NATIONAL THERMAL POWER CORPORATION LTD.

GADARWARA SUPER THERMAL POWER PROJECT

STAGE – II (2X800 MW)

TECHNICAL SPECIFICATION
FOR
COMPRESSED AIR SYSTEM

SPECIFICATION NO.: PE- TS- 395- 555- A001
Rev. 00

BHARAT HEAVY ELECTRICALS LTD

POWER SECTOR
PROJECT ENGINEERIING MANAGEMENT
NOIDA

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SECTION A

INTENT OF SPECIFICATION

1