183	DRESSER VALVE INDIA PVT LTD (Rating <= 600# , Size 3/4 to 6")
5 . P3437	EMET CONTROLS PVT. LTD. (Globe Valve Upto 4" 300#, Angle Valve upto 1½" 2500#)
6 . P3424	FLOWSERVE INDIA CONTROL PVT. LTD. (Globe Valve upto 30" 600#, upto 24" 900#, upto 16" 2500#, upto 4" 4500#)
7 . P0400	INSTRUMENTATION LTD. (PALAKKAD) (=<2500#,except slurry,noise,cavitation)
8 . P3401	KOSO INDIA PVT. LTD. (Globe Valves :Upto 8": 2500#, 10" to 18": 300#; Angle Valves : Upto 8" : 300#)
9 . P3463	L&T VALVES LTD. (Upto 24" - 1500#, except Urea Grade)
10 . P3495	MASCOT VALVES PRIVATE LIMITED (UP TO 12"-150-300#)
11 . P0536	MIL CONTROLS LIMITED (Globe Valves:Size upto 24" & Rating upto 2500#(except slurry); Angle Valves:Upto 20" & Rating upto 2500# (except slurry))
12 . P3441	NU TECH CONTROLS (10" 150# for non-critical services)
13 . P3455	PNEUCON VALVES PVT. LTD. (Globe Valves, Upto 6" - 300#, Non Critical)
14 . P0656	R K CONTROL INSTRUMENTS PVT. LTD. (½" to 4" 1500#; 6" to 8" 150#, Water and Non-critical services)
15 . P3105	SAMSON CONTROLS PVT. LTD. (Upto 6" & Rating :=<600# (for small Projects))
16 . P3406	SEVERN GLOCON INDIA PVT. LTD. (1" - 30" 900#; Upto 20" 2500#)
17 . P3426	TECNIK VALVES PVT. LTD. (Globe Valve (upto 4" - 150#, Air & Water service))

## 310602 : GLOBE / ANGLE VALVES

CODE	NAME
18 . P3508	TECNIK VALVES PVT.LTD.
19 . P3460	VALVE-TECH INDUSTRIES ((MOV - 8" Upto 300#, 4" Upto 2500#) Non Critical)
<b>india</b>	
20 . P3461	VALTECH INDUSTRIES ( Upto 3" - 300#)
<b>FRANCE</b>	
21 . P0518	DRESSER MASONEILAN (=<2500#,Urea service also)
<b>GERMANY</b>	
22 . P0058	ARCA-REGLER GMBH (=< 2500#)
<b>ITALY</b>	
23 . P0618	PARCOL SPA (=<2500#,Urea service also)
<b>JAPAN</b>	
24 . P0888	AZBIL CORPORATION (Formerly YAMATAKE CORPORATION) (=<2500#)
25 . P0582	NIPPON FISHER CO. LTD. (=<2500#)
<b>SINGAPORE</b>	
26 . P0261	FISHER XOMOX (=< 2500#)
<b>U.S.A.</b>	
27 . P0854	FLOWSERVE (=<2500#)

## 310603 : BALL VALVES

CODE	NAME
<b>INDIA</b>	
1 . P3419	ANAND TEKNOVA AIDS ENGINEERING INDIA LIMITED (UPTO 6", 600# (ON-OFF))
2 . P3434	BRAY CONTROLS INDIA PVT. LTD. (Upto 4" - 300#)
3 . P3505	CAIR EUROMATIC AUTOMATION PVT. LTD. (Non -critical services)
4 . P3484	DELVAL FLOW CONTROLS PVT.LTD. (up to 8"-300# and 8"-18"- 600#)
5 . P3437	EMET CONTROLS PVT. LTD. (Upto 8" 150#, For Air Service)
6 . P3424	FLOWSERVE INDIA CONTROL PVT. LTD. (Upto 16" 600#)
7 . P3450	INTERVALVE POONAWALLA LIMITED (Upto 10" 150#)
8 . P3401	KOSO INDIA PVT. LTD. (Upto 8": 2500 # , 10" to 18": 900#)
9 . P3463	L&T VALVES LTD. (Upto 24" - 2500#, except Urea Grade)
10 . P3495	MASCOT VALVES PRIVATE LIMITED (UP TO 14"-300#)
11 . P3464	METSO INDIA PVT. LTD. (ON-OFF VALVE Upto 18" - 150#)
12 . P3468	MICROFINISH VALVES PVT. LTD. (Ball Valve :24" - 300#, 18" - 600#, 16" - 900#)
13 . P3441	NU TECH CONTROLS (14" 600# for non-critical services)
14 . P3111	PENTAIR VALVES AND CONTROLS INDIA PRIVATE LIMITED (=< 150 #)
15 . P3455	PNEUCON VALVES PVT. LTD. (Upto 6" - 150#. Non Critical)
16 . P3196	ROTEX MANUFACTURERS & ENGINEERS PRIVATE LIMITED (6" - 600#, 6" to 10" - 300#)
17 . P3105	SAMSON CONTROLS PVT. LTD. (Upto 24" - 1500#)

## 310603 : BALL VALVES

CODE	NAME
18 . P3460	VALVE-TECH INDUSTRIES ((On-Off Metal Seated Valve 18" - 150#) Non Critical)
19 . P3518	VENTIL FLOWSERVE PVT. LTD. (1.5" TO 12" 150#)
20 . P0865	VIRGO ENGINEERS LTD. (=<600# with Maccair actuators)
21 . P3448	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Upto 16" 150#)
<b>india</b>	
22 . P3461	VALTECH INDUSTRIES (Upto 6" - 150#)
<b>CANADA</b>	
23 . P0857	VELAN INC. (Ball Valves (On/Off) Size : ¼" to 6" (Rating upto 2500 #), Size: 8" to 16"(Rating upto 900#), Size: 18" to 30" Rating upto 300#))
<b>GERMANY</b>	
24 . P3409	PERRIN GmbH (Size: ½ " to 12" & Rating 150# to 2500#; Size: 14" to 18" & Rating: 150# to 1500#; Size : 20" to 24" & Rating: 150# & 300#)
<b>ITALY</b>	
25 . P0476	GTC ITALIA, S.R.L. (=<300#)
26 . P0628	PETROL VALVES S.R.L
27 . P0631	PIBIVIESSE SRL (rating upto 2500 #)
<b>SINGAPORE</b>	
28 . P0568	METSO AUTOMATION (=<2500#)
29 . P0606	ORBIT VALVES PLC (=<2500#)

## 310604 : BUTTERFLY VALVES

CODE	NAME
<b>INDIA</b>	
1 . P3451	ADVANCE VALVES PVT.LTD. (Size: 2" to 24" upto 600 #)
2 . P3434	BRAY CONTROLS INDIA PVT. LTD. (Upto 300#)
3 . P3505	CAIR EUROMATIC AUTOMATION PVT. LTD. (Non -critical services)
4 . P3484	DELVAL FLOW CONTROLS PVT.LTD. (2"-24" 150# and 2"-14" 300#)
5 . P3437	EMET CONTROLS PVT. LTD. (Upto 4" 900#, 6" 150# to 16" 150#, double eccentric)
6 . P3424	FLOWERVE INDIA CONTROL PVT. LTD. (Upto 30" 300#, upto 12" 600#)
7 . P0400	INSTRUMENTATION LTD. (PALAKKAD) (= < 300#)
8 . P3450	INTERVALVE POONAWALLA LIMITED (2" to 48" 150#)
9 . P3401	KOSO INDIA PVT. LTD. (Upto 12": 600#, 12" to 40": 300#)
10 . P3463	L&T VALVES LTD. (Upto 36" - 1500#, except Urea Grade)
11 . P3495	MASCOT VALVES PRIVATE LIMITED (UP TO 30"-150#)
12 . P3464	METSO INDIA PVT. LTD. (CONTROL VALVE Upto 4" - 300# ; ON-OFF VALVE Upto 16" - 300#)
13 . P3441	NU TECH CONTROLS (16" 300# for non-critical services)
14 . P3111	PENTAIR VALVES AND CONTROLS INDIA PRIVATE LIMITED (= < 150 #)
15 . P3455	PNEUCON VALVES PVT. LTD. (Upto 8" - 150#, Non Critical)
16 . P0656	R K CONTROL INSTRUMENTS PVT. LTD. (Upto 8" 150# Cooling Water, Non-critical services)
17 . P3196	ROTEX MANUFACTURERS & ENGINEERS PRIVATE LIMITED (Upto 8" - 150#)

## 310604 : BUTTERFLY VALVES

CODE	NAME
18 . P3105	SAMSON CONTROLS PVT. LTD. (Upto 32 - 150#)
19 . P3406	SEVERN GLOCON INDIA PVT. LTD. (Up to 42"-150#, up to 30"-300#, up to 30"-600#)
20 . P3460	VALVE-TECH INDUSTRIES (Non-Critical)
21 . P0865	VIRGO ENGINEERS LTD. (=<300#)
22 . P3448	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Upto 16" 300#)
<b>KOREA</b>	
23 . P3403	KOREA UNICOM VALVE CO. LTD. (For Rating =<300 #)
<b>USA</b>	
24 . P3198	BRAY CONTROLS, USA (Rating : <= 300#)
<b>india</b>	
25 . P3461	VALTECH INDUSTRIES (Upto 6" - 300#)
<b>ITALY</b>	
26 . P3193	ORTON S.r.l. (Upto 2500#)
27 . P0618	PARCOL SPA (=< 2500# Urea Service also)
<b>SINGAPORE</b>	
28 . P0448	KEYSTONE (Upto 2500#)
29 . P0568	METSO AUTOMATION (Upto 2500#)
<b>U.K.</b>	
30 . P0489	LEEDS VALVE LTD





## 310605: SAUNDERS (PINCH) VALVES

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CODE	NAME
<i>INDIA</i>	
1 . P0093	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Upto 150#)

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## 310606 : SOLENOID VALVES

CODE	NAME
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1 .

### **INDIA**

2 . P0062 ASCO (INDIA) LIMITED

3 . P3438 AVCON CONTROLS PVT. LTD. (For Non-critical areas)

4 . P0682 ROTEX AUTOMATION LIMITED

5 . P3447 SCHRADER DUNCAN LTD. (1/8" to 1½" Port size (For Non-critical Applications))

6 . P3444 U FLOW AUTOMATION (Non-critical)

### **GERMANY**

7 . P0375 IMI NORGREN-HERION FLUIDTRONIC GMBH&CO.

### **U.K.**

8 . P0031 ALEXENDER CONTROLS LTD.,

9 . P0061 ASCO JOUCOMATIC LTD.

## 310607 : PRDS & SPRAY NOZZLE, VENT VALVES upto 2500#

CODE	NAME
<b>INDIA</b>	
1 . P3106	ARCA (FORBES MARSHAL) (Mech.spray nozzle type desuperheater only)
2 . P0153	CHEMTROLS INDUSTRIES LTD. ((PRDS Combine & Split))
3 . P3425	CIRCOR FLOW TECHNOLOGIES INDIA PVT. LTD. (1" to 20" Upto 150#, 1" to 10" Upto 1500#, 1" to 8" Upto 2500#)
4 . P0170	CONTROL COMPONENTS INC.
5 . P3401	KOSO INDIA PVT. LTD. (Hp steam Inlet Size & Rating: 10" 2500# MP/LP Steam Outlet size Rating: 12" 600#)
6 . P3495	MASCOT VALVES PRIVATE LIMITED (UP TO 8"-150-2500#)
7 . P3105	SAMSON CONTROLS PVT. LTD. (Upto 6" - 150#)
<b>SWEDEN</b>	
8 . P0135	CCI VALVE TECHNOLOGY AB
<b>U.S.A.</b>	
9 . P0174	SPX VALVES & CONTROLS (COPES-VULCAN LTD)

## 310611 : ELECTRIC ACTUATOR

CODE	NAME
<b>INDIA</b>	
1 . P3445	CAIR EUROMATIC AUTOMATION PVT.LTD. (Non-critical)
2 . P3500	AUMA INDIA PRIVATE LIMITED
3 . P3505	CAIR EUROMATIC AUTOMATION PVT. LTD.
4 . P1147	MARSH AUTOMATION PVT. LTD. (FOR SAFE AREA)
<b>GERMANY</b>	
5 . P0684	ROTORK CONTROL (DEUTSCHLAND) GMBH
<b>ITALY</b>	
6 . P0117	BIFFI ITALIA S.R.L.
<b>U.S.A.</b>	
7 . P0493	LIMITORQUE, U.S.A.

## 310613 : AIR FILTER REGULATOR

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
2 . P0207	DIVYA CONTROL ELEMENTS PVT. LTD.
3 . P0633	PLACKA INSTRUMENTS & CONTROLS PVT. LTD.
4 . P3447	SCHRADER DUNCAN LTD. (¼" to 2" Port Size)
5 . P0722	SHAVO NORGREN (INDIA) PVT. LTD.

## 310614 : LIMIT/PROXIMITY SWITCHES

CODE	NAME
<b>INDIA</b>	
1 . P3445	CAIR EUROMATIC AUTOMATION PVT.LTD. (Non-critical)
2 . P3505	CAIR EUROMATIC AUTOMATION PVT. LTD.
3 . P3195	EL-O-MATIC INDIA PRIVATE LIMITED
4 . P0608	OSNA ELECTRONICS PVT. LTD. (Intrinsically Safe Proximity Switches)
5 . P3109	PEPPERL + FUCH
6 . P3404	PROTOCONTROL INSTRUMENTS (I) PVT. LTD. (For Non Critical application)
7 . P3196	ROTEX MANUFACTURERS & ENGINEERS PRIVATE LIMITED
<b>GERMANY</b>	
8 . P3108	PEPPERL + FUCH
<b>SINGAPORE</b>	
9 . P0625	PEPPERL + FUCHS PTE LTD.
<b>U.S.A.</b>	
10 . P0363	HONEYWELL INC.,

## 310615 : VALVE ACTUATOR (PNEUMATIC / ROTARY)

CODE	NAME
<b>INDIA</b>	
1 . P3434	BRAY CONTROLS INDIA PVT. LTD.
2 . P3195	EL-O-MATIC INDIA PRIVATE LIMITED
3 . P3515	MICROFINISH VALVES PRIVATE LIMITED
4 . P3196	ROTEX MANUFACTURERS & ENGINEERS PRIVATE LIMITED
5 . P3447	SCHRADER DUNCAN LTD. (Linear Actuator, ½" to 20" dia & Rotary Actuators 14 N-m to 3260 N-m Torque (For Non-critical Applications))
6 . P3521	SUSIN I-TORK INDIA PRIVATE LIMITED

## 310616 : SELF ACTUATED PRESSURE CONTROL VALVES

CODE	NAME
<b>INDIA</b>	
1 . P3197	NIRMAL INDUSTRIAL CONTROLS PRIVATE LIMITED (Size: ½" to 6" & Rating : <= 300 #)
2 . P3441	NU TECH CONTROLS (Upto 10" 600#)
3 . P3455	PNEUCON VALVES PVT. LTD. (Upto 4" - 150#, Non Critical)
4 . P3105	SAMSON CONTROLS PVT. LTD. (Upto 2" - 150#)





# 310617: SLAM SHUT OFF VALVE

CODE	NAME
<i>INDIA</i>	
1 . P3197	NIRMAL INDUSTRIAL CONTROLS PRIVATE LIMITED (Size: Y2" to 6" & Rating: <= 300 #)



## 310618: ELECTROPNEUMATIC POSITIONER

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CODE	NAME
<i>INDIA</i>	
1.P3417	SIEMENS LTD.

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## 310619: TURBINE BYPASS VALVES

CODE	NAME
<i>INDIA</i>	
1 . P3425	CIRCOR FLOWTECHLOGIES INDIA PVT. LTD. (2" to 24" upto 2500#)

## 310620 : DESUPERHEATERS

CODE	NAME
<b>INDIA</b>	
1 .	CIRCOR FLOW TECHNOLOGIES INDIA PVT. LTD. (Upto 24" 300#, Upto 28" 150#, Multi-Nozzle 3" to 4" Upto 2500#)
2 . P3437	EMET CONTROLS PVT. LTD. (Desuperheating Control Valves 1½" 600# x 3" 2500#)
3 . P3495	MASCOT VALVES PRIVATE LIMITED (UP TO 8"-150-2500#)

## 310621 : PRESSURE REDUCING STATION

CODE	NAME
<b>INDIA</b>	
1 . P3425	CIRCOR FLOW TECHNOLOGIES INDIA PVT. LTD. (1" to 20" Upto 150#, 1" to 10" Upto 1500#, 1" to 8" Upto 2500#)

## 310622 : PRESSURE REGULATOR

CODE	NAME
<b>INDIA</b>	
1 . P0153	CHEMTROLS INDUSTRIES LTD.
2 . P3518	VENTIL FLOWSERVE PVT. LTD.

## 310701 : SAFETY VALVES & THERMAL RELIEF VALVES upto 2500#

CODE	NAME
<b>INDIA</b>	
1 . P3449	AST S.P.A (Pressure relief valve Up to 8" 2500#; Up to 10" 300# , Urea Grade Also; Series SMFN & SMF & SU-7000)
2 . P3414	BLISS ANAND PRIVATE LIMITED (8" x 10" 300#; 6" x 8" 600#; 4" x 6" 1500#)
3 . P3188	FAINGER LESER VALVES (P) LTD. (UPTO 600#, 1/2" TO 6")
4 . P0400	INSTRUMENTATION LTD. (PALAKKAD)
5 . P0711	MEKASTER ENGG. LTD.(FORMERLY SEBIM VALVES INDIA PVT. LTD.) (upto 600#, Safety - 4"x6",Th.Relief-3/4"x1")
6 . P3502	NIRMAL INDUSTRIAL CONTROLS PVT.LTD. (Up to 2500#)
7 . P3441	NU TECH CONTROLS (Upto 2" - 300# x 3" - 150#)
8 . P0838	PENTAIR SANMAR LTD. (Formerly TYCO SANMAR LTD. )
9 . P3472	UNI KLINGER LIMITED (Safety Valves: IBR & NON IBR: 4" x 6" - 1500#; 6" x 8 - 600#; 8" x 10" - 300#; Safety Valves: IBR for Boiler Service : 4" x 6" - 1500#; Thermal Relief Valves: 1/2"-1 1/2" - 1500#; 1"-1 1/2" - 600#)
10 . P3460	VALVE-TECH INDUSTRIES (Non-Critical)
11 . P3518	VENTIL FLOWSERVE PVT. LTD. (1/4" TO 1")
12 . P3448	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Pressure Relief Valve Upto 8" 150# x10 150#; Upto 6" 300# x 8"150#, Upto 3" 600# x 4" 150#; Thermal Relief Valves : Series 9 Upto 1/2" 2500# x 1/2")
<b>CANADA</b>	
13 . P0214	DRESSER VALVE & CONTROLS
<b>FRANCE</b>	
14 . P0698	SAPAG GEC ALSTHOM
<b>GERMANY</b>	
15 . P0121	BOPP & REUTHER MESSTECHNIK GMBH
<b>ITALY</b>	

## 310701 : SAFETY VALVES & THERMAL RELIEF VALVES upto 2500#

CODE	NAME
16 . P0618	PARCOL SPA (For Urea Service also)
17 . P0784	TAI MILANO S.P.A (For Urea Service also)
<b>JAPAN</b>	
18 . P0412	ITOCHU CORPORATION (REP.KUBOTA CORPN.)
<b>THAILAND</b>	
19 . P0794	TELEDYNE FLUID SYSTEMS
<b>U.K.</b>	
20 . P0186	CROSSBY VALVE & ENGG. COMPANY LTD.
21 . P0252	FARRIS
<b>U.S.A.</b>	
22 . P0213	DRESSER INDUSTRIES INCORPORATED



## 310703 : VACUUM BREAKERS

CODE	NAME
<b>INDIA</b>	
1 . P3509	GROTH CONTINENTALMANUFACTURING PRIVATE LIMITED
2 . P3443	PROTEGO INDIA PVT. LTD. (With Flame Arrestors (Breather Valves))
<b>GERMANY</b>	
3 . P0126	BRAUNSCHWEIGER FLAMMENFILTER GMBH
<b>ITALY</b>	
4 . P0618	PARCOL SPA
5 . P0784	TAI MILANO S.P.A
<b>JAPAN</b>	
6 . P0411	ITOCHU CORPORATION
<b>U.K.</b>	
7 . P0021	SAFETY SYSTEMS UK LTD.
8 . P0878	WHESOE VAREC LIMITED

## 310704 : RUPTURE DISCS

CODE	NAME
<b>INDIA</b>	
1 . P0134	BS&B SAFETY SYSTEMS (INDIA) LIMITED
<b>BELGIUM</b>	
2 . P0258	FIKE EUROPE
<b>FRANCE</b>	
3 . P0698	SAPAG GEC ALSTHOM
<b>THAILAND</b>	
4 . P0794	TELEDYNE FLUID SYSTEMS
<b>U.S.A.</b>	
5 . P0169	CONTINENTAL CONTROLS INC.

## 310705 : PILOT RELIEF VALVES

CODE	NAME
<b>INDIA</b>	
1 . P3449	AST S.P.A (Inlet size:- Upto 3", Upto 1500#, Outlet Size:- Upto 4", Upto 300 #; Inlet size:- Upto 4", Upto 300 #; Inlet size:- Upto 6" Upto 150# Outlet Size:- Upto 8" Upto 150 #)
2 . P3414	BLISS ANAND PRIVATE LIMITED (Size : 1" x 2" 2500#)
3 . P3509	GROTH CONTINENTALMANUFACTURING PRIVATE LIMITED
4 . P3472	UNI KLINGER LIMITED (PILOT OPERATED RELIEF VALVES: 4"X 6" - 900#; 8" X 10" - 300#)

## 310706 : LOW PRESSURE RELIEF VALVES

CODE	NAME
<b>INDIA</b>	
1 . P3509	GROTH CONTINENTALMANUFACTURING PRIVATE LIMITED
2 . P3443	PROTEGO INDIA PVT. LTD. (Less Than 1 Bar With Flame Arrestors (Breather Valves))

## 310708 : FLAME ARRESTOR

CODE	NAME
<b>INDIA</b>	
1 . P3509	GROTH CONTINENTALMANUFACTURING PRIVATE LIMITED
2 . P3443	PROTEGO INDIA PVT. LTD.

## 310801 : CONTROL PANEL

CODE	NAME
<b>INDIA</b>	
1 . P0230	ELECTRONICS CORPORATION OF INDIA LTD
2 . P3458	EX- PROTECTA
3 . P3442	HULASI METALS PVT. LTD. (For safe area.)
4 . P0389	INDUSTRIAL CONTROL APPLIANCES (P) LTD.,
5 . P3485	IRIS AUTOMATION PVT.LTD.
6 . P0421	JAISUN & HUTCHISUN CONTROLS LTD.,
7 . P3407	PRIMA AUTOMATION (INDIA) PVT. LTD. (For package equipments)
8 . P0653	PYROTECH ELECTRONICS PVT.LTD.
9 . P3499	RITTAL INDIA PVT.LTD.
10 . P3432	TAN SWA TECHNOLOGIES INC
11 . P0841	UNITED ELECTRIC CO. (DELHI) PVT. LTD. (Upto 10 Mtrs.)
12 . P0891	YOKOGAWA INDIA LIMITED
<b>HOLLAND</b>	
13 . P0397	INSTROMET INTERNATIONAL N.V
14	Bharat Heavy Electrical Ltd. Electronics Division Bangalore

## 310802 : PANEL ACCESS. ( Relay,Switch,Lamp,Terminal,Push Button)

CODE	NAME
<b>INDIA</b>	
1 . P3487	CONNECTWELL INDUSTRIES PVT.LTD. (Terminal Block)
2 . P3411	ECONIX HI-TECH COMPONENTS PVT. LTD. (For Terminal Blocks & Accessories only)
3 . P3410	ELMEX CONTROLS PVT. LTD. (For Terminal Blocks & Accessories only)
4 . P3458	EX- PROTECTA
5 . P0430	JYOTI LIMITED (Relay)
6 . P0484	LARSEN & TOUBRO LTD.(CONTROL& AUTOMATION (Lamp, Push Button)
7 . P3421	PHOENIX CONTACT (INDIA) PVT. LTD. (For Terminal Blocks only)
8 . P3435	POWERCAM ELECTRICALS PVT. LTD. (For Pilot Lamp, Push Button only.)
9 . P0033	ROCKWELL AUTOMATION INDIA PVT. LTD. (Relays)
<b>GERMANY</b>	
10 . P0206	DIGITABLE THIELEN GMBH & CO
11 . P0630	PHOENIX CONTACT GMBH & CO.
12 . P0735	SIEMENS AG, GERMANY (Lamp,PushButton,Contactors)
13 . P0750	STAHL-UND APPARATEBAU HANS LEFFER GMBH (Lamp,PushButton)
14 . P0872	WAGO KONTAKLTECHNIK GMBH
15 . P0875	WEIDMULLER LTD. (Terminal)
<b>JAPAN</b>	
16 . P0605	OMRON CORPORATION (Relay)



## 310802: PANEL ACCESS. ( Relay,Switch,Lamp,Terminai,Push Button)

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CODE	NAME
<i>SINGAPORE</i>	
17. P0625	PEPPERL +FUCHS PTE LTD. (Switch)

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## 310803 : PROGRAMABLE LOGIC CONTROLLER

CODE	NAME
<b>INDIA</b>	
1 . P3428	ABB INDIA LIMITED
2 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD. (Delta V SIS ESD System)
3 . P0296	GE FANUC SYSTEMS PRIVATE LIMITED
4 . P0787	HONEYWELL AUTOMATION INDIA LIMITED (Safety System)
5 . P0484	LARSEN & TOUBRO LTD.(CONTROL& AUTOMATION (Non Failsafe)
6 . P0543	MOORE CONTROLS LTD. (FailSafe)
7 . P3512	PHOENIX CONTACT INDIA PRIVATE LIMITED
8 . P0033	ROCKWELL AUTOMATION INDIA PVT. LTD. (Non Failsafe & Failsafe (ICS Triplex TMR, DMR))
9 . P3440	RTP CONTROLS INDIA PVT. LTD. (RTP 3000 TAS & SIS TMR/DMR SIL3 CERTIFIED PLS FOR TERMINAL AUTOMATION SYSTEM AND FIRE AND GAS APPLICATION)
10 . P0736	SIEMENS LTD. (Non Failsafe)
11 . P3417	SIEMENS LTD. (ESD- Simatic S7-400 FH / PLC - Simatic S-300, S7-400 (FMR/DMR))
12 . P0891	YOKOGAWA INDIA LIMITED (ESD System also)
<b>SINGAPORE</b>	
13 . P3503	TRISEN ASIA CONTROL PTE LTD.
<b>GERMANY</b>	
14 . P0348	HIMA PAUL HILDEBRANDT GMBH + CO KG (Failsafe)
<b>ITALY</b>	
15 . P0514	MARCONI ITALIANA (Non Failsafe)
<b>JAPAN</b>	

## 310803 : PROGRAMABLE LOGIC CONTROLLER

CODE	NAME
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16 . P0605 OMRON CORPORATION (Non Failsafe)

### ***SINGAPORE***

17 . P0829 TRICONEX (Fault Tolerant TMR)

### ***U.S.A.***

18 . P0295 GE FANUC AUTOMATION NORTH AMERICA, INC. (Fault Tolerant TMR)

## 310804 : DISTRIBUTED CONTROL SYSTEM

CODE	NAME
<b>INDIA</b>	
1 . P3428	ABB INDIA LIMITED
2 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
3 . P0787	HONEYWELL AUTOMATION INDIA LIMITED
4 . P3467	ROCKWELL AUTOMATION INDIA PRIVATE LIMITED (PLANTPax (Offisite like DM Water Plant, ETP, Captive Power Plant, Sugar & Pharmaceutical Plant, Steel Sector, Mines))
5 . P3417	SIEMENS LTD. (Simatic - PCS7)
6 . P0891	YOKOGAWA INDIA LIMITED
<b>USA</b>	
7 . P3471	ROCKWELL AUTOMATION, INC (PlantPax)
<b>GERMANY</b>	
8 . P0735	SIEMENS AG, GERMANY
<b>HOLLAND</b>	
9 . P0284	INVENSYS
<b>JAPAN</b>	
10 . P0892	YOKOGAWA ELECTRIC CORPORATION
<b>SINGAPORE</b>	
11 . P0262	EMERSON PROCESS MGT SINGAPORE LTD
<b>U.S.A.</b>	
12 . P0084	BAILEY CONTROLS COMPANY
13 . P0363	HONEYWELL INC.,
14.	Bharat Heavy Electrical Ltd. Electronics Division Bangalore

## 310805 : MULTIPLEXER / REMOTE I/O

CODE	NAME
<b>INDIA</b>	
1 . P0547	MTL INSTRUMENT LIMITED
2 . P3109	PEPPERL + FUCH
3 . P3512	PHOENIX CONTACT INDIA PRIVATE LIMITED
<b>GERMANY</b>	
4 . P3108	PEPPERL + FUCH
5 . P0750	STAHL-UND APPARATEBAU HANS LEFFER GMBH
<b>JAPAN</b>	
6 . P3415	M. SYSTEM CO., LTD., (Remote I/O: Model No. R3)
<b>SINGAPORE</b>	
7 . P0625	PEPPERL + FUCHS PTE LTD.
<b>U.K.</b>	
8 . P0554	M.T.L., U.K.

## 310806 : RECEIVER INSTRUMENTS (INDICATOR,CONTROLLER,RECORDER)

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
2 . P0156	CHINO-LAXSONS (INDIA) PVT. LIMITED (Only Recorder)
3 . P0244	EUROTHERM DEL INDIA LIMITED
4 . P0787	HONEYWELL AUTOMATION INDIA LIMITED
5 . P3408	MASIBUS AUTOMATION & INSTRUMENTATION PVT. LTD. (Receiver Instruments except Recorder)
6 . P0543	MOORE CONTROLS LTD.
7 . P0891	YOKOGAWA INDIA LIMITED
<b>GERMANY</b>	
8 . P0735	SIEMENS AG, GERMANY
<b>JAPAN</b>	
9 . P0155	CHINO CORPN.
10 . P0490	HERAEUS ELECTRO-NITE INTERNATIONAL N.V.
11 . P0892	YOKOGAWA ELECTRIC CORPORATION
<b>U.S.A.</b>	
12 . P0363	HONEYWELL INC.,

## 310807 : ALARM ANNUNCIATOR

CODE	NAME
<b>INDIA</b>	
1 . P0391	INDUSTRIAL INSTRUMENTS & CONTROLS
2 . P0729	SHREE ELECTRONICS
<b>U.K.</b>	
3 . P0554	M.T.L., U.K.
4 . P0674	ROCHESTER INSTRUMENT SYSTEMS LTD.,
<b>U.S.A.</b>	
5 . P0673	RILEY PANALARM
6 . P0677	RONAN ENGG. CO.,

## 310808 : BARRIER/ISOLATOR/TRIP AMPLIFIER

CODE	NAME
<b>INDIA</b>	
1 . P0547	MTL INSTRUMENT LIMITED
2 . P3109	PEPPERL + FUCH
3 . P3512	PHOENIX CONTACT INDIA PRIVATE LIMITED
<b>GERMANY</b>	
4 . P0206	DIGITABLE THIELEN GMBH & CO
5 . P0282	FOXBORO ECKARDT GmbH
6 . P3108	PEPPERL + FUCH
7 . P0750	STAHL-UND APPARATEBAU HANS LEFFER GMBH
<b>JAPAN</b>	
8 . P3415	M. SYSTEM CO., LTD., (Signal Isolators Fittings: Model Nos. M2VS; M5VS; W2VS; W5VS; M3LU & 2M3LU2)
9 . P0892	YOKOGAWA ELECTRIC CORPORATION
<b>SINGAPORE</b>	
10 . P0625	PEPPERL + FUCHS PTE LTD.
<b>SWITZERLAND</b>	
11 . P0145	CAMILLE BAUER AG
<b>U.K.</b>	
12 . P0554	M.T.L., U.K.
<b>U.S.A.</b>	
13 . P0363	HONEYWELL INC.,

## 310809 : TEMPERATURE SCANNER

CODE	NAME
<b>INDIA</b>	
1 . P0390	INDUSTRIAL INSTRUMENTATION,
2 . P3404	PROTOCONTROL INSTRUMENTS (I) PVT. LTD.



**310810: CCTV / ACCESS SYSTEM**

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CODE	NAME
<b>INDIA</b>	
1 . P0787	HONEYWELL AUTOMATION INDIA LIMITED

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**310815 : MISCELLENOUS ITEMS (RTU / SCADA ETC)**

CODE	NAME
<b>INDIA</b>	
1 . P3428	ABB INDIA LIMITED
2 . P3512	PHOENIX CONTACT INDIA PRIVATE LIMITED
3 . P0033	ROCKWELL AUTOMATION INDIA PVT. LTD.
4 . P3417	SIEMENS LTD. (Simatic WINcc)

**310816: ENERGY METER**

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CODE	NAME
<i>JAPAN</i>	
1.P3415	M. SYSTEM CO., LTD., (ModelNo. 53U)



## 310821 :SURGE PROTECTION DEVICES

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CODE	NAME
<i>INDIA</i>	
1 . P3421	PHOENIX CONTACT (INDIA) PVT. LTD.

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## 310824: WIRING DUCTS

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CODE	NAME
<i>INDIA</i>	
1 . P3422	TRINITY TOUCH PVT.LTD.

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## 310825 : DIN RAIL

CODE	NAME
<b>INDIA</b>	
1 . P3487	CONNECTWELL INDUSTRIES PVT.LTD.
2 . P3422	TRINITY TOUCH PVT. LTD.

## 310826 : INTERFACE MODULE

CODE	NAME
<b>INDIA</b>	
1 . P3487	CONNECTWELL INDUSTRIES PVT.LTD.
2 . P3422	TRINITY TOUCH PVT. LTD.



## 310827: CABLE CONNECTOR

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CODE	NAME
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<i>INDIA</i>	
1 . P3421	PHOENIX CONTACT (INDIA) PVT. LTD.





## 310828: ADVANCE PROCESS CONTROL SYSTEM

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CODE	NAME
<b>INDIA</b>	
1 . P0891	YOKOGAWA INDIA LIMITED

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**310829: VIDEO WALL DLP CUBE AND VIDEO WALL CONTROLLER**

CODE	NAME
<b>INDIA</b>	
1 . P3504	Delta Electronics India Private Limited

## 310901 : MACHINE MONITORING SYSTEM

CODE	NAME
<b>SWITZERLAND</b>	
1 . P3480	MEGGITT SA
<b>JAPAN</b>	
2 . P3452	SHINKAWA ELECTRIC COMPANY LTD.
<b>GERMANY</b>	
3 . P0131	BRUEL & KJAER GMBH
<b>SINGAPORE</b>	
4 . P0738	SKF CONDITION MONITORING INC.
<b>U.S.A.</b>	
5 . P0100	BENTLEY NEVEDA LLC
6.	Bharat Heavy Electrical Ltd. Electronics Division Bangalore

## 310902 : SPEED INDICATOR

CODE	NAME
<b>GERMANY</b>	
1 . P3108	PEPPERL + FUCH
<b>JAPAN</b>	
2 . P0725	SHINKAWA ELECTRIC CO.
<b>SINGAPORE</b>	
3 . P0625	PEPPERL + FUCHS PTE LTD.
<b>SWITZERLAND</b>	
4 . P0419	JACQUET
<b>U.S.A.</b>	
5 . P0100	BENTLEY NEVEDA LLC

**310903 : ANTI SURGE CONTROLLER**

CODE	NAME
<b>SINGAPORE</b>	
1 . P3503	TRISEN ASIA CONTROL PTE LTD.
2 . P0167	COMPRESSOR CONTROL CORPORATION
3 . P0215	DRESSER - RAND CO.
4 . P0830	INVENSYS TRICONEX
5	Bharat Heavy Electrical Ltd. Electronics Division Bangalore

## 311001 : BURNER MANAGEMENT SYSTEM

CODE	NAME
<b>INDIA</b>	
1 . P0216	DURAG INDUSTRIE ELEKTRONIK GMBH & CO KG
<b>GERMANY</b>	
2 . P0735	SIEMENS AG, GERMANY
<b>JAPAN</b>	
3 . P0888	AZBIL CORPORATION (Formerly YAMATAKE CORPORATION)
4 . P0540	MITSUBISHI HEAVY INDUSTRIES LTD.
5 . P0605	OMRON CORPORATION
<b>U.S.A.</b>	
6 . P0363	HONEYWELL INC.,
7.	Bharat Heavy Electrical Ltd. Electronics Division Bangalore



## 311002: FURNACE CAMERA, HEATER, THERMAL IMAGER

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CODE	NAME
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<i>INDIA</i>	
1 . P3420	TEMPSENS INSTRUMENTS (I) PVT. LTD.

## 311101 : TERMINAL AUTOMATION SYSTEM

CODE	NAME
<b>INDIA</b>	
1 . P3428	ABB INDIA LIMITED
2 . P0153	CHEMTROLS INDUSTRIES LTD.
3 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
4 . P0787	HONEYWELL AUTOMATION INDIA LIMITED



## 311501 : I/P CONVERTER

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
2 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
3 . P0891	YOKOGAWA INDIA LIMITED
<b>JAPAN</b>	
4 . P0892	YOKOGAWA ELECTRIC CORPORATION
<b>U.S.A.</b>	
5 . P0678	EMERSON PROCESS MANAGEMENT LTD
6 . P0544	MOORE PRODUCTS COMPANY

## 311601 : INSTRUMENT POWER & CONTROL CABLES

CODE	NAME
<b>INDIA</b>	
1 . P3514	ASSOCIATED CABLES PRIVATE LIMITED
2 . P0068	ASSOCIATED CABLES PVT. LTD.
3 . P0070	ASSOCIATED FLEXIBLES & WIRES PVT. LTD.
4 . P3501	CENTURION POWER CABLES PVT.LTD.
5 . P0176	CORDS CABLE INDUSTRIES LTD.
6 . P0200	DELTON CABLES LTD
7 . P3110	INSUCON CABLES & CONDUCTORS (P) LTD. (For smaller non-critical projects)
8 . P0416	J K CABLES LIMITED
9 . P0442	KEI INDUSTRIES LIMITED
10 . P3522	MIRACLE CABLES INDIA PVT. LTD.
11 . P0617	PARAMOUNT CABLE CORPORATION
12 . P3474	SUYOG ELECTRICALS LTD.
13 . P8086	T C COMMUNICATION PVT LTD
14 . P3506	TC WIRE & CABLES PRIVATE LIMITED
15 . P0809	THERMO CABLES LIMITED
16 . P0820	TOSHNIWAL CABLES
17 . P3191	UDEY PYRO CABLES PVT. LTD.

**311601 :INSTRUMENT POWER & CONTROL CABLES**

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CODE	NAME
<i>ITALY</i>	
18. P3516	RAMCRO S.P. A.

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## 311602 : EXTENSION & COMPENSATING CABLES

CODE	NAME
<b>INDIA</b>	
1 . P3514	ASSOCIATED CABLES PRIVATE LIMITED
2 . P0068	ASSOCIATED CABLES PVT. LTD.
3 . P0070	ASSOCIATED FLEXIBLES & WIRES PVT. LTD.
4 . P3501	CENTURION POWER CABLES PVT.LTD.
5 . P0176	CORDS CABLE INDUSTRIES LTD.
6 . P0200	DELTON CABLES LTD
7 . P0304	GENERAL INSTRUMENTS CONSORTIUM,
8 . P0416	J K CABLES LIMITED
9 . P0442	KEI INDUSTRIES LIMITED
10 . P0617	PARAMOUNT CABLE CORPORATION
11 . P3474	SUYOG ELECTRICALS LTD.
12 . P8086	T C COMMUNICATION PVT LTD
13 . P3506	TC WIRE & CABLES PRIVATE LIMITED
14 . P0809	THERMO CABLES LIMITED
15 . P0820	TOSHNIWAL CABLES
<b>ITALY</b>	
16 . P3516	RAMCRO S.P. A.

## 311603 : SPECIAL CABLES (FOUNDATION FIELD BUS CABLES)

CODE	NAME
<b>INDIA</b>	
1 . P3489	LEONI CABLE SOLUTIONS (INDIA) PVT.LTD.
2 . P3486	M/S LAPP INDIA PVT.LTD.
3 . P3474	SUYOG ELECTRICALS LTD.
4 . P8086	T C COMMUNICATION PVT LTD
5 . P0809	THERMO CABLES LIMITED
6 .	THERMO CABLES LIMITED
<b>ITALY</b>	
7 . P3516	RAMCRO S.P. A. (PROFIBUS, MODBUS, COMMUNICATION CABLE (CAT-6, OFC))

**311606 : CABLE TRAYS & ACCESSORIES (AL./GI)**

CODE	NAME
<b>INDIA</b>	
1 . P0312	GLOBE ELECTRICAL INDUSTRIES
2 . P0385	INDIANA ENGG WORKS PVT LTD
3 . P0529	METALITE INDUSTRIES
4 . P0619	PAREKH ENGINEERING COMPANY
5 . P3446	PARMAR METALS PVT. LIMITED
6 . P0695	SADHANA ENGINEERING CORPORATION
7 . P0756	STEELITE ENGINEERING LIMITED

## 311607 : MULTI TRANSIT INLET SYSTEM

CODE	NAME
<b>SWEDEN</b>	
1 . P0522	MCT BRATTBERG AKTIEBOLAG
2 . P0685	ROXTEC AB
<b>U.K.</b>	
3 . P0339	HAWKE INTERNATIONAL

## 311608 : JUNCTION BOX & CABLE GLAND

CODE	NAME
<b>INDIA</b>	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P3458	EX- PROTECTA
3 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
4 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
5 . P3412	FLEXPRO ELECTRICALS PVT. LTD.
6 . P3475	PHOENIX MECANO (INDIA) PVT.LTD.
7 . P3499	RITTAL INDIA PVT.LTD.
8 . P3432	TAN SWA TECHNOLOGIES INC (JUNCTION BOX)
9 . P3422	TRINITY TOUCH PVT. LTD. (Only Cable Glands upto Size 25M)
<b>GERMANY</b>	
10 . P0750	STAHL-UND APPARATEBAU HANS LEFFER GMBH



## 311615 : CS SEAMLESS PIPES

CODE	NAME
<b>INDIA</b>	
1 . P0814	INDIAN TUBE CO. (TATA DIV. OF TUBES & PIPES)
2 . P0800	ISMT LIMITED
3 . P0503	MAHARASHTRA SEAMLESS LTD.
<b>FRANCE</b>	
4 . P0834	ETS TROUVAY & CAUVIN
5 . P0629	PHOCEENNE
<b>GERMANY</b>	
6 . P0477	HORST KURVERS GmbH
7 . P0509	MANNESMANN HANDEL AG
<b>ITALY</b>	
8 . P0191	DALMINE SPA
9 . P0175	IBF SEAMLESS PIPES Spa
<b>JAPAN</b>	
10 . P0517	MARUBENI ITOCHU STEEL
11 . P0585	NIPPON STEEL CORPORATION
12 . P0588	NISSHO IWAI CORPORATION
13 . P0601	OKURA & CO. LTD.
14 . P0575	SOJITZ CORPORATION
15 . P0770	SUMITOMO METAL INDUSTRIES LTD.

## 311615 : CS SEAMLESS PIPES

CODE	NAME
<b>KOREA</b>	
16 . P0370	HYUNDAI CORPORATION
<b>U.K.</b>	
17 . P0870	VOMAL INTERNATIONAL LIMITED

## 311616 : SS SEAMLESS PIPES

CODE	NAME
<b>INDIA</b>	
1 . P0158	CHOKSI TUBE COMPANY LTD.
2 . P3488	DIVINE TUBES PVT.LTD. (UPTO 38 MM)
3 . P3418	MAXIM TUBES COMPANY PVT. LTD.
4 . P0593	NUCLEAR FUEL COMPLEX
5 . P0661	RATNAMANI METALS & TUBES LIMITED
6 . P0659	REMI EDELSTAHL TUBULARS LTD.(RAJENDRA MECHANICAL INDUSTRIES
<b>FRANCE</b>	
7 . P0629	PHOCEENNE
<b>GERMANY</b>	
8 . P0822	TPS-TECHNITUBE ROHRENWERKE GMBH
<b>ITALY</b>	
9 . P0191	DALMINE SPA
<b>SPAIN</b>	
10 . P2151	T.T.I. - TUBACEX TUBOS INOXIDABLES, S.A. (½" NB SS Pipe)

## 311617 : SS TUBES

CODE	NAME
<b>INDIA</b>	
1 . P3497	ASTEC VALVES & FITTINGS PRIVATE LIMITED
2 . P0158	CHOKSI TUBE COMPANY LTD.
3 . P3488	DIVINE TUBES PVT.LTD. (UPTO 18 MM)
4 . P3418	MAXIM TUBES COMPANY PVT. LTD.
5 . P0593	NUCLEAR FUEL COMPLEX
6 . P0661	RATNAMANI METALS & TUBES LIMITED
7 . P0659	REMI EDELSTAHL TUBULARS LTD.(RAJENDRA MECHANICAL INDUSTRIES
<b>JAPAN</b>	
8 . P0412	ITOCHU CORPORATION (REP.KUBOTA CORPN.)
9 . P0587	NISHITANI & CO. LTD.
10 . P0771	SUMITOMO METAL INDUSTRIES LTD.

## 311618 : PIPE FITTINGS

CODE	NAME
<b>INDIA</b>	
1 . P3476	COMFIT & VALVES PVT.LTD.
2 . P0222	EBY INDUSTRIES
3 . P0247	EXCEL HYDRO-PNEUMATICS PVT LTD,
4 . P3519	GLOBAL VALVES AND FITTING (INDIA) PVT. LTD. (FOR NON IBR APPLICATION)
5 . P0534	MICRO PRECISION PRODUCTS PRIVATE LTD.
6 . P2109	PRECISION ENGINEERING INDUSTRIES
7 . P0792	TECNOMATIC (INDIA) PVT. LTD.
8 . P3518	VENTIL FLOWSERVE PVT. LTD.
9 . P3413	WESMEC ENGINEERING PVT. LTD.
<b>FRANCE</b>	
10 . P0149	CELLIER S.A.
<b>GERMANY</b>	
11 . P0508	SIEMENS AG PGI
12 . P0813	THYSSEN-KRUPP STAHLUNION GmbH
<b>ITALY</b>	
13 . P0150	CESARE BONETTI SPA
14 . P0791	TECHNOMATIC SPA
<b>JAPAN</b>	
15 . P0771	SUMITOMO METAL INDUSTRIES LTD.

## 311618 : PIPE FITTINGS

CODE	NAME
<b>U.K.</b>	
16 . P0203	DEWRANCE & CO. LTD.
17 . P0366	HOPKINSONS LIMITED
18 . P0811	THOMPSON VALVES LTD.
19 . P0856	VELAN ENGINEERING CO. LIMITED
<b>U.S.A.</b>	
20 . P0049	ANDERSON GREENWOOD & CO.
21 . P0181	CRANE COMPANY INTL. SALES

## 311619 : COMPRESSION FITTINGS

CODE	NAME
<b>INDIA</b>	
1 . P3192	ARYA CRAFTS & ENGINEERING PVT.LTD. (Upto Line Pressure Class 600 # rating.)
2 . P3182	AURA INC
3 . P0088	BALDOTA VALVE & FITTING CO.PVT.LTD.
4 . P3476	COMFIT & VALVES PVT.LTD.
5 . P0247	EXCEL HYDRO-PNEUMATICS PVT LTD,
6 . P0248	EXCELSIOR ENGG WORKS
7 . P3194	FLUID CONTROLS PRIVATE LIMITED ((Double Ferrule Compression Tube Fittings))
8 . P3519	GLOBAL VALVES AND FITTING (INDIA) PVT. LTD. (FOR NON IBR APPLICATION)
9 . P3493	HAVI ENGINEERING INDIA PVT.LTD
10 . P3189	PANAM ENGINEERS
11 . P2109	PRECISION ENGINEERING INDUSTRIES
12 . P0664	RELIANCE ENGG. & ELECTRICAL CORPN.
13 . P3518	VENTIL FLOWSERVE PVT. LTD.
14 . P0862	VIKAS INDUSTRIAL PRODUCTS
15 . P3413	WESMEC ENGINEERING PVT. LTD.
<b>SINGAPORE</b>	
16 . P0620	PARKER HANNIFIN SINGAPORE PTE. LTD.,
<b>U.S.A.</b>	

**311619: COMPRESSION FITTINGS**

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CODE	NAME
17. P0778	SWAGELOCK COMPANY/CREXIMCO

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## 311620 : INSTRUMENT MINIATURE VALVES

CODE	NAME
<b>INDIA</b>	
1 . P0077	AUDCO INDIA LIMITED(L&T VALVES DIVN.)
2 . P3182	AURA INC
3 . P0115	BHEL (VALVES DIVISION)
4 . P0153	CHEMTROLS INDUSTRIES LTD.
5 . P3181	CHEMTROLS SAMIL (INDIA) PVT LTD.
6 . P3476	COMFIT & VALVES PVT.LTD.
7 . P0247	EXCEL HYDRO-PNEUMATICS PVT LTD,
8 . P0248	EXCELSIOR ENGG WORKS
9 . P3194	FLUID CONTROLS PRIVATE LIMITED
10 . P3519	GLOBAL VALVES AND FITTING (INDIA) PVT. LTD. (FOR NON IBR APPLICATION)
11 . P3493	HAVI ENGINEERING INDIA PVT.LTD
12 . P0473	KSB PUMPS LIMITED (VALVES DIVN)
13 . P3189	PANAM ENGINEERS
14 . P0792	TECNOMATIC (INDIA) PVT. LTD.
15 . P3518	VENTIL FLOWSERVE PVT. LTD.
16 . P3413	WESMEC ENGINEERING PVT. LTD.

### **FRANCE**

## 311620 : INSTRUMENT MINIATURE VALVES

CODE	NAME
17 . P0149	CELLIER S.A.
<b>ITALY</b>	
18 . P0103	BFE BONNEY FORGE VALVE LICENSEE
19 . P0243	EUROMISURE CREMONA
20 . P0791	TECHNOMATIC SPA
<b>JAPAN</b>	
21 . P0464	KOSEI SANGYO LTD
22 . P0771	SUMITOMO METAL INDUSTRIES LTD.
<b>U.K.</b>	
23 . P0203	DEWRANCE & CO. LTD.
24 . P0366	HOPKINSONS LIMITED
25 . P0856	VELAN ENGINEERING CO. LIMITED
<b>U.S.A.</b>	
26 . P0049	ANDERSON GREENWOOD & CO.
27 . P0181	CRANE COMPANY INTL. SALES
28 . P0778	SWAGELOCK COMPANY/CREXIMCO

## 311621 : PURGE ROTAMETER

CODE	NAME
<b>INDIA</b>	
1 . P3199	EUREKA INDUSTRIAL EQUIPMENTS PRIVATE LIMITED
2 . P0398	INSTRUMENTATION ENGINEERS PVT. LTD.
3 . P0633	PLACKA INSTRUMENTS & CONTROLS PVT. LTD.

## 311622 : AIR HEADER/ADPOT

CODE	NAME
<b>INDIA</b>	
1 . P3497	ASTEC VALVES & FITTINGS PRIVATE LIMITED
2 . P3476	COMFIT & VALVES PVT.LTD.
3 . P3413	WESMEC ENGINEERING PVT. LTD.

## 311623 : CONDENSATE POT

CODE	NAME
<b>INDIA</b>	
1 . P3497	ASTEC VALVES & FITTINGS PRIVATE LIMITED
2 . P3476	COMFIT & VALVES PVT.LTD.
3 . P3413	WESMEC ENGINEERING PVT. LTD.

## 311624 : VALVE MANIFOLDS

CODE	NAME
<b>INDIA</b>	
1 . P3497	ASTEC VALVES & FITTINGS PRIVATE LIMITED
2 . P3476	COMFIT & VALVES PVT.LTD.
3 . P3519	GLOBAL VALVES AND FITTING (INDIA) PVT. LTD. (FOR NON IBR APPLICATION)
4 . P3494	HAVI ENGINEERING INDIA PVT.LTD
5 . P3518	VENTIL FLOWSERVE PVT. LTD.
6 . P3413	WESMEC ENGINEERING PVT. LTD.



## 311626: CALIBRATION EQUIPMENT & SERVICES

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CODE	NAME
<i>INDIA</i>	
1 . P3420	TEMPSSENS INSTRUMENTS (I) PVT. LTD.

## 311627 : ENCLOSURES

CODE	NAME
<b>INDIA</b>	
1 . P3458	EX- PROTECTA
2 . P3499	RITTAL INDIA PVT.LTD.
3 . P3422	TRINITY TOUCH PVT. LTD. (Weatherproof size 80 X 80 mm)
4.	Bharat Heavy Electrical Ltd. Electronics Division Bangalore



**311628: MONOFLANGES**

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CODE	NAME
<b>INDIA</b>	
1 . P3497	ASTEC VALVES & FITTINGS PRIVATE LIMITED

## 311629 : CLOSE COUPLE HOOK-UPS (CCHU)

CODE	NAME
<b>INDIA</b>	
1 .	ASTEC VALVES & FITTINGS PRIVATE LIMITED
2 . P3476	COMFIT & VALVES PVT.LTD.

## 311631 : INSTRUMENTATION VALVES (NEEDLE VALVE & CHECK VALVES

CODE	NAME
<b>INDIA</b>	
1 . P3497	ASTEC VALVES & FITTINGS PRIVATE LIMITED
2 . P3476	COMFIT & VALVES PVT.LTD.

## 311701 : INSTRUMENT CONTRACTOR FOR INST. CONSTRUCTION/ERECTION WORKS

CODE	NAME
<b>INDIA</b>	
1 . P3178	ANI INSTRUMENT (upto 0.5 Crores)
2 . P3429	GODREJ & BOYCE MFG. CO. LTD.
3 . P3177	INSTROCON ENGINEERS AND CONTROLS (I) PVT. LTD (upto 0.5 Crores)
4 . P3172	JASUBHAI ENGINEERING PVT. LTD.
5 . P3180	L&T (CONSTRUCTION CONTRACTS DIVN.)
6 . P3179	MIRAJ INSTRUMENTATION SERVICE (upto 0.5 Crores)
7 . P3187	NARAYAN ENGINEERING (< RS. 5 LACS (SMALL PROJECT))
8 . P3175	PACE PROCESS CONTROL PVT. LTD.
9 . P3173	PETRON ENGG. CONSTRUCTION LTD.
10 . P3176	PROTECH CONTROL PVT. LTD. (upto 0.5 Crores)
11 . P3511	SPARK AUTOMATION
12 . P3171	TECHNIMONT ICB LTD.

## 311801 : ELECTRICAL HEAT TRACING

CODE	NAME
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1 .

**INDIA**

2 . P3478 THERMOPADS PVT.LTD.

	<b>MASTER VENDORS LIST FOR PROJECTS</b>	04-00MM-0011	18
		DOCUMENT NO	REV

**MASTER VENDORS LIST**  
**FOR**  
**PROJECTS**  
**CIVIL ENGG. ITEMS**

## INDEX CIVIL ENGINEERING ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE NO.
<b>6102</b>	<b>CIVIL CONTRACTS</b>	
610201	PILING	2
610202	PRILLING TOWER(UREA) (using slip from technique)	3
610203	CHIMNEY(using slip form technique)	4
610204	SILO(parabolic or a type)	5
610205	WORKS CIVIL &STRUCTURAL	6
610206	UNDERGROUND PIPING WORKS (AS PART OF CIVIL WORK)	8
610213	PRILLING TOWER LINING (INSIDE)	9
610216	COMPOSITE WORK	10
610221	ARCHITECTURAL SERVICES	11
610222	GEOTECHNICAL WORKS	12
610226	SMALL MAINTENANCE WORKS	13
610228	STRUCTURAL GRATINGS	14
610231	WATER PROOFING AND ROOF TREATMENT	15
610232	WATER SUPPLY AND SANITATION	16
610233	ANTI-CORROSIVE MATERIAL (MANUFACTURE & APPLICATOR)	17
610234	REHABILITATION WORKS	18
610235	TMT RE-BAR	19
610236	STRUCTURAL STEEL	20
610237	FRP, POLYCARBONATE AND METAL SHEET PRODUCTS	21
610238	CONST. CHEMICALS (ADMIXT, WATERPROOFING, FLOORING & COATING, REPAIR & RESTORE, GROUT & ANCHOR, BUILDINGS & JOIN SEALANTS)	22

## 610201 : PILING

CODE	NAME
<b>INDIA</b>	
1 . P6007	AFCONS INFRASTRUCTURE LIMITED
2 . P6005	BRIDGE AND ROOF CO.(INDIA) LTD.
3 . P6006	GAMMON INDIA LTD.
4 . P6003	GANNON DUNKERLEY & CO. LIMITED
5 . P6009	HINDUSTAN CONSTRUCTION CO.
6 . P6008	INTEGRATED PILE FOUNDATION(MADRAS) PVT. LTD.
7 . P6001	LARSEN & TOUBRO LTD( ECC Division)
8 . P6004	SIMPLEX INFRASTRUCTURES LIMITED
9 . P6002	SKANSKA CEMENTATION INDIA LIMITED.



## 610202 : PRILLING TOWER(UREA) (using slip from technique)

CODE	NAME
<b>INDIA</b>	
1 . P6005	BRIDGE AND ROOF CO.(INDIA) LTD.
2 . P6006	GAMMON INDIA LTD.
3 . P6001	LARSEN & TOUBRO LTD( ECC Division)
4 . P6004	SIMPLEX INFRASTRUCTURES LIMITED

## 610203 : CHIMNEY(using slip form technique)

CODE	NAME
<b>INDIA</b>	
1 . P6011	BYGGING INDIA
2 . P6006	GAMMON INDIA LTD.
3 . P6003	GANNON DUNKERLEY & CO. LIMITED
4 . P6001	LARSEN & TOUBRO LTD( ECC Division)
5 . P6010	NILA BAUART ENGINEERING LTD.

610204 : SILO(parabolic or a type)

CODE	NAME
<b>INDIA</b>	
1 . P6005	BRIDGE AND ROOF CO.(INDIA) LTD.
2 . P6006	GAMMON INDIA LTD.
3 . P6003	GANNON DUNKERLEY & CO. LIMITED
4 . P6001	LARSEN & TOUBRO LTD( ECC Division)
5 . P6004	SIMPLEX INFRASTRUCTURES LIMITED

## 610205 : WORKS CIVIL & STRUCTURAL

CODE	NAME
<b>INDIA</b>	
1 . P6027	A.N.S. CONSTRUCTION (UPTO Rs.7.5 CRORE)
2 . P6013	BHAGEERATHA ENGINEERING LIMITED
3 . P6005	BRIDGE AND ROOF CO.(INDIA) LTD.
4 . P6031	BSBK LTD.
5 . P6034	C.P. SYSTEMS PVT, LTD. (UPTO Rs.3.0 CRORE)
6 . P6017	DUAL STRUCTURAL (P) LTD. (UPTO Rs.3.0 CRORE)
7 . P6015	ENGINEERING PROJECTS(I) LTD. (UPTO Rs.7.5 CRORE)
8 . P6006	GAMMON INDIA LTD.
9 . P6003	GANNON DUNKERLEY & CO. LIMITED
10 . P6030	GILLANDERS ARBUTHNOT & CO. LTD.,UNIT-MICCO (UPTO RS. 3.0 CRORE)
11 . P6029	GLOBE HI-FAB (UPTO Rs. 7.5 CRORE)
12 . P6022	HINDUSTAN STEEL WORKS CONSTRUCTION LTD. (UPTO Rs.7.5 CRORE)
13 . P6036	INDIAN COMMERCE & INDUSTRIES CO. PVT. LTD. (UPTO Rs.3.0 CRORE)
14 . P6025	J.M.C. PROJECTS (INDIA) LIMITED. (UPTO Rs.7.5 CRORE)
15 . P6020	JAIHIND PROJECTS LIMITED (UPTO Rs.3.0 CRORE)
16 . P6001	LARSEN & TOUBRO LTD( ECC Division)
17 . P6018	MSK PROJECTS (INDIA) LIMITED. (UPTO Rs. 7.5 CRORE)

## 610205 : WORKS CIVIL & STRUCTURAL

CODE	NAME
18 . P6019	NATIONAL BUILDERS (UPTO Rs. 7.5 CRORE)
19 . P6021	NATIONAL BUILDINGS CONST. CORPORATION LTD. (UPTO Rs.7.5 CRORE)
20 . P6010	NILA BAUART ENGINEERING LTD. (UPTO Rs. 7.5 CRORE)
21 . P6023	ORIENTAL CIVIL ENGINEERING CO. LTD. (UPTO Rs. 7.5 CRORE)
22 . P6012	PETRON CIVIL ENGINEERING LIMITED
23 . P6033	POWER MAX INDIA PVT. LTD. (UPOT Rs. 7.5 CRORE)
24 . P6028	RAMJI DAS DARSHAN KUMAR (UPTO Rs. 7.5 CRORE)
25 . P6024	RASTRIYA PARIYOJNA NIRMAN NIGAM LTD. (UPTO Rs. 7.5 CRORE)
26 . P6004	SIMPLEX INFRASTRUCTURES LIMITED
27 . P6002	SKANSKA CEMENTATION INDIA LIMITED.
28 . P6026	SKB BUILDERS (UPTO Rs.7.5 CRORE)
29 . P6016	SVC PROJECTS PRIVATE LIMITED (UPTO Rs.3.0 CRORE)
30 . P6014	TARAPORE & COMPANY
31 . P6035	TEKNOW CONSULTANTS & ENGINEERS PVT. LTD. (UPTO Rs.3.0 CRORE)
32 . P6032	UNITECH LTD. (UPTO RS. 7.5 CRORE)
33 . P6037	VASAVI ENGINEERING CORPORATION (UPTO Rs.3.0 CRORE)

## 610206 : UNDERGROUND PIPING WORKS (AS PART OF CIVIL WORK)

CODE	NAME
<b>INDIA</b>	
1 . P6013	BHAGEERATHA ENGINEERING LIMITED
2 . P6005	BRIDGE AND ROOF CO.(INDIA) LTD.
3 . P6006	GAMMON INDIA LTD.
4 . P6003	GANNON DUNKERLEY & CO. LIMITED
5 . P6001	LARSEN & TOUBRO LTD( ECC Division)
6 . P6004	SIMPLEX INFRASTRUCTURES LIMITED
7 . P6014	TARAPORE & COMPANY

## 610213 : PRILLING TOWER LINING (INSIDE)

CODE	NAME
<b>INDIA</b>	
1 . P6063	ARIEN NEW DELHI PRIVATE LIMITED
2 . P6059	M.PALLONJI & CO. PRIVATE LIMITED
3 . P6071	MAJOR GRAIND CORROSSION CONTROLLERS
4 . P6060	WASPRABHA

**610216 : COMPOSITE WORK**

<b>CODE</b>	<b>NAME</b>
<b>INDIA</b>	
1 . P6005	BRIDGE AND ROOF CO.(INDIA) LTD.
2 . P6106	ESSAR STEEL INDIA LTD. (For H.R. Plates/ Sheets/Coils/CRCA Coils/Sheets)
3 . P6003	GANNON DUNKERLEY & CO. LIMITED
4 . P6001	LARSEN & TOUBRO LTD( ECC Division)
5 . P6051	MUKUND ENGINEERS LTD.
6 . P6012	PETRON CIVIL ENGINEERING LIMITED
7 . P6043	SPIC JEL ENGG. CONSTRUCTION LTD.
8 . P6045	STEWARTS & LLOYDS OF INDIA LTD.
9 . P6038	U.B.ENGINEERING LIMITED



## 610221 : ARCHITECTURAL SERVICES

CODE	NAME
<b>INDIA</b>	
1 . P6082	ALLIED ARCHITECTS PVT. LIMITED.
2 . P6081	GARG & ASSOCIATES
3 . P6085	KOTHARI ASSOCIATES PVT. LIMITED.
4 . P6084	R.K.ASSOCIATES
5 . P6083	S.K.INTEGRATED CONSULTANTS

## 610222 : GEOTECHNICAL WORKS

CODE	NAME
<b>INDIA</b>	
1 . P6087	CENGRS GEOTECHNICA PVT. LIMITED.
2 . P6086	GEOTECH CONSULTANTS PVT. LIMITED

**610226: SMALL MAINTENANCE WORKS**

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CODE	NAME
<b>INDIA</b>	
1 . P6088	SHIVA CONSTRUCTIONS

## 610228 : STRUCTURAL GRATINGS

CODE	NAME
<b>INDIA</b>	
1 . P6111	ERCON COMPOSITES (FRP Gratings)
2 . P6123	FERROTECH STRUCTURALS (INDIA) PVT.LTD.
3 . P6089	INDIANA GRATINGS PVT. LIMITED.
4 . P8089	KANADE ANAND UDYOG PVT. LTD.
5 . P6105	KEMROCK INDUSTRIES & EXPORTS LTD. ( For FRP Gratings)
6 . P6108	PENTAX FERRO INCORPORATE (For Gratings/Floor Grill - MS, MS Hot Dipped Galvanized.)
7 . P6110	PINAX STEEL INDUSTRIES PRIVATE LIMITED (Electroforged Gratings)
8 . P6125	PINAX STEEL INDUSTRIES PRIVATE LIMITED
9 . P6109	SUTTATTI ENTERPRISES LTD.

**610231 : WATER PROOFING AND ROOF TREATMENT**

<b>CODE</b>	<b>NAME</b>
<b>INDIA</b>	
1 . P6130	IWL INDIA PRIVATE LIMITED
2 . P6101	PIDILITE INDUSTRIES LIMITED (Including all Chemicals & Accessories)
3 . P6128	STP LIMITED
4 . P6126	SUNANDA SPECIALITY COATINGS PVT.LTD.
5 . P6100	TRISTAR INTECH PVT. LTD.



## 610232: WATER SUPPLY AND SANITATION

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CODE	NAME
<i>INDIA</i>	
1 . P6099	KAPILANSH DHATU UDYOG (P) LTD.

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**610233 : ANTI-CORROSIVE MATERIAL (MANUFACTURE & APPLICATOR)**

CODE	NAME
<b>INDIA</b>	
1 . P1032	ARCOY INDUSTRIES (Cement / Morter / Rubber / Tile Lining Work)
2 . P6130	IWL INDIA PRIVATE LIMITED
3 . P6128	STP LIMITED
4 . P6126	SUNANDA SPECIALITY COATINGS PVT.LTD.



# 610234: REHABILITATION WORKS

CODE	NAME
<i>INDIA</i>	
1 . P6107	STANDARD REHABILITATORS PVT. LTD. (For Civil Structure with Painting)



## 610235 : TMT RE-BAR

CODE	NAME
1 .	
	<b>INDIA</b>
2 . P6112	SHYAM STEEL INDUSTRIES LIMITED
3 . P6119	Jindal Steel & Power Limited
4 . P6114	M/S ELECTROSTEEL STEELS LTD. (V-XEGA)
5 . P6129	RASHMI METALIKS LIMITED
6 . P6121	SHRI BAJRANG POWER & ISPAT LTD. (GOEL TMT)
7 . P6115	SHRI RATHI STEEL LTD.
8 . P6127	SHYAM METALICS AND ENERGY LTD.
9 . P6122	SPS STEELS ROLLING MILLS LIMITED
10 . P6116	SRMB SRIJAN PRIVATE LIMITED

## 610236 : STRUCTURAL STEEL

CODE	NAME
<b>INDIA</b>	
1 . P6113	JINDAL STEEL & POWER LIMITED
2 . P6127	SHYAM METALICS AND ENERGY LTD.

## 610237 : FRP, POLYCARBONATE AND METAL SHEET PRODUCTS

CODE	NAME
<b>INDIA</b>	
1 . P6124	ROOFCLAD INFRA PVT.LTD.
2 . P6117	SHIV SHAKTI FIBER UDYOG

**610238 : CONST. CHEMICALS (ADMIXT, WATERPROOFING, FLOORING & COATING, REPAIR & RESTORE, GROUT & ANCHOR,BUILDINGS & JOIN**

CODE	NAME
<b>INDIA</b>	
1 . P6130	IWL INDIA PRIVATE LIMITED
2 . P6120	Jay Chemical Industries Pvt. Ltd. (K2)
3 . P6118	MYK ARMENT PRIVATE LIMITED
4 . P6128	STP LIMITED
5 . P6126	SUNANDA SPECIALITY COATINGS PVT.LTD.

	<b>MASTER VENDORS LIST FOR PROJECTS</b>	04-00MM-0011	18
		DOCUMENT NO	REV

**MASTER VENDORS LIST**  
**FOR**  
**PROJECTS**  
**PROCESS ENGG. ITEMS**

## INDEX PROCESS ENGINEERING ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE NO.
<b>7101</b>	<b>PROCESS ENGG. ITEMS (AMMONIA PLANT)</b>	
710101	CATALYST	3
710102	CATALYST BED SUPPORT,CERAMIC BALLS ,ALUMINA BALLS	4
710103	PURGE GAS RECOVERY	5
710104	ACTIVATED CARBON	6
710105	REFRIGERATION SYSTEMS INVOLVING AMMONIA AND HYDROCARBON	7
<b>7102</b>	<b>PROCESS ENGG ITEMS ( OFFSITE &amp; UTILITIES)</b>	
710201	OIL WATER SEPARATION UNIT (TPI/CPI TYPE DISC OIL)	8
710202	FLARE SYSTEM	9
710203	DM WATER / CONDENSATE POLISHING UNIT	10
710204	INSTRUMENT AIR DRYING UNIT	12
710205	PSA NITROGEN PLANT	13
710206	REVERSE OSMOSIS PLANT	14
710207	AIR LIQUIFICATION / LIQUID NITROGEN PLANT	16
710208	CHLORINATION UNIT	17
710209	VALVELESS AUTO WASH GRAVITY SAND FILTER	18
710210	WATER PRE-TREATMENT PLANT	19
710211	WASTE WATER TREATMENT PLANT	20
710212	CHEMICAL DOSING SYSTEM FOR COOLING TOWER	22
710213	COOLING TOWERS	23
710214	POLLUTION CONTROL EQUIPMENTS	24
710215	MIST TYPE COOLING TOWER	25
710216	EFFLUENT TREATMENT PLANT (ETP)	26
710217	SEA WATER DESALINATION PLANT	27
710218	SEWAGE TREATMENT PLANT	28
710219	JET AERATOR	29
710221	Chemicals-V2O5,Antifoam agent,TSP,KNO2,H2SO4,HCL,	30
710222	NATURAL GAS TREATMENT PLANT/SKID	32
710223	TOWER PACKING	33
710224	TOWER/SEPARATOR INTERNALS	34
710225	DISTILLATION TOWER TRAYS	35
710226	COLD BOXES	36
710227	MEMBRANE BIO REACTOR	37
710228	ULTRA FILTRATION PLANT	38

**INDEX CUSTOM CLEARANCE & TRANSPORTATION ITEMS**

<b>ITEMCODE</b>	<b>ITEM DESCRIPTION</b>	<b>PAGE NO.</b>
710229	SEWAGE / EFFLUENT TREATMENT PLANT	39
<b>7104</b>	<b>CONTRACTORS</b>	
710401	LOADING OF CATALYST & PACKING	40

## 710101 : CATALYST

CODE	NAME
<b>INDIA</b>	
1 . P7001	PROJECTS & DEVELOPMENT INDIA LTD.
2 . P7002	SUD CHEMIE
<b>DENMARK</b>	
3 . P7003	HALDOR TOPSOE
<b>GERMANY</b>	
4 . P7005	BASF AKTIENGESELL SC HAFT
<b>NETHERLAND</b>	
5 . P7006	NORSK HYDRO
<b>U.K.</b>	
6 . P7004	ICI



**710102 : CATALYST BED SUPPORT,CERAMIC BALLS ,ALUMINA BALLS**

CODE	NAME
<b>INDIA</b>	
1 . P7011	CALDERYS INDIA REFRACTORIES LTD
2 . P7007	OXIDE INDIA PVT. LTD.
<b>DENMARK</b>	
3 . P7003	HALDOR TOPSOE
<b>U.K.</b>	
4 . P7008	CARBORANDUM RESISTANT MATERIAL
<b>U.S.A.</b>	
5 . P7009	ALCOA
6 . P7010	AP GREEN REFRACTORIES

## 710103 : PURGE GAS RECOVERY

CODE	NAME
<b>INDIA</b>	
1 . P7012	BHPV
2 . P7017	LIQUID AIR ENGG. INDIA LTD.
<b>BELGIUM</b>	
3 . P7016	AIR PRODUCT
<b>FRANCE</b>	
4 . P7015	AIR LIQUIDE
<b>GERMANY</b>	
5 . P7013	LINDE
<b>JAPAN</b>	
6 . P7019	NIPPON SAUSO KK
7 . P7018	SUMITOMO CHEM ENGG. CO. LTD.
<b>U.K.</b>	
8 . P7014	COSTAIN ENGG. LTD.

## 710104 : ACTIVATED CARBON

CODE	NAME
<b>INDIA</b>	
1 . P7023	ACTIVE CARBON INDIA PVT. LTD.
2 . P7148	GRAND PRIX ENGINEERING PVT.LTD.
3 . P7020	INDUSTRIAL CARBON
4 . P7027	ION EXCHANGE INDIA LTD.
5 . P7021	SHRI RAJPIPLA AMAR CARBON
<b>GERMANY</b>	
6 . P7024	CARBOTECH AKTIVKOHLEN GMBH
<b>ITALY</b>	
7 . P7026	CHEM VIRON
<b>U.S.A.</b>	
8 . P7022	NORIT
9 . P7025	CALGON CORPORATION

## 710105 : REFRIGERATION SYSTEMS INVOLVING AMMONIA AND HYDROCARBON GASES BOIL OFF AND CRYOGENIC SYSTEMS

CODE	NAME
<b>INDIA</b>	
1 . P7142	SYSTEMS & COMPONENTS (INDIA) PVT. LTD. (49 TR at minus 75°C with Methanol / R22 as refrigerant; 175 TR at minus 20°C with R717 / Methanol as refrigerant; 787 TR at 8°C with water as refrigerant)

## 710201 : OIL WATER SEPARATION UNIT (TPI/CPI TYPE DISC OIL)

CODE	NAME
<b>INDIA</b>	
1 . P7032	BP LIMITED
2 . P7148	GRAND PRIX ENGINEERING PVT.LTD.
3 . P7029	HINDUSTAN DORR OLIVER LTD.
4 . P7027	ION EXCHANGE INDIA LTD.
5 . P7031	K-PACK
6 . P7150	MULTITEX FILTRATION ENGINEERS LTD.
7 . P7140	OSWAL INFRASTRUCTURE LIMITED (3508 Kg/Hr.)
8 . P7030	PARAMOUNT INDIA LTD.
<b>india</b>	
9 . P7141	OXYBEE SOLUTIONS (60 KLD)
<b>ITALY</b>	
10 . P7028	OCS

## 710202 : FLARE SYSTEM

CODE	NAME
<b>INDONESIA</b>	
1 . P7146	PT. KOTAMINYAK INTERNUSA (500 MMSCFD)
<b>INDIA</b>	
2 . P7033	ADOR SAMIA
3 . P0027	AIROIL FLAREGAS (INDIA) PVT.LIMITED,
4 . P7138	EUROPEM NV (25000-170891 Kg/hr)
5 . P7140	OSWAL INFRASTRUCTURE LIMITED (3508 Kg/Hr.)
<b>ITALY</b>	
6 . P7135	THERMOENGINEERING SRL (700 - 1620400 Kg/Hr.)
<b>UNITED STATES</b>	
7 . P7134	ZEECO, INC. (1921080 Kg/hr)
<b>U.K.</b>	
8 . P7034	CALIDUS
9 . P0429	JOHN ZINK COMPANY LIMITED

## 710203 : DM WATER / CONDENSATE POLISHING UNIT

CODE	NAME
<b>INDIA</b>	
1 . P7137	BGR ENGERGY SYSTEMS LIMITED (55 - 130 M3/Hr)
2 . P7055	DOSHI ION EXCHANGE & CHEMICAL INDUSTRIES LTD
3 . P7133	DRIPLEX WATER ENGINEERING PVT.LTD. (8 X 172 m3/hr)
4 . P7037	INDOCON ENGG. SYSTEM PVT. LTD.
5 . P7027	ION EXCHANGE INDIA LTD.
6 . P7030	PARAMOUNT INDIA LTD.
7 . P7136	PRAJ INDUSTRIES LIMITED (5 - 33 m3/hr)
8 . P7038	PROJECTS & DEVELOPMENT INDIA LTD.
9 . P7036	THERMAX INDIA LTD.
10 . P7035	V.A. TECH WABAG
11 . P7130	VA TECH WABAG LTD. (12-14400 m3/hr)
<b>india</b>	
12 . P7141	OXYBEE SOLUTIONS (1000 - 10000 LPH)
<b>AUSTRALIA</b>	
13 . P7042	VIVENDI WATER SYSTEM
<b>ITALY</b>	
14 . P7041	IDRECO
15 . P7039	TERMOKIMIK CORPORATION SPA
<b>KOREA</b>	

**710203: DM WATER / CONDENSATE POLISHING UNIT**

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CODE	NAME
16. P7040	KOREA HEAVY INDUSTRIES & CONSTRUCTION

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## 710204 : INSTRUMENT AIR DRYING UNIT

CODE	NAME
<b>INDIA</b>	
1 . P7047	ADVANCED COMPRESSED AIR SYSTEM
2 . P7045	CHEM TECH ENGINEERS
3 . P7044	CLEAN AIR SYSTEMS & EQUIPMENTS
4 . P7139	GAS PROCESSING EQUIPMENT PVT. LTD. (300 - 7750 NM3/Hr)
5 . P7046	GASO ENERGY SYSTEMS INDIA LTD.
6 . P7043	LLOYDS STEEL LTD.
7 . P7052	MAS GAS AIR SYSTEMS PVT. LTD.
8 . P7049	MECHNEIL & MAGOR
9 . P7053	MELLCON ENGINEERS PVT. LTD. (All Type & Capacity)
10 . P7050	MIRCH TECHNOLOGIES LIMITED
11 . P7150	MULTITEX FILTRATION ENGINEERS LTD.
12 . P7051	MVS ENGG. LIMITED
13 . P7107	NATIONAL ENGINEERING INDUSTRIES
14 . P7149	SUMMITS HYGRONICS PRIVATE LIMITED
15 . P7048	TECHNIP KT INDIA LIMITED
<b>ITALY</b>	
16 . P7123	PREMABERGO ITALIANA srl

## 710205 : PSA NITROGEN PLANT

CODE	NAME
<b>INDIA</b>	
1 . P7054	BRITISH OXYGEN
2 . P7139	GAS PROCESSING EQUIPMENT PVT. LTD. (25 - 700 NM3/Hr)
3 . P7149	SUMMITS HYGRONICS PRIVATE LIMITED
4 . P7048	TECHNIP KT INDIA LIMITED
<b>BELGIUM</b>	
5 . P7016	AIR PRODUCT
<b>FRANCE</b>	
6 . P7015	AIR LIQUIDE
<b>GERMANY</b>	
7 . P7024	CARBOTECH AKTIVKOHLEN GMBH
8 . P7013	LINDE

## 710206 : REVERSE OSMOSIS PLANT

CODE	NAME
<b>INDIA</b>	
1 . P7132	AQUA DESIGNS INDIA PVT. LTD. (7-105 m3/hr.)
2 . P7137	BGR ENGERGY SYSTEMS LIMITED (75 - 541.6 M3/Hr (13 MLD))
3 . P7055	DOSHI ION EXCHANGE & CHEMICAL INDUSTRIES LTD
4 . P7133	DRIPLEX WATER ENGINEERING PVT.LTD. (7 X 219 m3/hr)
5 . P7029	HINDUSTAN DORR OLIVER LTD.
6 . P7027	ION EXCHANGE INDIA LTD.
7 . P7057	METITO POLLUTION CONTROL INDIA PVT. LTD.
8 . P7056	NEWCHEM WEIR LTD.
9 . P7058	ONDEO DEGREMONT
10 . P7030	PARAMOUNT INDIA LTD.
11 . P7136	PRAJ INDUSTRIES LIMITED (10 - 80 m3/hr)
12 . P7036	THERMAX INDIA LTD.
13 . P7121	TRIVENI ENGINEERING & INDUSTRIES LIMITED
14 . P7130	VA TECH WABAG LTD. (50-8333 m3/hr)
<b>india</b>	
15 . P7141	OXYBEE SOLUTIONS (50 - 20000 LPH)
<b>ITALY</b>	
16 . P7041	IDRECO

## 710206 : REVERSE OSMOSIS PLANT

CODE	NAME
<b>JAPAN</b>	
17 . P7059	MHI
<b>U.S.A.</b>	
18 . P7061	DUPONT
19 . P7060	HYDRANAUTICS

## 710207 : AIR LIQUIFICATION / LIQUID NITROGEN PLANT

CODE	NAME
<b>INDIA</b>	
1 . P7012	BHPV
2 . P7054	BRITISH OXYGEN
3 . P7063	INOX
<b>FRANCE</b>	
4 . P7015	AIR LIQUIDE
<b>GERMANY</b>	
5 . P7013	LINDE
<b>U.S.A.</b>	
6 . P7062	AIR PRODUCTS

## 710208 : CHLORINATION UNIT

CODE	NAME
<b>INDIA</b>	
1 . P7066	BABUBAI NAROTTAM DAS
2 . P7065	CAPITAL CONTROL INDIA PVT. LTD.
3 . P7057	METITO POLLUTION CONTROL INDIA PVT. LTD.
4 . P7064	PENNWALT
5 . P7127	TOSHCON JESCO (INDIA) PVT. LTD.,
6 . P7145	VASU CHEMICALS (6-60 Kg/hr)
<b>india</b>	
7 . P7141	OXYBEE SOLUTIONS (30 - 480 LPH)
<b>ITALY</b>	
8 . P7123	PREMABERGO ITALIANA srl

**710209 : VALVELESS AUTO WASH GRAVITY SAND FILTER**

CODE	NAME
<b>INDIA</b>	
1 . P7069	DELKOR TECHNIK INDIA PVT. LTD.
2 . P7067	OTOKLIN INDIA LTD.
3 . P7036	THERMAX INDIA LTD.
<b>IRELAND</b>	
4 . P7068	DOLLINGER INTERNATIONAL AEROMECCANICA STRANIC
<b>INDIA</b>	
5 . P7144	SUREFLO TECHCON PVT.LTD. (10 m3/hr - 3264 m3/hr)

## 710210 : WATER PRE-TREATMENT PLANT

CODE	NAME
<b>INDIA</b>	
1 . P7116	AKAR IMPEX PVT LTD
2 . P7132	AQUA DESIGNS INDIA PVT. LTD. (500-6000 KLD)
3 . P7137	BGR ENGERGY SYSTEMS LIMITED (380 - 3800 M3/Hr)
4 . P7055	DOSHI ION EXCHANGE & CHEMICAL INDUSTRIES LTD
5 . P7133	DRIPLEX WATER ENGINEERING PVT.LTD. (2 X 3000 m3/hr)
6 . P7070	ENVIRO CONTROL ASSOCIATES (I) PVT. LTD.
7 . P7071	GEO MILLER
8 . P7029	HINDUSTAN DORR OLIVER LTD.
9 . P7058	ONDEO DEGREMONT
10 . P7030	PARAMOUNT INDIA LTD.
11 . P7136	PRAJ INDUSTRIES LIMITED (11 - 124 m3/hr)
12 . P7038	PROJECTS & DEVELOPMENT INDIA LTD.
13 . P7121	TRIVENI ENGINEERING & INDUSTRIES LIMITED
14 . P7035	V.A. TECH WABAG
<b>india</b>	
15 . P7141	OXYBEE SOLUTIONS (50 KLD)



## 710211 : WASTE WATER TREATMENT PLANT

CODE	NAME
<b>INDIA</b>	
1 . P7147	CHEM PROCESS SYSTEMS PVT.LTD
2 . P7137	BGR ENGERGY SYSTEMS LIMITED (10-331 M3/Hr)
3 . P7133	DRIPLEX WATER ENGINEERING PVT.LTD. (1400 m3/hr)
4 . P7070	ENVIRO CONTROL ASSOCIATES (I) PVT. LTD.
5 . P7071	GEO MILLER
6 . P7029	HINDUSTAN DORR OLIVER LTD.
7 . P7073	LARSEN & TOUBRO
8 . P7058	ONDEO DEGREMONT
9 . P7030	PARAMOUNT INDIA LTD.
10 . P7136	PRAJ INDUSTRIES LIMITED (65 - 6000 m3/day)
11 . P7038	PROJECTS & DEVELOPMENT INDIA LTD.
12 . P7074	TRIVENI ENGG.
13 . P7121	TRIVENI ENGINEERING & INDUSTRIES LIMITED
14 . P7072	UEM INDIA LIMITED
15 . P7035	V.A. TECH WABAG
16 . P7130	VA TECH WABAG LTD. (25-2300 m3/hr (including Recycle Plant - 12-4170 m3/hr))

**india**

**710211 :WASTE WATER TREATMENT PLANT**

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CODE	NAME
17. P7141	OXYBEE SOLUTIONS (25- 300 KLD)

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## 710212 : CHEMICAL DOSING SYSTEM FOR COOLING TOWER

CODE	NAME
<b>INDIA</b>	
1 . P3219	ALBATROSS FINE CHEM LTD
2 . P7076	AQUAPHARAM CHEMICAL CO. PVT. LTD.
3 . P7151	CHEMBOND WATER TECHNOLOGIES LIMITED
4 . P7133	DRIPLEX WATER ENGINEERING PVT.LTD. (83200 m3/hr)
5 . P7077	GE BETZ LTD.
6 . P7148	GRAND PRIX ENGINEERING PVT.LTD.
7 . P7027	ION EXCHANGE INDIA LTD.
8 . P3340	MILTON ROY INDIA (P) LTD.
9 . P7075	NLC NALCO INDIA LIMITED
10 . P7140	OSWAL INFRASTRUCTURE LIMITED (10 LPH)
11 . P7036	THERMAX INDIA LTD.
12 . P7145	VASU CHEMICALS (19794-80000 m3/hr)

## 710213 : COOLING TOWERS

CODE	NAME
<b>INDIA</b>	
1 . P7109	AADI HEAT EXCHANGERS PVT. LTD.
2 . P7080	BALKE DURR
3 . P7143	ENEXIO POWER COOLING SOLUTIONS INDIA PVT.LTD. (i. Induced Draft Cooling Tower ii. Natural Draft Cooling Tower)
4 . P7125	GACTEL TURNKEY PROJECTS LIMITED (RCC. All range)
5 . P7108	NORTH STREET COOLING TOWERS(P) LTD.
6 . P7078	PAHARPUR COOLING TOWER
7 . P7126	PALTECH COOLING TOWERS & EQUIPMENTS LTD (Wooden Cooling Tower; RCC Cooling Tower; Pultruded Cooling Tower ; FRP Cooling Tower)
8 . P7079	SHRIRAM TOWER TECH. LTD.
9 . P7124	SOUTHERN COOLING TOWERS PRIVATE LTD. (20-3500 m3/hr Single Cell)
<b>GERMANY</b>	
10 . P7083	BALKE DURR
<b>U.K.</b>	
11 . P7081	MARLEY C.T.
<b>U.S.A.</b>	
12 . P7082	TOWER TECH

## 710214 : POLLUTION CONTROL EQUIPMENTS

CODE	NAME
<b>INDIA</b>	
1 . P0353	HINDUSTAN DOOR-OLIVER LTD.
2 . P7107	NATIONAL ENGINEERING INDUSTRIES
3 . P7058	ONDEO DEGREMONT
4 . P7030	PARAMOUNT INDIA LTD.
5 . P7106	TECPRO TREMA LIMITED
<b>india</b>	
6 . P7141	OXYBEE SOLUTIONS (10 - 200 KLD)

**710215: MIST TYPE COOLING TOWER**

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CODE	NAME
<b>INDIA</b>	
1 . P7120	MIST RESSONANCE ENGG.PVT.LTD. (UPTO 10000 CUBIC MTR/HR.)

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## 710216: EFFLUENT TREATMENT PLANT (ETP)

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CODE	NAME
<i>INDIA</i>	
1.P7132	AQUA DESIGNS INDIA PVT. LTD. (600-7200 KLD)



# 710217: SEA WATER DESALINATION PLANT

CODE	NAME
<i>INDIA</i>	
1 . P7130	VA TECH WABAG LTD. (100 MLD)





## 710218: SEWAGE TREATMENT PLANT

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CODE	NAME
<i>INDIA</i>	
1.P7132	AQUA DESIGNS INDIA PVT. LTD. (30-3000 KLD)



## 710219: JET AERATOR

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CODE	NAME
<hr/>	
<i>INDIA</i>	
1 . P7131	KOERTING ENGINEERING PVT. LTD. (7.5- 2 x 106M3/hr.)

710221 : Chemicals-V<sub>2</sub>O<sub>5</sub>,Antifoam agent,TSP,KNO<sub>2</sub>,H<sub>2</sub>SO<sub>4</sub>,HCL,  
Methanol,DEA,Hydrazin

CODE	NAME
<b>INDIA</b>	
1 . P7110	AMINES & PLASTICIZERS
2 . P7104	AMJEY CHEMICALS (All Capacity)
3 . P7076	AQUAPHARAM CHEMICAL CO. PVT. LTD.
4 . P7085	ATUL CO.
5 . P7084	AVM SALES CORPN.
6 . P7086	BHANWARILAL JHANWAR & SONS
7 . P7088	CATALYST INDIA PVT.LTD.
8 . P7087	CATLCO CHEMICALS PVT. LTD.
9 . P7151	CHEMBOND WATER TECHNOLOGIES LIMITED
10 . P7090	CHEMICALS & INSTS. CORPN.
11 . P7091	EVERLIGHT INTERNATIONAL
12 . P7092	FELCHEM
13 . P7093	HARYANA CHEMICALS & PESTICIDES
14 . P7089	HENKEL CHEMBOND SURFACE TECHONOLOGIES LTD.
15 . P7094	INDUSTRIAL ALLOYS
16 . P7103	J.BROTHERS
17 . P7095	JYOTI DYE CHEM

710221 : Chemicals-V<sub>2</sub>O<sub>5</sub>,Antifoam agent,TSP,KNO<sub>2</sub>,H<sub>2</sub>SO<sub>4</sub>,HCL,  
Methanol,DEA,Hydrazin

CODE	NAME
18 . P7096	MULTICHEM
19 . P7105	PARAS INTERMEDIATES PVT LTD
20 . P7097	RARE METALS & CHEMICALS
21 . P7098	S.G.ENTERPRISES
22 . P7099	SHREE RAM CHEMICALS
23 . P7100	SUCHEM INTERNATIONAL
24 . P7101	SUNIL CHEMICALS
25 . P7102	VEE CHEM INDUSTRIES
<b>india</b>	
26 . P7141	OXYBEE SOLUTIONS (50 - 1000 Ltr.)

## 710222 : NATURAL GAS TREATMENT PLANT/SKID

CODE	NAME
<b>INDIA</b>	
1 . P7139	GAS PROCESSING EQUIPMENT PVT. LTD. (300 - 45200 NM3/Hr)
2 . P7150	MULTITEX FILTRATION ENGINEERS LTD.
3 . P7140	OSWAL INFRASTRUCTURE LIMITED (0.3 MMSCFD)
<b>ITALY</b>	
4 . P7123	PREMABERGO ITALIANA srl



# 710223: TOWER PACKING

CODE	NAME
INDIA	
1. P7128	FENIX PROCESS TECHNOLOGIES PVT. LTD.

## 710224 : TOWER/SEPARATOR INTERNALS

CODE	NAME
<b>INDIA</b>	
1 .	FENIX PROCESS TECHNOLOGIES PVT. LTD.
2 . P7148	GRAND PRIX ENGINEERING PVT.LTD.



## 710225: DISTILLATION TOWER TRAYS

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CODE	NAME
<i>INDIA</i>	
1. P7128	FENIX PROCESS TECHNOLOGIES PVT. LTD.

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**710226: COLD BOXES**

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CODE	NAME
<i>UK</i>	
1 . P7129	CHART ENERGY & CHEMICALS INC.



## 710227: MEMBRANE BIO REACTOR

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CODE	NAME
<i>INDIA</i>	
1. P7132	AQUA DESIGNS INDIA PVT. LTD. (30-1050 KLD)

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**710228: ULTRA FILTRATION PLANT**

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CODE	NAME
<b>INDIA</b>	
1 . P7133	DRIPLEX WATER ENGINEERING PVT.LTD. (7 X 200 m3/hr)

**710229: SEWAGE / EFFLUENT TREATMENT PLANT**

CODE	NAME
<i>INDIA</i>	
1.	DRIPLEX WATER ENGINEERING PVT.LTD. (1400 m3/hr)

## 710401 : LOADING OF CATALYST & PACKING

CODE	NAME
<b>INDIA</b>	
1 . P6074	AMOL CONSTRUCTIONS
2 . P6020	JAIHIND PROJECTS LIMITED
3 . P6073	PASHUPATI SINGH & CO.
4 . P6012	PETRON CIVIL ENGINEERING LIMITED

	<b>MASTER VENDORS LIST FOR PROJECTS</b>	04-00MM-0011	18
		DOCUMENT NO	REV

**MASTER VENDORS LIST**  
**FOR**  
**PROJECTS**  
**ELECTRICAL ITEMS**

## INDEX ELECTRICAL ENGINEERING ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE N O.
<b>8101</b>	<b>CIRCUIT BREAKERS</b>	
810101	CIRCUIT BREAKERS,66KV & ABOVE.	6
810102	HIGH VOLTAGE CIRCUIT BREAKERS.	7
810103	MV ACB.	8
810104	MOULDED CASE CIRCUIT BREAKERS (MCCB)	9
810105	MINIATURE CIRCUIT BREAKERS(MCB)	10
810106	MV ELCB	11
<b>8102</b>	<b>SWITCHES / ISOLATORS</b>	
810201	EHV SWITCHES/ISOLATORS	12
810202	HV SWITCHES/ISOLATORS	13
810203	LOW VOLTAGE INDUSTRIAL SWITCHES/ISOLATORS	14
<b>8103</b>	<b>TRANSFORMERS / REACTORS</b>	
810301	POWER TRANSFORMER, 66 KV & ABOVE (OIL FILLED)	15
810302	POWER TRANSFORMER,33KV & BELOW	16
810303	AUXILIARY SUPPLY TRANSFORMER	17
810304	AUTO TRANSFORMER	18
810305	REACTOR	19
810306	EARTHING TRANSFORMER	20
810307	CURRENT TRANSFORMERS, 66KV & ABOVE	21
810308	POTENTIAL TRANSFORMER, 66KV & ABOVE	22
810309	HV CURRENT TRANSFORMERS	23
810310	HV POTENTIAL TRANSFORMER	24
810311	MV CURRENT TRANSFORMERS	25
810312	MV POTENTIAL TRANSFORMERS	26
<b>8104</b>	<b>SWITCH BOARDS / PANELS / AUXILIARY BOARDS</b>	
810401	HIGH VOLTAGE SWITCH BOARD	27
810402	MEDIUM VOLTAGE SWITCH BOARD(PCC/MCC)	28
810403	DRAW-OUT MCC	29
810404	NON-DRAWOUT M.C.C.	30
810405	ELECTROMAGNETIC TYPE CONTROL PANEL/DESKS	32
810406	PROGRAMMABLE LOGIC CONTROLLER.	33

## INDEX CUSTOM CLEARANCE & TRANSPORTATION ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE NO.
810407	STATIC TYPE CONTROL PANEL/DESKS.	34
810408	FLOOR MOUNTING TYPE DISTRIBUTION BOARDS.	35
810409	WALL MOUNTING TYPE DISTRIBUTION BOARDS.	37
810410	VARIABLE SPEED MOTOR PACKAGE	39
810411	SOFT STARTER	41
<b>8105</b>	<b>CABLES</b>	
810501	HT POWER CABLE	42
810502	LT POWER CABLES	44
810503	CONTROL CABLE	47
810504	FLEXIBLE CABLE.	50
810505	TELEPHONE CABLE	52
810506	CABLES FOR EARTHING	54
810507	SPECIAL CABLES	55
<b>8106</b>	<b>MOTORS</b>	
810601	HIGH VOLTAGE INDUCTION MOTORS	56
810602	MEDIUM VOLTAGE INDUCTION MOTORS	58
810603	MEDIUM VOLTAGE FLAME PROOF/ INCREASED SAFETY MOTORS	60
810604	SYNCHRONOUS MOTORS	62
810605	CANNED MOTORS	64
810606	GEARED MOTORS	65
<b>8107</b>	<b>BATTERY CHARGER / UPS / VOLTAGE STABILIZERS</b>	
810701	BATTERY CHARGER	66
810703	STATIC TYPE UPS SYSTEM	67
810705	ELECTROSTATIC TYPE VOLTAGE STABILIZERS	68
<b>8108</b>	<b>EARTHING / LIGHTNING PROTECTION MATERIAL</b>	
810801	NEUTRAL EARTHING RESISTOR	69
810802	EARTHING & LIGHTNING PROTECTION MATERIAL, AL WIRE/STRIP	70
810803	EARTHING & LIGHTNING PROTECTION MATERIAL,G.I.WIRE/STRIP	71
<b>8109</b>	<b>EXPLOSION PROOF ITEMS</b>	
810901	MV Ex. Proof Items(Switches/Switch Skt./Plugs/Isolators/J.Box/LCS/ DB)	72



## INDEX CUSTOM CLEARANCE & TRANSPORTATION ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE NO.
810903	EXPLOSION PROOF LIGHTING FIXTURES	74
810904	EXPLOSION PROOF PANIC LIGHTS	75
810906	FLAMEPROOF CABLE GLAND	76
810909	EXPLOSION PROOF EXHAUST FAN	77
<b>8110</b>	<b>LIGHTING FITTINGS AND ACCESSORIES</b>	
811001	COMMERCIAL LTG FIXTURES	78
811002	CORROSION PROOF INDUSTRIAL LTG.FIXTURES	79
811003	HOSE PROOF INDUSTRIAL LTG.FIXTURES	80
811004	STREET/FLOOD LTG.FIXTURES	81
811005	AIR OBSTRUCTION LIGHTS (NEON TYPE)	82
811006	LAMPS & TUBES	83
811007	COMPACT FLUORESCENT LAMPS	84
<b>8111</b>	<b>BATTERY</b>	
811101	ALKALINE BATTERY	85
811102	LEAD ACID BATTERY	86
<b>8112</b>	<b>LIFT</b>	
811201	LIFT	87
<b>8113</b>	<b>D G SET</b>	
811301	DIESEL GENERATOR SET.	88
<b>8114</b>	<b>BUSDUCTS</b>	
811401	HIGH VOLTAGE BUS DUCT.	90
811402	MEDIUM VOLTAGE BUS DUCT	91
<b>8115</b>	<b>ELECTRICAL ERECTION PACKAGE</b>	
811501	SWITCHYARD PACKAGE	93
811502	SUB-STATION PACKAGE	94
811503	PLANT ELECTRIFICATION PACKAGE(Major Projects)	95
811504	PLANT ELECTRIFICATION PACKAGE(MINOR PROJECTS)	96
811505	AIR PRESSURISATION / VENTILLATION SYSTEM	97
811506	FIRE DETECTION AND ALARM SYSTEM	104

## INDEX CUSTOM CLEARANCE & TRANSPORTATION ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE NO.
<b>8116</b>	<b>ELECTRICAL ERECTION MATERIALS</b>	
811601	PRE-FABRICATED AL-CABLE TRAYS	98
811602	PRE-FABRICATED G.I. CABLE TRAYS	99
811603	FRP CABLE TRAYS	100
811604	GI PIPES & CONDUITS	101
811605	PVC PIPES & CONDUITS	102
811606	INDUSTRIAL CABLE GLAND	103
811607	CABLE LUGS	104
811608	BITUMENOUS BASED CABLE TERMINATION/STRAIGHT THROUGH	105
811609	EPOXY BASED TERMINATION/STRAIGHT THROUGH JOINTING KITS.	106
811610	SI RUBBER BASED CABLE TERM./STRAIGHT THRU JOINTING KITS.	107
811611	LIGHTING POLES	108
811612	TRANSFORMER OIL	109
811613	INDUSTRIAL EXHAUST FAN	110
<b>8117</b>	<b>RELAYS / METERS / RECORDERS</b>	
811701	ELECTRO-MECHANICAL RELAYS	111
811702	MICROPROCESSOR / NUMERICAL RELAYS	112
811703	METERS	113
811704	RECORDERS	114
<b>8118</b>	<b>CAPACITORS</b>	
811801	HIGH VOLTAGE SHUNT CAPACITORS	115
811802	MEDIUM VOLTAGE SHUNT CAPACITORS	116
811803	LOW VOLTAGE SHUNT CAPACITORS	117
<b>8119</b>	<b>OVERHEAD TRANSMISSION EQUIPMENT</b>	
811901	OVERHEAD CONDUCTORS-AL /ACSR	118
811902	EHV/HV INSULATORS	119
811903	M.V.INSULATORS	120
811904	LIGHTNING ARRESTOR	121
<b>8120</b>	<b>TELEPHONE EXCHANGE / PA / PAGING EQUIPMENT</b>	
812001	TELEPHONE EXCHANGE EQUIPMENTS	122

## INDEX CUSTOM CLEARANCE & TRANSPORTATION ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE NO.
812002	PAGING EQUIPMENTS / PUBLIC ADDRESS SYTEM	123
<b>8121</b>	<b>INDUSTRIAL HEATERS ETC.</b>	
812101	INDUSTRIAL HEATER	124
<b>8122</b>	<b>INDUSTRIAL CONTROL &amp; SIGNALLING EQUIPMENT</b>	
812201	HOSE PROOF LOCAL CONTROL STATION	125
812202	INDUSTRIAL TYPE SW. SOCKET & PLUG	126
812203	HOSEPROOF JUNCTION BOXES	127
812204	ELECTROMAGNETIC EQUIPMENT	128
812205	LIMIT SWITCHES / BELT MONITORING SWITCHES	129
812206	LIMIT SWITCHES (FLAMEPROOF TYPE)	130
812207	HORN/HOOTER/KLAXON	131
<b>8123</b>	<b>CATHODIC PROTECTION SYSTEM</b>	
812301	CATHODIC PROTECTION SYSTEM	132

**810101 : CIRCUIT BREAKERS,66KV & ABOVE.**

CODE	NAME
<b>INDIA</b>	
1 . P0066	ASEA BROWN BOVERI LTD.
2 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
3 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
4 . P0869	VOLTAS LTD. (PUMPS & PROJECTS BUSINESS DIV)

## 810102 : HIGH VOLTAGE CIRCUIT BREAKERS.

CODE	NAME
<b>INDIA</b>	
1 . P0036	ALSTOM LIMITED ( AREVA T & D)
2 . P0066	ASEA BROWN BOVERI LTD.
3 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
4 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
5 . P8173	CG POWER AND INDUSTRIAL SOLUTIONS LIMITED
6 . P8104	JYOTI LIMITED
7 . P0736	SIEMENS LTD.
8 . P0802	THE MYSORE ELECTRICAL INDUSTRIES LTD.

810103 : MV ACB.

CODE	NAME
<b>INDIA</b>	
1 . P0173	C&S ELECTRIC LTD. (Upto 6300A)
2 . P0573	GE POWER CONTROLS INDIA PVT. LTD.
3 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
4 . P0736	SIEMENS LTD.
5 . P8051	SPACEAGE SWITCHGEARS LIMITED

**810104 : MOULDED CASE CIRCUIT BREAKERS (MCCB)**

CODE	NAME
<b>INDIA</b>	
1 . P0173	C&S ELECTRIC LTD. (Upto 400A)
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0573	GE POWER CONTROLS INDIA PVT. LTD.
4 . P0337	HAVELLS INDIA LTD.
5 . P8060	HPL ELECTRIC & POWER PVT. LTD. (10A to 800A)
6 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
7 . P0736	SIEMENS LTD.
8 . P8051	SPACEAGE SWITCHGEARS LIMITED
9 . P8070	STANDARD ELECTRICALS LIMITED (MCCB)

**810105 : MINIATURE CIRCUIT BREAKERS(MCB)**

CODE	NAME
<b>INDIA</b>	
1 . P8068	ADHUNIK SWITCHGEARS (P) LTD.
2 . P0173	C&S ELECTRIC LTD.
3 . P0337	HAVELLS INDIA LTD.
4 . P8060	HPL ELECTRIC & POWER PVT. LTD.
5 . P0384	INDIANA CURRENT CONTROL LTD.
6 . P0413	INDO ASIAN FUSEGEAR LTD
7 . P0523	LEGRAND INDIA LTD
8 . P0693	S & S POWER SWITCHGEAR LTD
9 . P8070	STANDARD ELECTRICALS LIMITED



## 810106 : MV ELCB

CODE	NAME
<b>INDIA</b>	
1 . P0173	C&S ELECTRIC LTD.
2 . P0573	GE POWER CONTROLS INDIA PVT. LTD.
3 . P0337	HAVELLS INDIA LTD.
4 . P0413	INDO ASIAN FUSEGEAR LTD
5 . P0523	LEGRAND INDIA LTD
6 . P0693	S & S POWER SWITCHGEAR LTD
7 . P0736	SIEMENS LTD.
8 . P8070	STANDARD ELECTRICALS LIMITED

## 810201 : EHV SWITCHES/ISOLATORS

CODE	NAME
<b>INDIA</b>	
1 . P0780	ELPRO INTERNATIONAL LIMITED
2 . P0693	S & S POWER SWITCHGEAR LTD
3 . P0824	TRANSLECT

## 810202 : HV SWITCHES/ISOLATORS

CODE	NAME
<b>INDIA</b>	
1 . P0066	ASEA BROWN BOVERI LTD.
2 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
3 . P8190	ELEKTROLITES (POWER) PRIVATE LIMITED
4 . P0780	ELPRO INTERNATIONAL LIMITED
5 . P0736	SIEMENS LTD.
6 . P0824	TRANSLECT

## 810203 : LOW VOLTAGE INDUSTRIAL SWITCHES/ISOLATORS

CODE	NAME
<b>INDIA</b>	
1 . P0066	ASEA BROWN BOVERI LTD.
2 . P0173	C&S ELECTRIC LTD.
3 . P0573	GE POWER CONTROLS INDIA PVT. LTD.
4 . P0337	HAVELLS INDIA LTD.
5 . P8060	HPL ELECTRIC & POWER PVT. LTD.
6 . P0440	KAYCEE INDUSTRIES LTD
7 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
8 . P0736	SIEMENS LTD.

## 810301 : POWER TRANSFORMER, 66 KV & ABOVE (OIL FILLED)

CODE	NAME
<b>INDIA</b>	
1 . P0036	ALSTOM LIMITED ( AREVA T & D)
2 . P0066	ASEA BROWN BOVERI LTD.
3 . P8162	ATLANTA ELECTRICALS PVT. LTD
4 . P0104	BHARAT BIJLEE LTD
5 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
6 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
7 . P0236	EMCO LIMITED (upto 100 MVA)
8 . P0392	IMP POWER LTD.
9 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
10 . P0868	VOLTAMP TRANSFORMERS LTD. (upto 132KV , 50MVA)

## 810302 : POWER TRANSFORMER,33KV & BELOW

CODE	NAME
<b>INDIA</b>	
1 . P0036	ALSTOM LIMITED ( AREVA T & D)
2 . P8162	ATLANTA ELECTRICALS PVT. LTD
3 . P0104	BHARAT BIJLEE LTD
4 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
5 . P0236	EMCO LIMITED
6 . P8124	ESENNAR TRANSFORMERS (P) LTD.
7 . P0378	INDCOIL TRANSFORMERS PVT. LTD.
8 . P0432	KANOHAR ELECTRICALS LTD. (upto 10 MVA)
9 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
10 . P8157	RAYCHEM RPG PRIVATE LIMITED
11 . P8136	VARDHMAN ELECTRO-MECH PVT. LTD. (Upto 8 MVA)
12 . P0868	VOLTAMP TRANSFORMERS LTD. (upto 132KV,50MVA)
13 . P0869	VOLTAS LTD. (PUMPS & PROJECTS BUSINESS DIV)

## 810303 : AUXILIARY SUPPLY TRANSFORMER

CODE	NAME
<b>INDIA</b>	
1 . P8124	ESENNAR TRANSFORMERS (P) LTD.
2 . P8111	GUJARAT PLUG-IN DEVICES PVT. LTD. (Upto 300 KVA)
3 . P0392	IMP POWER LTD.
4 . P0378	INDCOIL TRANSFORMERS PVT. LTD.
5 . P8052	KALPA ELECTRICAL PRIVATE LIMITED ( DRY TYPE UPTO 100 KVA)
6 . P0079	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LIMITED)
7 . P8157	RAYCHEM RPG PRIVATE LIMITED
8 . P0723	SHEPHARD TRANSFORMERS LTD
9 . P8136	VARDHMAN ELECTRO-MECH PVT. LTD.

## 810304 : AUTO TRANSFORMER

CODE	NAME
<b>INDIA</b>	
1 . P0036	ALSTOM LIMITED ( AREVA T & D)
2 . P0104	BHARAT BIJLEE LTD
3 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
4 . P0236	EMCO LIMITED
5 . P0329	HACKBRIDGE - HEWITTIC & EASUN LTD
6 . P0378	INDCOIL TRANSFORMERS PVT. LTD.
7 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
8 . P0823	TRANSFORMERS & ELECTRICALS KERALA LTD



## 810305 : REACTOR

CODE	NAME
<b>INDIA</b>	
1 . P0036	ALSTOM LIMITED ( AREVA T & D)
2 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
3 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
4 . P0329	HACKBRIDGE - HEWITTIC & EASUN LTD

## 810306 : EARTHING TRANSFORMER

CODE	NAME
<b>INDIA</b>	
1 . P0036	ALSTOM LIMITED ( AREVA T & D)
2 . P0104	BHARAT BIJLEE LTD
3 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
4 . P0236	EMCO LIMITED
5 . P0329	HACKBRIDGE - HEWITTIC & EASUN LTD
6 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
7 . P0823	TRANSFORMERS & ELECTRICALS KERALA LTD

**810307 : CURRENT TRANSFORMERS, 66KV & ABOVE**

CODE	NAME
<b>INDIA</b>	
1 . P0066	ASEA BROWN BOVERI LTD.
2 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
3 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
4 . P0079	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LIMITED)
5 . P0560	NAGPUR TRANSFORMERS LTD
6 . P0823	TRANSFORMERS & ELECTRICALS KERALA LTD

## 810308 : POTENTIAL TRANSFORMER, 66KV & ABOVE

CODE	NAME
<b>INDIA</b>	
1 . P0066	ASEA BROWN BOVERI LTD.
2 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
3 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
4 . P0079	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LIMITED)
5 . P0560	NAGPUR TRANSFORMERS LTD
6 . P0823	TRANSFORMERS & ELECTRICALS KERALA LTD

## 810309 : HV CURRENT TRANSFORMERS

CODE	NAME
<b>INDIA</b>	
1 . P8128	ANANT POWERTECH ((11 KV to 33 KV))
2 . P0066	ASEA BROWN BOVERI LTD.
3 . P8052	KALPA ELECTRICAL PRIVATE LIMITED
4 . P0079	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LIMITED)
5 . P8053	PERFECT SALES CORPORATION

## 810310 : HV POTENTIAL TRANSFORMER

CODE	NAME
<b>INDIA</b>	
1 . P8128	ANANT POWERTECH ((11 KV to 33 KV))
2 . P0066	ASEA BROWN BOVERI LTD.
3 . P8052	KALPA ELECTRICAL PRIVATE LIMITED
4 . P0079	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LIMITED)
5 . P8053	PERFECT SALES CORPORATION

## 810311 : MV CURRENT TRANSFORMERS

CODE	NAME
<b>INDIA</b>	
1 . P0036	ALSTOM LIMITED ( AREVA T & D)
2 . P8128	ANANT POWERTECH
3 . P0378	INDCOIL TRANSFORMERS PVT. LTD.
4 . P0434	KAPPA ELECTRICALS
5 . P0079	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LIMITED)
6 . P8155	NEWTEK ELECTRICALS
7 . P8053	PERFECT SALES CORPORATION
8 . P0736	SIEMENS LTD.

## 810312 : MV POTENTIAL TRANSFORMERS

CODE	NAME
<b>INDIA</b>	
1 . P0036	ALSTOM LIMITED ( AREVA T & D)
2 . P0378	INDCOIL TRANSFORMERS PVT. LTD.
3 . P8052	KALPA ELECTRICAL PRIVATE LIMITED
4 . P0434	KAPPA ELECTRICALS
5 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
6 . P0079	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LIMITED)
7 . P8155	NEWTEK ELECTRICALS
8 . P8053	PERFECT SALES CORPORATION
9 . P0736	SIEMENS LTD.



## 810401 : HIGH VOLTAGE SWITCH BOARD

CODE	NAME
<b>INDIA</b>	
1 . P0036	ALSTOM LIMITED ( AREVA T & D)
2 . P8191	APPLICATION CONTROL PANELS PVT. LTD.
3 . P0066	ASEA BROWN BOVERI LTD.
4 . P8197	ASTEK ELECTRICAL INDIA PRIVATE LIMITED
5 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
6 . P0116	BIECCO LAWRIE LIMITED
7 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
8 . P8104	JYOTI LIMITED
9 . P8101	LARSEN & TOUBRO LIMITED
10 . P8041	LOTUS POWERGEAR PVT LTD
11 . P0736	SIEMENS LTD.
12 . P8176	STELMEC LIMITED
13 . P8183	TENCO SYSTEMS & SWITCH GEARS PVT. LTD.

## 810402 : MEDIUM VOLTAGE SWITCH BOARD(PCC/MCC)

CODE	NAME
<b>INDIA</b>	
1 . P0036	ALSTOM LIMITED ( AREVA T & D)
2 . P8191	APPLICATION CONTROL PANELS PVT. LTD.
3 . P8197	ASTEK ELECTRICAL INDIA PRIVATE LIMITED
4 . P0113	BHARTIA INDUSTRIES LTD. (DIVN. BCH)
5 . P0173	C&S ELECTRIC LTD.
6 . P8069	COSMIC POWER SYSTEMS PVT. LTD.
7 . P0231	ELECMECH CORPORATION
8 . P0573	GE POWER CONTROLS INDIA PVT. LTD.
9 . P0405	INTRELEC
10 . P8008	JAKSON ENGINEERS LTD
11 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
12 . P8041	LOTUS POWERGEAR PVT LTD
13 . P8210	RASHMI ELECTRICALS
14 . P0736	SIEMENS LTD.
15 . P8051	SPACEAGE SWITCHGEARS LIMITED
16 . P8183	TENCO SYSTEMS & SWITCH GEARS PVT. LTD.
17 . P8106	VENUS CONTROLS & SWITCHGEAR (P) LTD.

## 810403 : DRAW-OUT MCC

CODE	NAME
<b>INDIA</b>	
1 . P8129	ADVANCE PANELS & SWITCHGEARS (P) LTD.
2 . P8191	APPLICATION CONTROL PANELS PVT. LTD.
3 . P8197	ASTEK ELECTRICAL INDIA PRIVATE LIMITED
4 . P0173	C&S ELECTRIC LTD.
5 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
6 . P0172	CONTROLS & SCHEMATICS PVT LTD.
7 . P8069	COSMIC POWER SYSTEMS PVT. LTD.
8 . P0231	ELECMECH CORPORATION
9 . P0573	GE POWER CONTROLS INDIA PVT. LTD.
10 . P0405	INTRELEC
11 . P8054	JASPER SWITCHGEARS LIMITED
12 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
13 . P8041	LOTUS POWERGEAR PVT LTD
14 . P8126	POWERTECH SWITCHGEARS (INDIA) PVT. LTD.
15 . P8210	RASHMI ELECTRICALS
16 . P0736	SIEMENS LTD.
17 . P8051	SPACEAGE SWITCHGEARS LIMITED

## 810403 : DRAW-OUT MCC

CODE	NAME
18 . P8183	TENCO SYSTEMS & SWITCH GEARS PVT. LTD.
19 . P8106	VENUS CONTROLS & SWITCHGEAR (P) LTD.
20 . P8046	VIDHYUT CONTROL(INDIA) PVT LTD

## 810404 : NON-DRAWOUT M.C.C.

CODE	NAME
<b>INDIA</b>	
1 . P0045	ANAND POWER LIMITED (upto 1800 Amp.)
2 . P0071	ASSOCIATED SWITCHGEARS & PROJECTS LTD.
3 . P8105	AVONE SYSTEM & CONTROLS
4 . P0173	C&S ELECTRIC LTD.
5 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
6 . P0172	CONTROLS & SCHEMATICS PVT LTD.
7 . P8069	COSMIC POWER SYSTEMS PVT. LTD.
8 . P0231	ELECMECH CORPORATION
9 . P0226	ELECTRIC SUPPLY & SERVICES (P) LTD
10 . P0352	HINDUSTAN CONTROL & EQPT PV. LTD.
11 . P0405	INTRELEC
12 . P8054	JASPER SWITCHGEARS LIMITED
13 . P8041	LOTUS POWERGEAR PVT LTD
14 . P0670	REUNION ELECTRICAL MANUFACTURERS (P) LTD
15 . P8107	SHIVALIC POWER CONTROL (P) LTD.
16 . P8051	SPACEAGE SWITCHGEARS LIMITED
17 . P0828	TRICOLITE ELECTRICAL INDUSTRIES PVT.LTD.

810404 : NON-DRAWOUT M.C.C.

CODE	NAME
18 . P8106	VENUS CONTROLS & SWITCHGEAR (P) LTD.
19 . P8046	VIDHYUT CONTROL(INDIA) PVT LTD

## 810405 : ELECTROMAGNETIC TYPE CONTROL PANEL/DESKS

CODE	NAME
<b>INDIA</b>	
1 . P8129	ADVANCE PANELS & SWITCHGEARS (P) LTD.
2 . P0078	AUTOMATIC CONTROLS CORPORATION
3 . P0231	ELECMECH CORPORATION
4 . P0226	ELECTRIC SUPPLY & SERVICES (P) LTD
5 . P0352	HINDUSTAN CONTROL & EQPT PV. LTD.
6 . P0405	INTRELEC
7 . P8008	JAKSON ENGINEERS LTD
8 . P8041	LOTUS POWERGEAR PVT LTD
9 . P8126	POWERTECH SWITCHGEARS (INDIA) PVT. LTD.

## 810406 : PROGRAMMABLE LOGIC CONTROLLER.

CODE	NAME
<b>INDIA</b>	
1 . P0066	ASEA BROWN BOVERI LTD.
2 . P8076	HONEYWELL AUTOMATION INDIA LIMITED
3 . P0399	INSTRUMENTATION LTD
4 . P8008	JAKSON ENGINEERS LTD
5 . P0444	KERALA STATE ELECTRONICS DEV. CORPN. LTD.
6 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
7 . P0033	ROCKWELL AUTOMATION INDIA PVT. LTD.
8 . P0736	SIEMENS LTD.
<b>GERMANY</b>	
9 . P0348	HIMA PAUL HILDEBRANDT GMBH + CO KG
<b>SINGAPORE</b>	
10 . P0362	HONEYWELL HIPACK ASIA PACIFIC



## 810407 : STATIC TYPE CONTROL PANEL/DESKS.

CODE	NAME
<b>INDIA</b>	
1 . P8129	ADVANCE PANELS & SWITCHGEARS (P) LTD.
2 . P0036	ALSTOM LIMITED ( AREVA T & D)
3 . P0066	ASEA BROWN BOVERI LTD.
4 . P0172	CONTROLS & SCHEMATICS PVT LTD.
5 . P0231	ELECMECH CORPORATION
6 . P0391	INDUSTRIAL INSTRUMENTS & CONTROLS
7 . P8054	JASPER SWITCHGEARS LIMITED
8 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
9 . P8041	LOTUS POWERGEAR PVT LTD
10 . P8126	POWERTECH SWITCHGEARS (INDIA) PVT. LTD.
11 . P0736	SIEMENS LTD.
12 . P0737	SILKAANS ELECTRICAL MFG. CO. PVT.LTD.

## 810408 : FLOOR MOUNTING TYPE DISTRIBUTION BOARDS.

CODE	NAME
<b>INDIA</b>	
1 . P0045	ANAND POWER LIMITED
2 . P8191	APPLICATION CONTROL PANELS PVT. LTD.
3 . P0071	ASSOCIATED SWITCHGEARS & PROJECTS LTD.
4 . P8197	ASTEK ELECTRICAL INDIA PRIVATE LIMITED
5 . P0078	AUTOMATIC CONTROLS CORPORATION
6 . P8105	AVONE SYSTEM & CONTROLS
7 . P0173	C&S ELECTRIC LTD.
8 . P0172	CONTROLS & SCHEMATICS PVT LTD.
9 . P8069	COSMIC POWER SYSTEMS PVT. LTD.
10 . P8203	DURGA TECHNO INDUSTRIES
11 . P0231	ELECMECH CORPORATION
12 . P0226	ELECTRIC SUPPLY & SERVICES (P) LTD
13 . P8200	EX-PROTECTA
14 . P0573	GE POWER CONTROLS INDIA PVT. LTD.
15 . P0312	GLOBE ELECTRICAL INDUSTRIES
16 . P8114	HI-TECH ENGINEERS
17 . P0352	HINDUSTAN CONTROL & EQPT PV. LTD.

## 810408 : FLOOR MOUNTING TYPE DISTRIBUTION BOARDS.

CODE	NAME
18 . P0405	INTRELEC
19 . P8008	JAKSON ENGINEERS LTD
20 . P8054	JASPER SWITCHGEARS LIMITED
21 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
22 . P8041	LOTUS POWERGEAR PVT LTD
23 . P8210	RASHMI ELECTRICALS
24 . P0670	REUNION ELECTRICAL MANUFACTURERS (P) LTD
25 . P8107	SHIVALIC POWER CONTROL (P) LTD.
26 . P0736	SIEMENS LTD.
27 . P8051	SPACEAGE SWITCHGEARS LIMITED
28 . P0828	TRICOLITE ELECTRICAL INDUSTRIES PVT.LTD.
29 . P0831	TRIDENT SWITCHGEARS PVT. LTD. (upto 3200 A)
30 . P0841	UNITED ELECTRIC CO. (DELHI) PVT. LTD.
31 . P0845	UNIVERSAL INDUSTRIAL PRODUCTS
32 . P8106	VENUS CONTROLS & SWITCHGEAR (P) LTD.
33 . P8046	VIDHYUT CONTROL(INDIA) PVT LTD

## 810409 : WALL MOUNTING TYPE DISTRIBUTION BOARDS.

CODE	NAME
<b>INDIA</b>	
1 . P8068	ADHUNIK SWITCHGEARS (P) LTD.
2 . P0045	ANAND POWER LIMITED
3 . P8191	APPLICATION CONTROL PANELS PVT. LTD.
4 . P0071	ASSOCIATED SWITCHGEARS & PROJECTS LTD.
5 . P8197	ASTEK ELECTRICAL INDIA PRIVATE LIMITED
6 . P0078	AUTOMATIC CONTROLS CORPORATION
7 . P8105	AVONE SYSTEM & CONTROLS
8 . P0173	C&S ELECTRIC LTD.
9 . P0172	CONTROLS & SCHEMATICS PVT LTD.
10 . P8203	DURGA TECHNO INDUSTRIES
11 . P0231	ELECMECH CORPORATION
12 . P8200	EX-PROTECTA
13 . P0312	GLOBE ELECTRICAL INDUSTRIES
14 . P0337	HAVELLS INDIA LTD.
15 . P8114	HI-TECH ENGINEERS
16 . P0352	HINDUSTAN CONTROL & EQPT PV. LTD.
17 . P0384	INDIANA CURRENT CONTROL LTD.

**810409 : WALL MOUNTING TYPE DISTRIBUTION BOARDS.**

<b>CODE</b>	<b>NAME</b>
18 . P0413	INDO ASIAN FUSEGEAR LTD
19 . P0405	INTRELEC
20 . P8008	JAKSON ENGINEERS LTD
21 . P0523	LEGRAND INDIA LTD
22 . P8041	LOTUS POWERGEAR PVT LTD
23 . P8210	RASHMI ELECTRICALS
24 . P0670	REUNION ELECTRICAL MANUFACTURERS (P) LTD
25 . P8107	SHIVALIC POWER CONTROL (P) LTD.
26 . P8070	STANDARD ELECTRICALS LIMITED
27 . P0828	TRICOLITE ELECTRICAL INDUSTRIES PVT.LTD.
28 . P0831	TRIDENT SWITCHGEARS PVT. LTD.
29 . P8106	VENUS CONTROLS & SWITCHGEAR (P) LTD.

## 810410 : VARIABLE SPEED MOTOR PACKAGE

CODE	NAME
<b>INDIA</b>	
1 . P8082	AMTECH ELECTRONICS (INDIA) LTD. (LT)
2 . P0066	ASEA BROWN BOVERI LTD.
3 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
4 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
5 . P8098	DANFOSS INDUSTRIES PVT. LTD. (Upto 1400 KW)
6 . P8152	DELTA ELECTRONICS INDIA PVT.LTD. (VARIABLE FREQUENCY DRIVE SYSTEM UP TO 75 KW)
7 . P8178	HITACHI HI-REL POWER ELECTRONICS PRIVATE LIMITED
8 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
9 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
10 . P0033	ROCKWELL AUTOMATION INDIA PVT. LTD.
11 . P0736	SIEMENS LTD.
12 . P8142	TMEIC INDUSTRIAL SYSTEMS INDIA PRIVATE LIMITED
13 . P8120	VACON DRIVES & CONTROL PVT. LTD. (Variable Frequency Drive System)
14 . P8164	YASKAWA INDIA PRIVATE LIMITED (UPTO 355 KW)
<b>FRANCE</b>	
15 . P0034	ALSTHOM ATLANTIQUE
<b>GERMANY</b>	
16 . P0735	SIEMENS AG, GERMANY

## 810410 : VARIABLE SPEED MOTOR PACKAGE

CODE	NAME
<b>ITALY</b>	
17 . P0052	ANSALDO ROBICON
<b>JAPAN</b>	
18 . P0287	FUJI ELECTRIC SYSTEMS CO. LTD.
19 . P8127	TOSHIBA MITSUBISHI ELECTRIC INDUSTRIAL SYSTEMS CORPORATION
<b>SWITZERLAND</b>	
20 . P0130	BROWN BOVERI CORPORATION
<b>U.K.</b>	
21 . P0300	GEC INDUSTRIAL CONTROL LTD.

## 810411 : SOFT STARTER

CODE	NAME
<b>INDIA</b>	
1 . P8082	AMTECH ELECTRONICS (INDIA) LTD.
2 . P8098	DANFOSS INDUSTRIES PVT. LTD. (Upto 800 KW)
3 . P8178	HITACHI HI-REL POWER ELECTRONICS PRIVATE LIMITED
4 . P8071	INNOVATIVE TECHNOMATICS PVT. LTD.
5 . P8122	JAYASHREE ELECTRON PVT. LTD.
6 . P8066	KIMO ELECTRONICS PVT. LTD.
7 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
8 . P0033	ROCKWELL AUTOMATION INDIA PVT. LTD.
9 . P0736	SIEMENS LTD.
10 . P8142	TMEIC INDUSTRIAL SYSTEMS INDIA PRIVATE LIMITED



## 810501 : HT POWER CABLE

CODE	NAME
<b>INDIA</b>	
1 . P8151	CMI LIMITED
2 . P8121	ADVANCE CABLE TECHNOLOGIES PRIVATE LIMITED
3 . P8087	APAR INDUSTRIES LTD. (UNIT: UNIFLEX CABLES)
4 . P0142	CABLE CORPN. OF INDIA LIMITED
5 . P8103	DIAMOND POWER INFRASTRUCTURE LTD.
6 . P8184	DYNAMIC CABLES LIMITED
7 . P8159	GEMSCAB INDUSTRIES LTD (Upto 33 KV (Single core upto 500 sq.mm & Three core upto 300 sq.mm.))
8 . P8195	GLOSTER CABLES LIMITED
9 . P8171	GRANDLAY ELECTRICALS INDIA
10 . P8117	GUPTA POWER INFRASTRUCTURE LTD. ((Up to 33 KV & size up to 3CX400 sq.mm and 1CX1000 sq.mm))
11 . P0337	HAVELLS INDIA LTD.
12 . P0388	INDUSTRIAL CABLES (I) LIMITED (3.3 KV PVC/XLPE & 11 KV XLPV Insulated)
13 . P8209	KEC INTERNATIONAL LIMITED
14 . P0687	KEC INTERNATIONAL LTD. (FORMERLY RPG CABLES LIMITED-
15 . P0442	KEI INDUSTRIES LIMITED (Upto 33 KV)
16 . P0574	NICCO CORPORATION LTD
17 . P8116	PARAMOUNT COMMUNICATIONS LTD. ( (Up to 33 KV & size up to 3CX400 sq.mm and 1CX630 sq.mm))

## 810501 : HT POWER CABLE

CODE	NAME
18 . P8199	PARAMOUNT COMMUNICATIONS LTD.
19 . P8055	PLAZA CABLE INDUSTRIES LIMITED
20 . P8001	POLYCAB INDIA LIMITED (FORMERLY POLYCAB WIRES PRIVATE LTD.)
21 . P8043	RAVIN CABLES LIMITED
22 . P8130	STERLITE TECHNOLOGIES LTD., (6.6 kV to 33 kV)
23 . P0818	TORRENT CABLES LTD.
24 . P0843	UNIVERSAL CABLES LTD.
25 . P8177	V-MARC INDIA LIMITED

## 810502 : LT POWER CABLES

CODE	NAME
<b>INDIA</b>	
1 . P8151	CMI LIMITED
2 . P8056	ALPHA COMMUNICATION LIMITED
3 . P8087	APAR INDUSTRIES LTD. (UNIT: UNIFLEX CABLES)
4 . P8182	AXELON INDUSTRIES
5 . P0142	CABLE CORPN. OF INDIA LIMITED
6 . P8166	CHANDRESH CABLES LIMITED
7 . P8149	CORDS CABLE INDUSTRIES LTD.
8 . P0200	DELTON CABLES LTD
9 . P8103	DIAMOND POWER INFRASTRUCTURE LTD.
10 . P8184	DYNAMIC CABLES LIMITED
11 . P0260	FINOLEX CABLES LTD
12 . P8204	GEEP POLYMERS INDIA PRIVATE LIMITED
13 . P8159	GEMSCAB INDUSTRIES LTD
14 . P8112	GENUS ELECTROTECH LTD.
15 . P8195	GLOSTER CABLES LIMITED
16 . P0319	GRANDLAY ELECTRICALS (INDIA) (1.1 KV PVC/XLPE Insulated)
17 . P8171	GRANDLAY ELECTRICALS INDIA

## 810502 : LT POWER CABLES

CODE	NAME
18 . P8113	GRID INDIA POWER CABLES PVT. LTD.
19 . P0327	GUPTA ELECTRIC & MACHINERY STORES (GEMSCAB) (3-1/2 core 400 mm2)
20 . P8117	GUPTA POWER INFRASTRUCTURE LTD.
21 . P0337	HAVELLS INDIA LTD.
22 . P8180	HPL ELECTRIC & POWER LIMITED
23 . P0388	INDUSTRIAL CABLES (I) LIMITED (1.1 KV PVC/XLPE Insulated)
24 . P0416	J K CABLES LIMITED
25 . P8209	KEC INTERNATIONAL LIMITED
26 . P0687	KEC INTERNATIONAL LTD. (FORMERLY RPG CABLES LIMITED-
27 . P0442	KEI INDUSTRIES LIMITED
28 . P8175	KLJ PARAFLEX INDIA LIMITED
29 . P0466	KRISHNA ELECTRICAL INDUSTRIES LTD.
30 . P8193	LUMINO INDUSTRIES LIMITED
31 . P8093	MANSFIELD CABLE CO.
32 . P8187	NEC WIRE & CABLES PRIVATE LIMITED
33 . P0569	NETCO CABLE INDUSTRIES (PVT.) LTD. (Upto 3-1/2 core 400 mm2)
34 . P0574	NICCO CORPORATION LTD

## 810502 : LT POWER CABLES

CODE	NAME
35 . P0604	OMEGA CABLES LTD.
36 . P8057	PARAGON CABLES
37 . P8199	PARAMOUNT COMMUNICATIONS LTD.
38 . P8055	PLAZA CABLE INDUSTRIES LIMITED
39 . P8001	POLYCAB INDIA LIMITED (FORMERLY POLYCAB WIRES PRIVATE LTD.)
40 . P8207	POLYVION CABLES PVT. LTD
41 . P8090	PRESTIGE CABLE INDUSTRIES
42 . P0647	PREW INDUSTRIES LTD.
43 . P8147	R R KABEL LIMITED
44 . P0658	RADIANT CABLES PVT. LIMITED
45 . P8167	RAVI INDUSTRIES
46 . P8043	RAVIN CABLES LIMITED
47 . P0702	SATELLITE CABLES PVT. LTD. (3-1/2 core 400 mm <sup>2</sup> )
48 . P8078	SHYAM CABLES INDUSTRIES
49 . P0739	SKYTONE ELECTRICALS (I) LTD. (3-1/2 core 400 mm <sup>2</sup> )
50 . P0744	SPECIAL CABLES PVT. LTD.
51 . P0777	SUYOG ELECTRICALS LTD.

## 810502 : LT POWER CABLES

CODE	NAME
52 . P8086	T C COMMUNICATION PVT LTD
53 . P8109	TCL CABLES LTD.
54 . P8094	TERACOM LIMITED
55 . P0818	TORRENT CABLES LTD.
56 . P8165	TORTEK INDIA PRIVATE LIMITED
57 . P0843	UNIVERSAL CABLES LTD.
58 . P8177	V-MARC INDIA LIMITED
59 . P8206	ZENIUM CABLES LIMITED

## 810503 : CONTROL CABLE

CODE	NAME
<b>INDIA</b>	
1 . P8151	CMI LIMITED
2 . P8056	ALPHA COMMUNICATION LIMITED
3 . P8087	APAR INDUSTRIES LTD. (UNIT: UNIFLEX CABLES)
4 . P8182	AXELON INDUSTRIES
5 . P8058	BHANSALI CABLES & CONDUCTORS PVT. LTD
6 . P0142	CABLE CORPN. OF INDIA LIMITED
7 . P8166	CHANDRESH CABLES LIMITED
8 . P8149	CORDS CABLE INDUSTRIES LTD.
9 . P0200	DELTON CABLES LTD
10 . P8103	DIAMOND POWER INFRASTRUCTURE LTD.
11 . P8184	DYNAMIC CABLES LIMITED
12 . P0260	FINOLEX CABLES LTD
13 . P8204	GEEP POLYMERS INDIA PRIVATE LIMITED
14 . P8159	GEMSCAB INDUSTRIES LTD
15 . P8112	GENUS ELECTROTECH LTD.
16 . P8195	GLOSTER CABLES LIMITED
17 . P0319	GRANDLAY ELECTRICALS (INDIA) (PVC/XLPE Insulated)

## 810503 : CONTROL CABLE

CODE	NAME
18 . P8171	GRANDLAY ELECTRICALS INDIA
19 . P8113	GRID INDIA POWER CABLES PVT. LTD.
20 . P0327	GUPTA ELECTRIC & MACHINERY STORES (GEMSCAB) (19 core 2.5 mm2)
21 . P8117	GUPTA POWER INFRASTRUCTURE LTD.
22 . P0337	HAVELLS INDIA LTD.
23 . P8180	HPL ELECTRIC & POWER LIMITED
24 . P0416	J K CABLES LIMITED
25 . P8209	KEC INTERNATIONAL LIMITED
26 . P0687	KEC INTERNATIONAL LTD. (FORMERLY RPG CABLES LIMITED-
27 . P0442	KEI INDUSTRIES LIMITED
28 . P8175	KLJ PARAFLEX INDIA LIMITED
29 . P0466	KRISHNA ELECTRICAL INDUSTRIES LTD.
30 . P8193	LUMINO INDUSTRIES LIMITED
31 . P8093	MANSFIELD CABLE CO.
32 . P8059	N.C. CABLES LIMITED (FORMERLY NATIONAL CABLES)
33 . P8187	NEC WIRE & CABLES PRIVATE LIMITED
34 . P0569	NETCO CABLE INDUSTRIES (PVT.) LTD. (Upto 19 core 2.5 mm2)



## 810503 : CONTROL CABLE

CODE	NAME
35 . P0574	NICCO CORPORATION LTD
36 . P0604	OMEGA CABLES LTD.
37 . P8057	PARAGON CABLES
38 . P8199	PARAMOUNT COMMUNICATIONS LTD.
39 . P8055	PLAZA CABLE INDUSTRIES LIMITED
40 . P8001	POLYCAB INDIA LIMITED (FORMERLY POLYCAB WIRES PRIVATE LTD.)
41 . P8207	POLYVION CABLES PVT. LTD
42 . P8090	PRESTIGE CABLE INDUSTRIES
43 . P0647	PREW INDUSTRIES LTD.
44 . P8147	R R KABEL LIMITED
45 . P0658	RADIANT CABLES PVT. LIMITED
46 . P8167	RAVI INDUSTRIES
47 . P8043	RAVIN CABLES LIMITED
48 . P0702	SATELLITE CABLES PVT. LTD. (19 core 2.5 mm2)
49 . P8078	SHYAM CABLES INDUSTRIES
50 . P0739	SKYSTONE ELECTRICALS (I) LTD. (19 core 2.5 mm2, 1.1 KV)
51 . P0744	SPECIAL CABLES PVT. LTD.

## 810503 : CONTROL CABLE

CODE	NAME
52 . P0777	SUYOG ELECTRICALS LTD.
53 . P8168	SVARN INFRATEL PRIVATE LIMITED
54 . P8086	T C COMMUNICATION PVT LTD
55 . P8109	TCL CABLES LTD.
56 . P8094	TERACOM LIMITED
57 . P0818	TORRENT CABLES LTD.
58 . P8165	TORTEK INDIA PRIVATE LIMITED
59 . P0843	UNIVERSAL CABLES LTD.
60 . P8177	V-MARC INDIA LIMITED
61 . P8206	ZENIUM CABLES LIMITED

## 810504 : FLEXIBLE CABLE.

CODE	NAME
<b>INDIA</b>	
1 . P8002	ANCHOR ELECTRICALS PVT. LTD.
2 . P8182	AXELON INDUSTRIES
3 . P8058	BHANSALI CABLES & CONDUCTORS PVT. LTD
4 . P8166	CHANDRESH CABLES LIMITED
5 . P0200	DELTON CABLES LTD
6 . P0260	FINOLEX CABLES LTD
7 . P8204	GEEP POLYMERS INDIA PRIVATE LIMITED
8 . P8195	GLOSTER CABLES LIMITED
9 . P8171	GRANDLAY ELECTRICALS INDIA
10 . P8117	GUPTA POWER INFRASTRUCTURE LTD.
11 . P0337	HAVELLS INDIA LTD.
12 . P8180	HPL ELECTRIC & POWER LIMITED
13 . P8075	KALINGA CABLES & CONDUIT CO.
14 . P8175	KLJ PARAFLEX INDIA LIMITED
15 . P8059	N.C. CABLES LIMITED (FORMERLY NATIONAL CABLES)
16 . P8187	NEC WIRE & CABLES PRIVATE LIMITED
17 . P0574	NICCO CORPORATION LTD

## 810504 : FLEXIBLE CABLE.

CODE	NAME
18 . P8199	PARAMOUNT COMMUNICATIONS LTD.
19 . P8055	PLAZA CABLE INDUSTRIES LIMITED
20 . P8001	POLYCAB INDIA LIMITED (FORMERLY POLYCAB WIRES PRIVATE LTD.)
21 . P8207	POLYVION CABLES PVT. LTD
22 . P8090	PRESTIGE CABLE INDUSTRIES
23 . P0647	PREW INDUSTRIES LTD.
24 . P8147	R R KABEL LIMITED
25 . P8167	RAVI INDUSTRIES
26 . P8078	SHYAM CABLES INDUSTRIES
27 . P0739	SKYTONE ELECTRICALS (I) LTD. (3-1/2 core, 185 mm <sup>2</sup> )
28 . P0744	SPECIAL CABLES PVT. LTD.
29 . P0777	SUYOG ELECTRICALS LTD.
30 . P8168	SVARN INFRATEL PRIVATE LIMITED
31 . P8086	T C COMMUNICATION PVT LTD
32 . P8094	TERACOM LIMITED
33 . P0818	TORRENT CABLES LTD.
34 . P8165	TORTEK INDIA PRIVATE LIMITED

810504 : FLEXIBLE CABLE.

CODE	NAME
35 . P8177	V-MARC INDIA LIMITED
36 . P8206	ZENIUM CABLES LIMITED

## 810505 : TELEPHONE CABLE

CODE	NAME
<b>INDIA</b>	
1 . P8056	ALPHA COMMUNICATION LIMITED
2 . P8058	BHANSALI CABLES & CONDUCTORS PVT. LTD
3 . P0163	CMI LIMITED
4 . P8149	CORDS CABLE INDUSTRIES LTD.
5 . P0200	DELTON CABLES LTD
6 . P0260	FINOLEX CABLES LTD
7 . P0351	HINDUSTAN CABLES LTD
8 . P0574	NICCO CORPORATION LTD
9 . P8057	PARAGON CABLES
10 . P8055	PLAZA CABLE INDUSTRIES LIMITED
11 . P8001	POLYCAB INDIA LIMITED (FORMERLY POLYCAB WIRES PRIVATE LTD.)
12 . P8090	PRESTIGE CABLE INDUSTRIES
13 . P0647	PREW INDUSTRIES LTD.
14 . P0665	RELIANCE ENGINEERS LTD.
15 . P0688	RPG TELECOM LTD
16 . P8078	SHYAM CABLES INDUSTRIES
17 . P0744	SPECIAL CABLES PVT. LTD.

## 810505 : TELEPHONE CABLE

CODE	NAME
18 . P8168	SVARN INFRATEL PRIVATE LIMITED
19 . P0850	USHA BELTRON LIMITED,
20 . P0863	VINDHYA TELELINK LTD

## 810506 : CABLES FOR EARTHING

CODE	NAME
<b>INDIA</b>	
1 . P8121	ADVANCE CABLE TECHNOLOGIES PRIVATE LIMITED
2 . P0200	DELTON CABLES LTD
3 . P0260	FINOLEX CABLES LTD
4 . P0327	GUPTA ELECTRIC & MACHINERY STORES (GEMSCAB)
5 . P0416	J K CABLES LIMITED
6 . P0569	NETCO CABLE INDUSTRIES (PVT.) LTD.
7 . P0574	NICCO CORPORATION LTD
8 . P8001	POLYCAB INDIA LIMITED (FORMERLY POLYCAB WIRES PRIVATE LTD.)
9 . P8090	PRESTIGE CABLE INDUSTRIES
10 . P8078	SHYAM CABLES INDUSTRIES
11 . P0744	SPECIAL CABLES PVT. LTD.
12 . P0777	SUYOG ELECTRICALS LTD.
13 . P8168	SVARN INFRATEL PRIVATE LIMITED
14 . P8086	T C COMMUNICATION PVT LTD
15 . P0843	UNIVERSAL CABLES LTD.



**810507 : SPECIAL CABLES**

CODE	NAME
<b>INDIA</b>	
1 . P8121	ADVANCE CABLE TECHNOLOGIES PRIVATE LIMITED
2 . P8056	ALPHA COMMUNICATION LIMITED
3 . P8058	BHANSALI CABLES & CONDUCTORS PVT. LTD
4 . P8057	PARAGON CABLES
5 . P8055	PLAZA CABLE INDUSTRIES LIMITED
6 . P8090	PRESTIGE CABLE INDUSTRIES
7 . P8078	SHYAM CABLES INDUSTRIES

## 810601 : HIGH VOLTAGE INDUCTION MOTORS

CODE	NAME
<b>INDIA</b>	
1 . P8158	ABB INDIA LIMITED
2 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
3 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
4 . P8140	JEUMONT ELECTRIC INDIA PVT. LTD. (Excluding Flame Proof (Exd) type Motors but Pressurised (Exp) Type Motors - upto 1300 KW; Increased Safety (Exe) Type Motors - Upto 770 KW; Non-Sparking (Exn) Type Motors - Upto 860 KW and Safe Area Motors - Upto
5 . P8104	JYOTI LIMITED
6 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
7 . P8163	MARATHON ELECTRIC MOTORS (INDIA ) LTD. (UP TO 2800KW)
8 . P8142	TMEIC INDUSTRIAL SYSTEMS INDIA PRIVATE LIMITED
9 . P8137	WEG INDUSTRIES (INDIA) PVT. LTD (Up to Frame Size 1600 and rating up to 16 MW)
<b>FRANCE</b>	
10 . P0034	ALSTHOM ATLANTIQUE
11 . P0426	JEUMONT INDUSTRIE
<b>GERMANY</b>	
12 . P0016	AEG TELEFUNKEN AG
<b>ITALY</b>	
13 . P0052	ANSALDO ROBICON
<b>JAPAN</b>	
14 . P0287	FUJI ELECTRIC SYSTEMS CO. LTD.
15 . P0539	MITSUBISHI CORPORATION

## 810601 : HIGH VOLTAGE INDUCTION MOTORS

CODE	NAME
16 . P0726	SHINKO ELECTRICALS CO. LTD.
17 . P0819	TOSHIBA CORPORATION
18 . P8127	TOSHIBA MITSUBISHI ELECTRIC INDUSTRIAL SYSTEMS CORPORATION ((Excludin g Flame-proof motors of frame size more than 900))
<b>SWEDEN</b>	
19 . P0064	ASEA BROWN BOVERI
<b>U.K.</b>	
20 . P0486	LAURENCE, SCOTT & ELECTROMOTORS LTD.
21 . P0621	PEEBLES ELECTRICAL MACHINES
<b>U.S.A.</b>	
22 . P0303	GENERAL ELECTRIC CO.
23 . P0877	WESTINGHOUSE ELECTRIC CORPORATION

## 810602 : MEDIUM VOLTAGE INDUCTION MOTORS

CODE	NAME
<b>INDIA</b>	
1 . P0036	ALSTOM LIMITED ( AREVA T & D)
2 . P0066	ASEA BROWN BOVERI LTD.
3 . P0104	BHARAT BIJLEE LTD
4 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
5 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
6 . P8042	ELGI ELECTRIC INDUSTRIES LTD
7 . P8102	HEM INDUSTRIES
8 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
9 . P8081	LAXMI HYDRAULICS PVT. LTD. (Upto 355L Frame Size)
10 . P8202	ROTOMOTIVE POWERDRIVES INDIA LTD.
11 . P0736	SIEMENS LTD.
<b>FRANCE</b>	
12 . P0034	ALSTHOM ATLANTIQUE
13 . P0426	JEUMONT INDUSTRIE
<b>GERMANY</b>	
14 . P0016	AEG TELEFUNKEN AG
15 . P0735	SIEMENS AG, GERMANY
<b>ITALY</b>	

## 810602 : MEDIUM VOLTAGE INDUCTION MOTORS

CODE	NAME
16 . P0052	ANSALDO ROBICON
<b>JAPAN</b>	
17 . P0287	FUJI ELECTRIC SYSTEMS CO. LTD.
18 . P0539	MITSUBISHI CORPORATION
19 . P0726	SHINKO ELECTRICALS CO. LTD.
20 . P0819	TOSHIBA CORPORATION
<b>SWEDEN</b>	
21 . P0064	ASEA BROWN BOVERI
<b>U.K.</b>	
22 . P0486	LAURENCE, SCOTT & ELECTROMOTORS LTD.
23 . P0621	PEEBLES ELECTRICAL MACHINES
<b>U.S.A.</b>	
24 . P0303	GENERAL ELECTRIC CO.
25 . P0877	WESTINGHOUSE ELECTRIC CORPORATION

## 810603 : MEDIUM VOLTAGE FLAME PROOF/ INCREASED SAFETY MOTORS

CODE	NAME
<b>INDIA</b>	
1 . P0066	ASEA BROWN BOVERI LTD.
2 . P0104	BHARAT BIJLEE LTD
3 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
4 . P8102	HEM INDUSTRIES (0.18 KW TO 200 KW)
5 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
6 . P8081	LAXMI HYDRAULICS PVT. LTD. (Upto 315L Frame Size)
7 . P8202	ROTOMOTIVE POWERDRIVES INDIA LTD.
<b>FRANCE</b>	
8 . P0426	JEUMONT INDUSTRIE
<b>GERMANY</b>	
9 . P0735	SIEMENS AG, GERMANY
<b>ITALY</b>	
10 . P0052	ANSALDO ROBICON
<b>JAPAN</b>	
11 . P0287	FUJI ELECTRIC SYSTEMS CO. LTD.
12 . P0539	MITSUBISHI CORPORATION
13 . P0819	TOSHIBA CORPORATION
<b>SWEDEN</b>	
14 . P0064	ASEA BROWN BOVERI
<b>U.K.</b>	

## 810603 : MEDIUM VOLTAGE FLAME PROOF/ INCREASED SAFETY MOTORS

CODE	NAME
15 . P0486	LAURENCE, SCOTT & ELECTROMOTORS LTD.
16 . P0621	PEEBLES ELECTRICAL MACHINES
<b>U.S.A.</b>	
17 . P0303	GENERAL ELECTRIC CO.
18 . P0877	WESTINGHOUSE ELECTRIC CORPORATION

## 810604 : SYNCHRONOUS MOTORS

CODE	NAME
<b>INDIA</b>	
1 . P0066	ASEA BROWN BOVERI LTD.
2 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
3 . P8202	ROTOMOTIVE POWERDRIVES INDIA LTD.
4 . P8137	WEG INDUSTRIES (INDIA) PVT. LTD (Up to Frame Size 1600 and rating up to 16 MW)
<b>FRANCE</b>	
5 . P0034	ALSTHOM ATLANTIQUE
6 . P0426	JEUMONT INDUSTRIE
<b>GERMANY</b>	
7 . P0016	AEG TELEFUNKEN AG
8 . P0735	SIEMENS AG, GERMANY
<b>ITALY</b>	
9 . P0052	ANSALDO ROBICON
<b>JAPAN</b>	
10 . P0287	FUJI ELECTRIC SYSTEMS CO. LTD.
11 . P0539	MITSUBISHI CORPORATION
12 . P0726	SHINKO ELECTRICALS CO. LTD.
13 . P0819	TOSHIBA CORPORATION
14 . P8127	TOSHIBA MITSUBISHI ELECTRIC INDUSTRIAL SYSTEMS CORPORATION
<b>SWEDEN</b>	



## 810604 : SYNCHRONOUS MOTORS

CODE	NAME
15 . P0064	ASEA BROWN BOVERI
<b>U.K.</b>	
16 . P0486	LAURENCE, SCOTT & ELECTROMOTORS LTD.
17 . P0621	PEEBLES ELECTRICAL MACHINES
<b>U.S.A.</b>	
18 . P0303	GENERAL ELECTRIC CO.
19 . P0877	WESTINGHOUSE ELECTRIC CORPORATION

## 810605 : CANNED MOTORS

CODE	NAME
<b>INDIA</b>	
1 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
2 . P0736	SIEMENS LTD.

**810606 : GEARED MOTORS**

CODE	NAME
<b>INDIA</b>	
1 . P0321	GREAVES COTTON & CO. LTD.
2 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
3 . P0571	NEW ALLENBERRY WORKS
4 . P8084	NORD DRIVESYSTEMS PVT. LTD.
5 . P0638	POWER BUILD LTD
6 . P8202	ROTOMOTIVE POWERDRIVES INDIA LTD.
7 . P8091	SEW EURODRIVE INDIA PRIVATE LIMITED

## 810701 : BATTERY CHARGER

CODE	NAME
<b>INDIA</b>	
1 . P0040	AMCO POWER SYSTEMS LIMITED
2 . P0154	CHHABI ELECTRICALS PVT. LTD.
3 . P0144	CHLORIDE POWER SYSTEMS AND SOLUTIONS LTD. (formerly CALDYNE
4 . P8092	DUBAS ENGINEERING PVT. LTD.
5 . P0694	HBL NIFE POWER SYSTEMS LTD.
6 . P0444	KERALA STATE ELECTRONICS DEV. CORPN. LTD.
7 . P0079	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LIMITED)
8 . P8131	SERVILINK ENGINEERS PVT. LTD.
9 . P0845	UNIVERSAL INDUSTRIAL PRODUCTS

## 810703 : STATIC TYPE UPS SYSTEM

CODE	NAME
<b>INDIA</b>	
1 . P0195	DB POWER ELECTRONICS PVT. LTD.
2 . P8092	DUBAS ENGINEERING PVT. LTD.
3 . P8003	EMERSON NETWORK POWER (INDIA) PVT. LTD.
4 . P0573	GE POWER CONTROLS INDIA PVT. LTD.
5 . P0360	HITACHI HI-REL POWER ELECTRONICS PVT. LTD.
6 . P0399	INSTRUMENTATION LTD
7 . P0444	KERALA STATE ELECTRONICS DEV. CORPN. LTD.
8 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
<b>GERMANY</b>	
9 . P0016	AEG TELEFUNKEN AG
<b>JAPAN</b>	
10 . P0287	FUJI ELECTRIC SYSTEMS CO. LTD.
11 . P0819	TOSHIBA CORPORATION
<b>SWEDEN</b>	
12 . P0064	ASEA BROWN BOVERI
<b>U.S.A.</b>	
13 . P0303	GENERAL ELECTRIC CO.
14 . P0742	SOLIDSTATE CONTROL INC.
15 . P0877	WESTINGHOUSE ELECTRIC CORPORATION

**810705: ELECTROSTATIC TYPE VOLTAGE STABILIZERS**

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CODE	NAME
<b>INDIA</b>	
1 . P0055	APLAB LIMITED

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## 810801 : NEUTRAL EARTHING RESISTOR

CODE	NAME
<b>INDIA</b>	
1 . P0113	BHARTIA INDUSTRIES LTD. (DIVN. BCH)
2 . P0231	ELECMECH CORPORATION
3 . P8041	LOTUS POWERGEAR PVT LTD
4 . P8004	PEFCO FOUNDRY & CHEM LTD
5 . P0669	RESITECH ELECTRICALS PRIVATE LIMITED
6 . P0689	RSI SWITCHGEAR PRIVATE LTD.
7 . P0692	S R NARKHEDE ENGINEERING PVT. LTD.

**810802 : EARTHING & LIGHTNING PROTECTION MATERIAL, AL  
WIRE/STRIP**

<b>CODE</b>	<b>NAME</b>
<b>INDIA</b>	
1 . P0046	ANAND ELECTRIC TRADING CO.
2 . P8135	INDMARK FORMTECH PVT. LTD.
3 . P8085	JAMNA METAL COMPANY
4 . P0423	JAYANT METAL MFG CO
5 . P0504	MAHAVIR INDUSTRIAL CORPORATION
6 . P0533	METROPOLITAN INDUSTRIES
7 . P8072	PREMIER POWER PRODUCTS (CALCUTTA) PVT. LTD.
8 . P0696	SAI GALVANISERS & FABRICATORS PVT LTD



## 810803 : EARTHING & LIGHTNING PROTECTION MATERIAL,G.I.WIRE/STRIP

CODE	NAME
<b>INDIA</b>	
1 . P0046	ANAND ELECTRIC TRADING CO.
2 . P0112	BHARTI EXPORTS
3 . P8203	DURGA TECHNO INDUSTRIES
4 . P8205	INDIANA GRATINGS PRIVATE LIMITED
5 . P8135	INDMARK FORMTECH PVT. LTD.
6 . P8085	JAMNA METAL COMPANY
7 . P0423	JAYANT METAL MFG CO
8 . P0504	MAHAVIR INDUSTRIAL CORPORATION
9 . P0529	METALITE INDUSTRIES
10 . P0533	METROPOLITAN INDUSTRIES
11 . P8189	PINAX STEEL INDUSTRIES PRIVATE LIMITED
12 . P8072	PREMIER POWER PRODUCTS (CALCUTTA) PVT. LTD.
13 . P8174	R.K. Engineering Works
14 . P8179	RATAN PROJECTS AND ENGINEERING CO. PVT. LTD.
15 . P8044	RUKMANI ELECTRICALS & COMPONENTS PVT LTD
16 . P0695	SADHANA ENGINEERING CORPORATION
17 . P0696	SAI GALVANISERS & FABRICATORS PVT LTD

## 810803 : EARTHING & LIGHTNING PROTECTION MATERIAL,G.I.WIRE/STRIP

CODE	NAME
18 . P0753	STEALITE ENGG CO
19 . P8154	TELECOM NETWORK SOLUTIONS PVT.LTD.

## 810901 : MV Ex. Proof Items(Switches/Switch Skt./Plugs/Isolators/J.Box/LCS/DB)

CODE	NAME
<b>INDIA</b>	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P8138	EX-PROTECTA
3 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
4 . P8007	FCG POWER INDUSTRIES PVT.LTD.
5 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
6 . P0272	FLEXPLO ELECTRICALS PVT. LTD.
7 . P8134	INDUSTRIAL PRODUCTS EQUIPMENT
8 . P8132	KAYSONS TECHNO EQUIPMENTS PVT. LTD.
9 . P8045	PETROLEUM SAFETY PRODUCTS INDUSTRIES PRIVATE LTD.
10 . P8088	PROMPT ENGINEERING WORKS
11 . P8194	Phoenix Mecano (India) Pvt.Ltd.
12 . P8156	SHREYA EX-TECH PRIVATE LIMITED
13 . P0763	SUDHIR SWITCHGEARS PVT. LTD.
<b>FRANCE</b>	
14 . P0491	LEGRAND S.A.
<b>GERMANY</b>	
15 . P0016	AEG TELEFUNKEN AG
16 . P0092	BBC-BROWN BOVERI & CIE AG

## 810901 : MV Ex. Proof Items(Switches/Switch Skt./Plugs/Isolators/J.Box/LCS/DB)

CODE	NAME
17 . P0657	R STAHL SCHALTGERATE GMBH
18 . P0735	SIEMENS AG, GERMANY
19 . P0875	WEIDMULLER LTD.
<b>ITALY</b>	
20 . P0178	CORTEM S.p.A.
<b>JAPAN</b>	
21 . P0287	FUJI ELECTRIC SYSTEMS CO. LTD.
22 . P0815	TOGAMI ELECTRIC MFG. COMPANY
23 . P0819	TOSHIBA CORPORATION
<b>SWEDEN</b>	
24 . P0064	ASEA BROWN BOVERI
<b>U.K.</b>	
25 . P0187	CROUSE-HINDS (EUROPE) LTD.
26 . P0300	GEC INDUSTRIAL CONTROL LTD.
27 . P0555	M&C SWITCHGEAR

## 810903 : EXPLOSION PROOF LIGHTING FIXTURES

CODE	NAME
<b>INDIA</b>	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P8138	EX-PROTECTA
4 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
5 . P8007	FCG POWER INDUSTRIES PVT.LTD.
6 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
7 . P0272	FLEXPRO ELECTRICALS PVT. LTD.
8 . P8132	KAYSONS TECHNO EQUIPMENTS PVT. LTD.
9 . P8045	PETROLEUM SAFETY PRODUCTS INDUSTRIES PRIVATE LTD.
10 . P8148	SAIEX FLAMEPROOF EQUIPMENTS PVT LTD
11 . P8156	SHREYA EX-TECH PRIVATE LIMITED
12 . P0763	SUDHIR SWITCHGEARS PVT. LTD.

## 810904 : EXPLOSION PROOF PANIC LIGHTS

CODE	NAME
<b>INDIA</b>	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
3 . P8007	FCG POWER INDUSTRIES PVT.LTD.
4 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
5 . P0272	FLEXPRO ELECTRICALS PVT. LTD.
6 . P8132	KAYSONS TECHNO EQUIPMENTS PVT. LTD.
<b>FRANCE</b>	
7 . P0513	MAPELEC SA
<b>GERMANY</b>	
8 . P0148	CEAG LIGHT-UDN STROMVERSORGUNGS TECHNIK

## 810906 : FLAMEPROOF CABLE GLAND

CODE	NAME
<b>INDIA</b>	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P0165	COMET BRASS PRODUCTS
3 . P8100	COMET INDUSTRIES
4 . P0211	DOWELL'S ELECTRICALS
5 . P0228	ELECTROMAC INDUSTRIES
6 . P8138	EX-PROTECTA
7 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
8 . P8007	FCG POWER INDUSTRIES PVT.LTD.
9 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
10 . P0272	FLEXPRO ELECTRICALS PVT. LTD.
11 . P8134	INDUSTRIAL PRODUCTS EQUIPMENT
12 . P8132	KAYSONS TECHNO EQUIPMENTS PVT. LTD.
13 . P0639	POWER ENGG CO
14 . P8088	PROMPT ENGINEERING WORKS
15 . P8194	Phoenix Mecano (India) Pvt.Ltd.
16 . P8148	SAIEX FLAMEPROOF EQUIPMENTS PVT LTD
17 . P8156	SHREYA EX-TECH PRIVATE LIMITED

**810906: FLAMEPROOF CABLE GLAND**

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CODE	NAME
18. P0763	SUDHIR SWITCHGEARS PVT. LTD.

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**810909 : EXPLOSION PROOF EXHAUST FAN**

<b>CODE</b>	<b>NAME</b>
<b>INDIA</b>	
1 . P0036	ALSTOM LIMITED ( AREVA T & D)
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
4 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
5 . P8134	INDUSTRIAL PRODUCTS EQUIPMENT
6 . P8156	SHREYA EX-TECH PRIVATE LIMITED

## 811001 : COMMERCIAL LTG FIXTURES

CODE	NAME
<b>INDIA</b>	
1 . P0085	BAJAJ ELECTRICALS LIMITED
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0337	HAVELLS INDIA LTD.
4 . P8099	KESELEC SCHREDER PRIVATE LIMITED
5 . P8170	LIGHTING TECHNOLOGIES INDIA PRIVATE LIMITED (-)
6 . P8208	ORIENT ELECTRIC LIMITED
7 . P0623	PHILIPS INDIA LTD.
8 . P8186	PYROTECH ELECTRONICS PVT. LTD.
9 . P8096	SURYA ROSHNI LTD.
10 . P0881	WIPRO LIGHTING

**811002 : CORROSION PROOF INDUSTRIAL LTG.FIXTURES**

<b>CODE</b>	<b>NAME</b>
<b>INDIA</b>	
1 . P0085	BAJAJ ELECTRICALS LIMITED
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0337	HAVELLS INDIA LTD.
4 . P8099	KESELEC SCHREDER PRIVATE LIMITED
5 . P0623	PHILIPS INDIA LTD.
6 . P8186	PYROTECH ELECTRONICS PVT. LTD.

## 811003 : HOSE PROOF INDUSTRIAL LTG.FIXTURES

CODE	NAME
<b>INDIA</b>	
1 . P0085	BAJAJ ELECTRICALS LIMITED
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P8099	KESELEC SCHREDER PRIVATE LIMITED
4 . P0623	PHILIPS INDIA LTD.
5 . P8186	PYROTECH ELECTRONICS PVT. LTD.
6 . P8051	SPACEAGE SWITCHGEARS LIMITED
7 . P8096	SURYA ROSHNI LTD.
8 . P0881	WIPRO LIGHTING

## 811004 : STREET/FLOOD LTG.FIXTURES

CODE	NAME
<b>INDIA</b>	
1 . P0085	BAJAJ ELECTRICALS LIMITED
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0337	HAVELLS INDIA LTD.
4 . P8099	KESELEC SCHREDER PRIVATE LIMITED
5 . P8170	LIGHTING TECHNOLOGIES INDIA PRIVATE LIMITED (-)
6 . P8208	ORIENT ELECTRIC LIMITED
7 . P0623	PHILIPS INDIA LTD.
8 . P8186	PYROTECH ELECTRONICS PVT. LTD.
9 . P8051	SPACEAGE SWITCHGEARS LIMITED
10 . P8096	SURYA ROSHNI LTD.
11 . P0881	WIPRO LIGHTING

**811005 : AIR OBSTRUCTION LIGHTS (NEON TYPE)**

CODE	NAME
<b>INDIA</b>	
1 . P0085	BAJAJ ELECTRICALS LIMITED
2 . P0686	ELECAB POYSHA
3 . P0881	WIPRO LIGHTING

## 811006 : LAMPS & TUBES

CODE	NAME
<b>INDIA</b>	
1 . P8002	ANCHOR ELECTRICALS PVT. LTD.
2 . P0085	BAJAJ ELECTRICALS LIMITED
3 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
4 . P8006	ECE BULBS & TUBES
5 . P0337	HAVELLS INDIA LTD.
6 . P8170	LIGHTING TECHNOLOGIES INDIA PRIVATE LIMITED (-)
7 . P8208	ORIENT ELECTRIC LIMITED
8 . P8005	OSRAM INDIA LTD.
9 . P0623	PHILIPS INDIA LTD.
10 . P8096	SURYA ROSHNI LTD.
11 . P0881	WIPRO LIGHTING

## 811007 : COMPACT FLUORESCENT LAMPS

CODE	NAME
<b>INDIA</b>	
1 . P0085	BAJAJ ELECTRICALS LIMITED
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0337	HAVELLS INDIA LTD.
4 . P0413	INDO ASIAN FUSEGEAR LTD (Ecolite make)
5 . P8005	OSRAM INDIA LTD.
6 . P0623	PHILIPS INDIA LTD.
7 . P8070	STANDARD ELECTRICALS LIMITED
8 . P8096	SURYA ROSHNI LTD.



## 811101 : ALKALINE BATTERY

CODE	NAME
<b>INDIA</b>	
1 . P0040	AMCO POWER SYSTEMS LIMITED
2 . P0694	HBL NIFE POWER SYSTEMS LTD.
3 . P0346	HIGH ENERGY BATTERIES (INDIA) LTD.
<b>JAPAN</b>	
4 . P0287	FUJI ELECTRIC SYSTEMS CO. LTD.
5 . P0357	HITACHI LTD.

## 811102 : LEAD ACID BATTERY

CODE	NAME
<b>INDIA</b>	
1 . P0151	ABB INDIA LIMITED
2 . P0038	AMARA RAJA BATTERIES LTD
3 . P0249	EXIDE INDUSTRIES LIMITED
4 . P8108	MICROTEX ENERGY P LTD.

## 811201 : LIFT

CODE	NAME
<b>INDIA</b>	
1 . P0609	OTIS ELEVATOR CO (I) LTD
<b>JAPAN</b>	
2 . P0190	DAIICHI JITSUGYO CO., LTD.
3 . P0287	FUJI ELECTRIC SYSTEMS CO. LTD.
4 . P0581	NIPPON ELEVATOR IND.CO. LIMITED
<b>SWITZERLAND</b>	
5 . P0705	SCHINDLER AG

## 811301 : DIESEL GENERATOR SET.

CODE	NAME
<b>INDIA</b>	
1 . P0091	BATLIBOI & CO. LTD.
2 . P8009	BHASKAR POWER PROJECTS LTD.
3 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
4 . P8014	CATERPILLAR
5 . P0188	CUMMINS INDIA LIMITED
6 . P0292	GARDEN REACH SHIPBUILDERS & ENGINEERS LTD.
7 . P0321	GREAVES COTTON & CO. LTD.
8 . P8114	HI-TECH ENGINEERS (Upto 625 KVA)
9 . P8008	JAKSON ENGINEERS LTD
10 . P8015	JEEVAN DIESEL & ELECTRICALS LTD.
11 . P8013	KIRLOSKAR OIL ENGINES
12 . P8188	STERLING GENERATORS PRIVATE LIMITED
13 . P8010	SUDHIR GENSETS LTD.
14 . P8012	TOYO DENKI POWER SYSTEMS PVT. LTD.
15 . P8011	WARTSILLA INDIA LTD.
<b>JAPAN</b>	
16 . P0539	mitsubishi corporation

## 811301 : DIESEL GENERATOR SET.

CODE	NAME
17 . P0821	TOYO ELECT. MFG. CO. LTD.

### **SWEDEN**

18 . P0064      ASEA BROWN BOVERI

**811401 : HIGH VOLTAGE BUS DUCT.**

CODE	NAME
<b>INDIA</b>	
1 . P0102	BEST & CROMPTON ENGG. CO.
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0405	INTRELEC
4 . P0435	KARAMCHAND THAPAR
5 . P8041	LOTUS POWERGEAR PVT LTD
6 . P0640	POWERGEAR LIMITED
7 . P8051	SPACEAGE SWITCHGEARS LIMITED

## 811402 : MEDIUM VOLTAGE BUS DUCT

CODE	NAME
<b>INDIA</b>	
1 . P0045	ANAND POWER LIMITED
2 . P0071	ASSOCIATED SWITCHGEARS & PROJECTS LTD.
3 . P8197	ASTEK ELECTRICAL INDIA PRIVATE LIMITED
4 . P8105	AVONE SYSTEM & CONTROLS
5 . P0102	BEST & CROMPTON ENGG. CO.
6 . P0173	C&S ELECTRIC LTD.
7 . P0172	CONTROLS & SCHEMATICS PVT LTD.
8 . P8069	COSMIC POWER SYSTEMS PVT. LTD.
9 . P0195	DB POWER ELECTRONICS PVT. LTD.
10 . P0312	GLOBE ELECTRICAL INDUSTRIES
11 . P0352	HINDUSTAN CONTROL & EQPT PV. LTD.
12 . P0405	INTRELEC
13 . P8041	LOTUS POWERGEAR PVT LTD
14 . P8074	MAHESHWARI ELECTRICAL MFRS. (P) LTD.
15 . P0640	POWERGEAR LIMITED
16 . P0670	REUNION ELECTRICAL MANUFACTURERS (P) LTD
17 . P8107	SHIVALIC POWER CONTROL (P) LTD.

**811402 : MEDIUM VOLTAGE BUS DUCT**

CODE	NAME
18 . P8051	SPACEAGE SWITCHGEARS LIMITED
19 . P0841	UNITED ELECTRIC CO. (DELHI) PVT. LTD.
20 . P8106	VENUS CONTROLS & SWITCHGEAR (P) LTD.



## 811501 : SWITCHYARD PACKAGE

CODE	NAME
<b>INDIA</b>	
1 . P0036	ALSTOM LIMITED ( AREVA T & D)
2 . P0066	ASEA BROWN BOVERI LTD.
3 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
4 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
5 . P8104	JYOTI LIMITED (upto 33KV only)
6 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
7 . P8016	L&T (ECE DIVISION)
8 . P0079	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LIMITED)
9 . P0132	RELIANCE POWER
10 . P0670	REUNION ELECTRICAL MANUFACTURERS (P) LTD
11 . P0736	SIEMENS LTD.
12 . P0798	THE AHMEDABAD ELECTRICITY CO LTD
13 . P0869	VOLTAS LTD. (PUMPS & PROJECTS BUSINESS DIV)

## 811502 : SUB-STATION PACKAGE

CODE	NAME
<b>INDIA</b>	
1 . P0036	ALSTOM LIMITED ( AREVA T & D)
2 . P0102	BEST & CROMPTON ENGG. CO.
3 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
4 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
5 . P8016	L&T (ECE DIVISION)
6 . P0132	RELIANCE POWER
7 . P0670	REUNION ELECTRICAL MANUFACTURERS (P) LTD
8 . P0736	SIEMENS LTD.
9 . P0798	THE AHMEDABAD ELECTRICITY CO LTD

## 811503 : PLANT ELECTRIFICATION PACKAGE(Major Projects)

CODE	NAME
<b>INDIA</b>	
1 . P0036	ALSTOM LIMITED ( AREVA T & D)
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
4 . P8077	KMG ATOZ SYSTEMS PVT. LTD.
5 . P0132	RELIANCE POWER
6 . P0736	SIEMENS LTD.
7 . P8145	STERLING ELECTRO ENTERPRISES PVT.LTD.
8 . P0798	THE AHMEDABAD ELECTRICITY CO LTD
9 . P0860	VIDUIT AND COMPANY (I) PVT. LTD.
<b>U.K.</b>	
10 . P0481	LA BOUR PUMP CO. LTD.

## 811504 : PLANT ELECTRIFICATION PACKAGE(MINOR PROJECTS)

CODE	NAME
<b>INDIA</b>	
1 . P0045	ANAND POWER LIMITED
2 . P8169	ARYAN ELECTRICALS PRIVATE LIMITED (-)
3 . P8017	CHASMITA ENGRS PVT LTD
4 . P8192	GENICS ELECTROTECH PVT. LTD.
5 . P8077	KMG ATOZ SYSTEMS PVT. LTD.
6 . P8118	MEC ENGINEERS
7 . P8020	PACE PROCESS CONTROLS
8 . P8021	POWERMAX ELECTRICALS PVT LTD
9 . P0670	REUNION ELECTRICAL MANUFACTURERS (P) LTD
10 . P8018	ROHINI ELECTRIC
11 . P8145	STERLING ELECTRO ENTERPRISES PVT.LTD.
12 . P0860	VIDUIT AND COMPANY (I) PVT. LTD.
13 . P8019	ZODIAC POWER PROJECTS

## 811505 : AIR PRESSURISATION / VENTILLATION SYSTEM

CODE	NAME
<b>INDIA</b>	
1 . P0267	ABB FLAKT INDIA LTD.
2 . P0024	AIR CONDITIONING CORPN LTD
3 . P0041	AMERICAN REFRIGERATION CO LTD.
4 . P0119	BLUE STAR LTD.
5 . P0869	VOLTAS LTD. (PUMPS & PROJECTS BUSINESS DIV)



## 811506: FIRE DETECTION AND ALARM SYSTEM

CODE	NAME
<b>INDIA</b>	
1 .P8201	ZAP FIRE

## 811601 : PRE-FABRICATED AL-CABLE TRAYS

CODE	NAME
<b>INDIA</b>	
1 . P8203	DURGA TECHNO INDUSTRIES
2 . P0312	GLOBE ELECTRICAL INDUSTRIES
3 . P0355	HINUSTAN VIDYUT PRODUCTS
4 . P0385	INDIANA ENGG WORKS PVT LTD
5 . P8205	INDIANA GRATINGS PRIVATE LIMITED
6 . P8135	INDMARK FORMTECH PVT. LTD.
7 . P8085	JAMNA METAL COMPANY
8 . P8089	KANADE ANAND UDYOG PVT. LTD.
9 . P8074	MAHESHWARI ELECTRICAL MFRS. (P) LTD.
10 . P0529	METALITE INDUSTRIES
11 . P0619	PAREKH ENGINEERING COMPANY
12 . P8189	PINAX STEEL INDUSTRIES PRIVATE LIMITED
13 . P8072	PREMIER POWER PRODUCTS (CALCUTTA) PVT. LTD.
14 . P8174	R.K. Engineering Works
15 . P8179	RATAN PROJECTS AND ENGINEERING CO. PVT. LTD.
16 . P8044	RUKMANI ELECTRICALS & COMPONENTS PVT LTD
17 . P0695	SADHANA ENGINEERING CORPORATION

**811601 : PRE-FABRICATED AL-CABLE TRAYS**

CODE	NAME
18 . P0748	SREE ATREYA ENTERPRISES
19 . P0753	STEALITE ENGG CO



## 811602 : PRE-FABRICATED G.I. CABLE TRAYS

CODE	NAME
<b>INDIA</b>	
1 . P8203	DURGA TECHNO INDUSTRIES
2 . P0312	GLOBE ELECTRICAL INDUSTRIES
3 . P0385	INDIANA ENGG WORKS PVT LTD
4 . P8205	INDIANA GRATINGS PRIVATE LIMITED
5 . P8135	INDMARK FORMTECH PVT. LTD.
6 . P8085	JAMNA METAL COMPANY
7 . P8089	KANADE ANAND UDYOG PVT. LTD.
8 . P8074	MAHESHWARI ELECTRICAL MFRS. (P) LTD.
9 . P0529	METALITE INDUSTRIES
10 . P0619	PAREKH ENGINEERING COMPANY
11 . P8189	PINAX STEEL INDUSTRIES PRIVATE LIMITED
12 . P8072	PREMIER POWER PRODUCTS (CALCUTTA) PVT. LTD.
13 . P8174	R.K. Engineering Works
14 . P8179	RATAN PROJECTS AND ENGINEERING CO. PVT. LTD.
15 . P8044	RUKMANI ELECTRICALS & COMPONENTS PVT LTD
16 . P0695	SADHANA ENGINEERING CORPORATION
17 . P8067	SLOTCO STEEL PRODUCTS PVT. LTD.

## 811602 : PRE-FABRICATED G.I. CABLE TRAYS

CODE	NAME
18 . P0748	SREE ATREYA ENTERPRISES
19 . P0753	STEALITE ENGG CO

## 811603 : FRP CABLE TRAYS

CODE	NAME
<b>INDIA</b>	
1 . P8022	ENERCON
2 . P8146	EPP COMPOSITES PVT.LTD.
3 . P8079	ERCON COMPOSITES (upto 600 mm wide)
4 . P8205	INDIANA GRATINGS PRIVATE LIMITED
5 . P8024	KEMROCK
6 . P8125	KEMROCK INDUSTRIES & EXPORTS LTD.
7 . P8119	SATYAM COMPOSITES PVT. LTD.
8 . P8023	SINTEX INDUSTRIES LTD.
9 . P8083	SUMIP COMPOSITES PVT. LTD.

## 811604 : GI PIPES &amp; CONDUITS

CODE	NAME
<b>INDIA</b>	
1 . P0112	BHARTI EXPORTS
2 . P0814	INDIAN TUBE CO. (TATA DIV. OF TUBES & PIPES)
3 . P0427	JINDAL PIPES LTD.
4 . P0527	MEGHJYOT ENTERPRISES
5 . P8044	RUKMANI ELECTRICALS & COMPONENTS PVT LTD
6 . P0755	STEELCRAFT

## 811605 : PVC PIPES &amp; CONDUITS

CODE	NAME
<b>INDIA</b>	
1 . P8037	A.K.G.
2 . P8039	FINOLEX INDUSTRIES LTD. (PIPES & PVC DIVN.)
3 . P8075	KALINGA CABLES & CONDUIT CO.
4 . P8055	PLAZA CABLE INDUSTRIES LIMITED
5 . P8040	POLYPACK
6 . P8038	PRAKASH INDUSTRIES LTD.

## 811606 : INDUSTRIAL CABLE GLAND

CODE	NAME
<b>INDIA</b>	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P0165	COMET BRASS PRODUCTS
3 . P8100	COMET INDUSTRIES
4 . P0211	DOWELL'S ELECTRICALS
5 . P0228	ELECTROMAC INDUSTRIES
6 . P8200	EX-PROTECTA
7 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
8 . P0310	GLAND-MECH. INDUSTRIES
9 . P8134	INDUSTRIAL PRODUCTS EQUIPMENT
10 . P0639	POWER ENGG CO
11 . P0655	QUALITY & PRECISION INDL. EQUIPMENT
12 . P8025	S J METAL INDUSTRIES (JAINSON)

## 811607 : CABLE LUGS

CODE	NAME
<b>INDIA</b>	
1 . P0211	DOWELL'S ELECTRICALS
2 . P0279	FORWARD ENGG INDUSTRIES
3 . P0474	KSE ELECTRICAL PVT. LTD.
4 . P8133	MG ELECTRICA
5 . P0639	POWER ENGG CO
6 . P8025	S J METAL INDUSTRIES (JAINSON)
7 . P0851	USHA MARTIN INDUSTRIES LTD. (ISMAL DIVN)

## 811608 : BITUMENOUS BASED CABLE TERMINATION/STRAIGHT THROUGH JOINTING KITS.

CODE	NAME
<b>INDIA</b>	
1 . P0118	BIRLA 3M LTD.
2 . P0142	CABLE CORPN. OF INDIA LIMITED
3 . P0505	MAHINDRA ENGG. & CHEMICAL PRODUCTS LTD.
4 . P8026	RAYCHEM RPG LTD.
5 . P0900	YAMUNA POWER & INFRASTRUCTURE LIMITED



## 811609 : EPOXY BASED TERMINATION/STRAIGHT THROUGH JOINTING KITS.

CODE	NAME
<b>INDIA</b>	
1 . P0118	BIRLA 3M LTD.
2 . P0142	CABLE CORPN. OF INDIA LIMITED
3 . P8198	GALA SHRINK FIT (Epoxy/Cross linked Polyolefine)
4 . P8027	HARI CONSOLIDATED PVT LTD.
5 . P0505	MAHINDRA ENGG. & CHEMICAL PRODUCTS LTD.
6 . P8026	RAYCHEM RPG LTD.
7 . P0900	YAMUNA POWER & INFRASTRUCTURE LIMITED
8 . P0890	YASHWANT INDUSTRIAL WORKS PVT. LTD.

**811610 : SI RUBBER BASED CABLE TERM./STRAIGHT THRU JOINTING KITS.**

<b>CODE</b>	<b>NAME</b>
<b>INDIA</b>	
1 . P0142	CABLE CORPN. OF INDIA LIMITED
2 . P8027	HARI CONSOLIDATED PVT LTD.
3 . P0505	MAHINDRA ENGG. & CHEMICAL PRODUCTS LTD.
4 . P8026	RAYCHEM RPG LTD.
5 . P0900	YAMUNA POWER & INFRASTRUCTURE LIMITED

## 811611 : LIGHTING POLES

CODE	NAME
<b>INDIA</b>	
1 . P0112	BHARTI EXPORTS
2 . P8146	EPP COMPOSITES PVT.LTD.
3 . P8125	KEMROCK INDUSTRIES & EXPORTS LTD. (For FRP Type only)
4 . P8170	LIGHTING TECHNOLOGIES INDIA PRIVATE LIMITED (-)
5 . P0529	METALITE INDUSTRIES
6 . P8208	ORIENT ELECTRIC LIMITED
7 . P8072	PREMIER POWER PRODUCTS (CALCUTTA) PVT. LTD.
8 . P0695	SADHANA ENGINEERING CORPORATION
9 . P8119	SATYAM COMPOSITES PVT. LTD.
10 . P8096	SURYA ROSHNI LTD.
11 . P8181	UTKARSH INDIA LIMITED

## 811612 : TRANSFORMER OIL

CODE	NAME
<b>INDIA</b>	
1 . P0053	APAR INUSTRIES LTD.
2 . P0381	INDIAN OIL CORPORATION LTD

## 811613 : INDUSTRIAL EXHAUST FAN

CODE	NAME
<b>INDIA</b>	
1 . P0024	AIR CONDITIONING CORPN LTD
2 . P0036	ALSTOM LIMITED ( AREVA T & D)
3 . P0041	AMERICAN REFRIGERATION CO LTD.
4 . P0085	BAJAJ ELECTRICALS LIMITED
5 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
6 . P0337	HAVELLS INDIA LTD.
7 . P0782	S.F. INDIA LTD
8 . P8028	TLT ENGINEERING INDIA PVT LTD

## 811701 : ELECTRO-MECHANICAL RELAYS

CODE	NAME
<b>INDIA</b>	
1 . P0036	ALSTOM LIMITED ( AREVA T & D)
2 . P0066	ASEA BROWN BOVERI LTD.
3 . P0219	EASUN REYROLLE LIMITED
4 . P8104	JYOTI LIMITED

**811702 : MICROPROCESSOR / NUMERICAL RELAYS**

CODE	NAME
<b>INDIA</b>	
1 . P0036	ALSTOM LIMITED ( AREVA T & D)
2 . P0066	ASEA BROWN BOVERI LTD.
3 . P8173	CG POWER AND INDUSTRIAL SOLUTIONS LIMITED
4 . P0219	EASUN REYROLLE LIMITED
5 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
6 . P8123	PROK DEVICES PRIVATE LIMITED ((Over Current and Earth Fault Relay, Earth Fault Relay, Earth Leakage Relay with CBCT))
7 . P0736	SIEMENS LTD.

## 811703 : METERS

CODE	NAME
<b>INDIA</b>	
1 . P0036	ALSTOM LIMITED ( AREVA T & D)
2 . P8047	HOTLINE SWITCHGEAR & CONTROLS
3 . P0392	IMP POWER LTD.
4 . P0420	JAIPUR METALS & ELECTRICAL LTD
5 . P8095	M.B. CONTROL & SYTSTEMS PVT. LTD. ((Only for Multifunctional Meter))
6 . P0526	MECO INSUTRUMENTS
7 . P0079	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LIMITED)
8 . P8155	NEWTEK ELECTRICALS
9 . P8123	PROK DEVICES PRIVATE LIMITED
10 . P8029	RISHABH INSTRUMENTS PVT. LTD.
11 . P0710	SEAHORSE INDUSTRIES LTD.
12 . P8196	THE MOTWANE MANUFACTURING COMPANY PVT. LTD. (ELETRICAL TESTING & MEASURING EQUIPMENTS)



## 811704 : RECORDERS

CODE	NAME
<b>INDIA</b>	
1 . P8030	ALACRITY ELECTRONICS LTD.
2 . P8022	ENERCON
3 . P0479	L & G SWITZERLAND

## 811801 : HIGH VOLTAGE SHUNT CAPACITORS

CODE	NAME
<b>INDIA</b>	
1 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0449	KAPSALES ELECTRICALS LTD.
4 . P0730	SHREEM CAPACITORS PVT. LTD.
5 . P0843	UNIVERSAL CABLES LTD.

**811802 : MEDIUM VOLTAGE SHUNT CAPACITORS**

CODE	NAME
<b>INDIA</b>	
1 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0449	KAPSALES ELECTRICALS LTD.
4 . P0730	SHREEM CAPACITORS PVT. LTD.
5 . P0843	UNIVERSAL CABLES LTD.

## 811803 : LOW VOLTAGE SHUNT CAPACITORS

CODE	NAME
<b>INDIA</b>	
1 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0449	KAPSALES ELECTRICALS LTD.
4 . P0730	SHREEM CAPACITORS PVT. LTD.
5 . P0843	UNIVERSAL CABLES LTD.

## 811901 : OVERHEAD CONDUCTORS-AL /ACSR

CODE	NAME
<b>INDIA</b>	
1 . P0037	ALUMINIUM INDUSTRIES LTD
2 . P8184	DYNAMIC CABLES LIMITED
3 . P8171	GRANDLAY ELECTRICALS INDIA
4 . P8193	LUMINO INDUSTRIES LIMITED
5 . P0574	NICCO CORPORATION LTD
6 . P8167	RAVI INDUSTRIES
7 . P8177	V-MARC INDIA LIMITED

## 811902 : EHV/HV INSULATORS

CODE	NAME
<b>INDIA</b>	
1 . P0036	ALSTOM LIMITED ( AREVA T & D)
2 . P0109	BHARAT HEAVY ELECTRICALS LTD.
3 . P0717	SESHASAYEE INDUSTRIES LTD

## 811903 : M.V.INSULATORS

CODE	NAME
<b>INDIA</b>	
1 . P0036	ALSTOM LIMITED ( AREVA T & D)
2 . P0347	HIGH TENSION INSULATORS FACTORY
3 . P0717	SESHASAYEE INDUSTRIES LTD

## 811904 : LIGHTNING ARRESTOR

CODE	NAME
<b>INDIA</b>	
1 . P0036	ALSTOM LIMITED ( AREVA T & D)
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P8190	ELEKTROLITES (POWER) PRIVATE LIMITED
4 . P0234	ELPRO INTERNATIONAL LTD
5 . P0595	OBLUM ELEC. INDUSTRIES PVT LTD



## 812001 : TELEPHONE EXCHANGE EQUIPMENTS

CODE	NAME
<b>INDIA</b>	
1 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
2 . P0330	HAKOTRONICS PRIVATE LIMITED
3 . P0383	INDIAN TELEPHONE INDUSTRIES LTD.
4 . P0623	PHILIPS INDIA LTD.
5 . P0736	SIEMENS LTD.
6 . P0788	TATA TELECOM LIMITED
<b>GERMANY</b>	
7 . P0570	NEUMANN GMBH ELEKTRONIK
<b>SINGAPORE</b>	
8 . P0546	MOTOROLA SINGAPORE PTE LTD.

## 812002 : PAGING EQUIPMENTS / PUBLIC ADDRESS SYTEM

CODE	NAME
<b>GERMANY</b>	
1 . P8161	INDUSTRONIC INDUSTRIE-ELECTRONIC GMBH & CO. KG
<b>INDIA</b>	
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0330	HAKOTRONICS PRIVATE LIMITED
4 . P0383	INDIAN TELEPHONE INDUSTRIES LTD.
5 . P0623	PHILIPS INDIA LTD.
6 . P0788	TATA TELECOM LIMITED
7 . P0795	TELEMAX CORPROATION
<b>SINGAPORE</b>	
8 . P8144	COMTROL PTE.LTD.
<b>RUSSIA</b>	
9 . P8150	ARMTEL LLC
<b>GERMANY</b>	
10 . P0570	NEUMANN GMBH ELEKTRONIK
<b>INDIA</b>	
11 . P8185	LARAON ENGINEERS AND CONSULTANTS PVT. LTD.
<b>SINGAPORE</b>	
12 . P0546	MOTOROLA SINGAPORE PTE LTD.
<b>U.K.</b>	
13 . P0289	GAI TRONICS SRL

## 812101 : INDUSTRIAL HEATER

CODE	NAME
<b>France</b>	
1 . P8153	Chromalox Etirex SAS
<b>INDIA</b>	
2 . P0030	ALCO HEATING CO.
3 . P0091	BATLIBOI & CO. LTD.
4 . P0234	ELPRO INTERNATIONAL LTD
5 . P0242	ESCORTS LTD
6 . P8139	FATI GENERAL EQUIPMENTS PVT.LTD.
7 . P8031	KANTILAL CHUNNILAL & SONS APPLIANCES PVT. LTD.
8 . P8032	MACNEIL & MAGOR (KILNBURN)
9 . P0535	MIDDLETON ENGG CO
10 . P8033	RAYCOLD LTD.
11 . P8034	T.M.I (TRANSFORMERS MFG. INDUSTRIES)
<b>GERMANY</b>	
12 . P8080	KLOPPER-THERM GmbH & Co. KG

## 812201 : HOSE PROOF LOCAL CONTROL STATION

CODE	NAME
<b>INDIA</b>	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P0113	BHARTIA INDUSTRIES LTD. (DIVN. BCH)
3 . P8138	EX-PROTECTA
4 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
5 . P8007	FCG POWER INDUSTRIES PVT.LTD.
6 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
7 . P8047	HOTLINE SWITCHGEAR & CONTROLS
8 . P0639	POWER ENGG CO
9 . P8160	SHRENIK & COMPANY

## 812202 : INDUSTRIAL TYPE SW. SOCKET & PLUG

CODE	NAME
<b>INDIA</b>	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0144	CHLORIDE POWER SYSTEMS AND SOLUTIONS LTD. (formerly CALDYNE
4 . P0902	CYCLO ELECTRIC DEVICES & SERVICES CO.
5 . P8138	EX-PROTECTA
6 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
7 . P8007	FCG POWER INDUSTRIES PVT.LTD.
8 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
9 . P0523	LEGRAND INDIA LTD
10 . P8160	SHRENIK & COMPANY
<b>FRANCE</b>	
11 . P0491	LEGRAND S.A.
<b>GERMANY</b>	
12 . P0092	BBC-BROWN BOVERI & CIE AG
13 . P0657	R STAHL SCHALTGERATE GMBH
14 . P0875	WEIDMULLER LTD.
<b>ITALY</b>	
15 . P0178	CORTEM S.p.A.

## 812203 : HOSEPROOF JUNCTION BOXES

CODE	NAME
<b>INDIA</b>	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P0113	BHARTIA INDUSTRIES LTD. (DIVN. BCH)
3 . P8138	EX-PROTECTA
4 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
5 . P8007	FCG POWER INDUSTRIES PVT.LTD.
6 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
7 . P8194	Phoenix Mecano (India) Pvt.Ltd.
8 . P8160	SHRENIK & COMPANY

## 812204 : ELECTROMAGNETIC EQUIPMENT

CODE	NAME
<b>INDIA</b>	
1 . P0229	ELEKTROMAG DEVICES PVT. LTD
2 . P0638	POWER BUILD LTD
3 . P0757	STERLING CONTROLS PVT. LTD.
4 . P0760	STORM KRAFT CONTROLS

## 812205 : LIMIT SWITCHES / BELT MONITORING SWITCHES

CODE	NAME
<b>INDIA</b>	
1 . P0002	A G SYSTEM CONTROLS
2 . P0022	AG MECHANICAL ENTERPRISES (P) LTD.
3 . P8036	BALAJI ELECTRICALS
4 . P0113	BHARTIA INDUSTRIES LTD. (DIVN. BCH)
5 . P0424	JAYASHREE ELECTRODEVICES PVT. LTD.
6 . P8097	PROTOCONTROL INSTRUMENTS (I) PVT. LTD.
7 . P0691	R.K. ELECTRICAL ENGG. WORKS



## 812206 : LIMIT SWITCHES (FLAMEPROOF TYPE)

CODE	NAME
<b>INDIA</b>	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P8138	EX-PROTECTA
3 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
4 . P8007	FCG POWER INDUSTRIES PVT.LTD.
5 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
6 . P8097	PROTOCONTROL INSTRUMENTS (I) PVT. LTD.
7 . P8148	SAIEX FLAMEPROOF EQUIPMENTS PVT LTD

## 812207 : HORN/HOOTER/KLAXON

CODE	NAME
<b>INDIA</b>	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P8138	EX-PROTECTA
3 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
4 . P0883	WORTHMAX ENGINEERS

## 812301 : CATHODIC PROTECTION SYSTEM

CODE	NAME
<b>INDIA</b>	
1 . P8073	CONSTRUCTION GUILD PVT. LTD.
2 . P8110	ELECTRO PROTECTION SERVICES INDIA PVT. LTD. ((Also manufacturer of Anodes for CP System))
3 . P8141	SARK EPC PROJECTS PVT.LTD.
4 . P8143	UNDERGROUND PIPELINE & NDT SERVICES PRIVATE LIMITED
5 .	UNDERGROUND PIPELINE & NDT SERVICES PRIVATE LIMITED
6 . P8172	UNIVERSAL CORROSION PREVENTION INDIA

	<b>MASTER VENDORS LIST FOR PROJECTS</b>	04-00MM-0011	18
		DOCUMENT NO	REV

**MASTER VENDORS LIST**  
**FOR**  
**PROJECTS**  
**CUSTOM CLEARANCE & TRANSPORTATION ITEMS**



## INDEX CUSTOM CLEARANCE &amp; TRANSPORTATION ITEMS

ITEMCODE	ITEM DESCRIPTION	PAGE NO.
9101	CUSTOM CLEARANCE & TRANSPORTATION (INCLUDING ODC /OWC)	
910101	CUSTOM CLEARANCE & TRANSPORTATION (INCLUDING ODC /OVVC)	2

## 910101 : CUSTOM CLEARANCE & TRANSPORTATION (INCLUDING ODC / OWC)

CODE	NAME
<b>INDIA</b>	
1 . P9002	J M BAXI & CO.
2 . P9003	PREMIER TRANSPORT LIMITED
3 . P9001	RRC INTERNATIONAL FREIGHT SERVICES LTD.



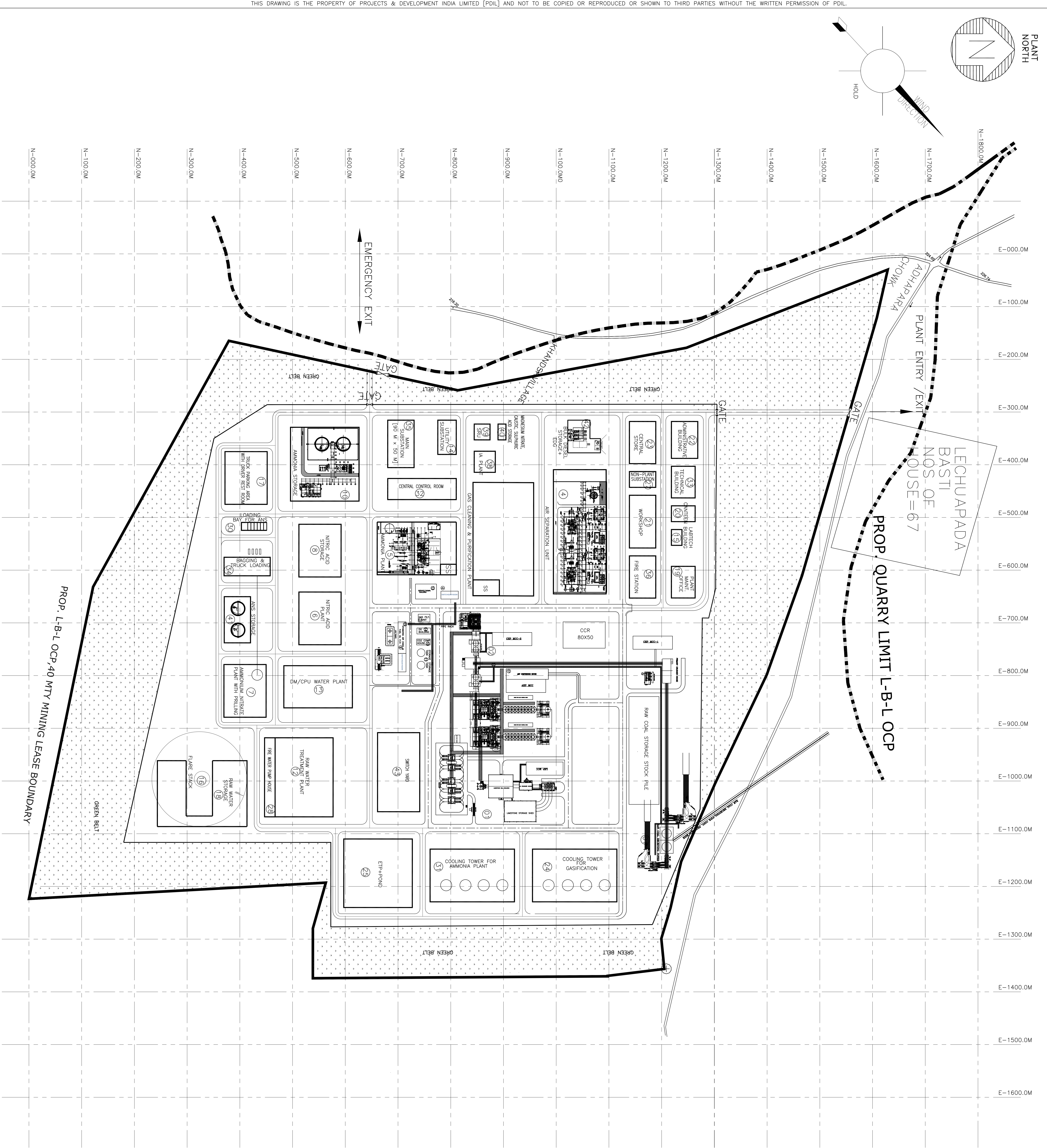


TABLE FOR FACILITIES/UNITS

S.NO.	BLOCK DESCRIPTION	SIZE IN METER	REMARKS
1.	COAL & LIME STORAGE PACKAGE	215 M X 115 M	
2.	GASIFICATION PLANT	250 M X 100 M	
3.	GAS CLEANING & PURIFICATION PLANT	150 M X 80 M	
4.	AIR SEPARATION UNIT	100 M X 80 M	
5.	AMMONIA PLANT	100 M X 80 M	
6.	NITRIC ACID PLANT	100 M X 80 M	
7.	AMMONIUM NITRATE PLANT WITH PERLING	100 M X 80 M	
8.	NITRIC ACID STORAGE	100 M X 80 M	
9.	DELETED	-	
10.	AMMONIA STORAGE PACKAGE	140 M X 130 M	
11.	STEAM GENERATION PLANT	150 M X 110 M	
12.	RAW WATER TREATMENT PLANT	130 M X 80 M	
13.	DM/CPU WATER PLANT	65 M X 35 M	
14.	UTILITY SUBSTATION	30 M X 20 M	
15.	LAB TECH BUILDING	R 90M	
16.	FLARE STACK	160 M X 120 M	
17.	TRUCK PARKING AREA WITH DRIVER REST ROOM	1600 SQ.M.	
18.	RAW WATER STORAGE	60 M X 45 M	
19.	PLANT MAINT. OFFICE	45 M X 30 M	
20.	CANTEEN	100 M X 50 M	
21.	WORKSHOP	70 M X 50 M	
22.	ADMINISTRATIVE BUILDING	80 M X 50 M	
23.	CENTRAL STORE	160 M X 100 M	
24.	COOLING TOWER FOR GASIFICATION AND UTILITY	130 M X 130 M	
25.	ETP-POND	-	
26.	DELETED	-	
27.	NON-TECH. SUBSTATION	50 M X 30 M	
28.	FIRE WATER STORAGE	170 M X 20 M	
29.	DELETED	-	
30.	LOADING BAY ANS (6 NOS.)	48 M X 15 M	
31.	COOLING TOWER FOR NH3, NITRIC ACID AND AN PLANT	160 M X 100 M	
32.	CENTRAL CONTROL ROOM	100 M X 50 M	
33.	TECHNICAL BUILDING	60 M X 45 M	
34.	AMP STORAGE, BAGGING & TRUCK LOADING	85 M X 35M	
35.	MAIN SUB-STATION	90 M X 50 M	
36.	FIRE STATION	80 M X 50 M	
37.	ASH SLO/UTILITY BUILDING	40 M X 40 M	
38.	IA PLANT	30 M X 30 M	
39.	SRU UNIT	30 M X 15 M	
40.	MAGNESIUM NITRATE CAUSTIC, SULPHURIC ACID STORAGE	85 M X 50 M	
41.	ANS STORAGE	-	
42.	BULK DIESEL STORAGE + EOG	-	
43.	SWITCHYARD	-	

- NOTES:-
1. ALL DIMENSIONS AND COORDINATES ARE IN METERS UNLESS OTHERWISE SPECIFIED.
  2. REFERENCE BENCH MARK (⊕) POINTS IS W.R.T GLOBAL CO-ORDINATES HAVING N-\*\*\*\* & E-\*\*\*\* (GRID COORDINATES N-000.0M, E-000.0M).
  3. BLOCK SIZE OF FACILITIES ARE TO BE FINALIZED AFTER GETTING VENDOR INFO.
  4. \* INDICATES HOLD.

LEGEND :-

PROPOSED FACILITIES  
GREEN BELT AREA

TOTAL PLANT AREA WITH GREEN BELT = 350.00 ACRE (APPROX.)  
PLANT AREA = 225.00 ACRE (APPROX.)  
GREENBELT AREA = 125.00 ACRE (APPROX.)

ISSUED FOR  
TENDER PURPOSE

REV	DATE	DESCRIPTION	BY	CHKD	APPD
P	15.03.24	PRELIMINARY ISSUE	AM	AS/NS	PK
REV	DATE	DESCRIPTION	BY	CHKD	APPD
REV	DATE	DESCRIPTION	BY	CHKD	APPD
REV	DATE	DESCRIPTION	BY	CHKD	APPD

LOCATION :  
MCL, LAKHANPUR AREA  
JHARSUGUDA, ODISHA  
TITLE :  
PRELIMINARY LAYOUT OF  
COAL BASED AMMONIUM NITRATE PLANT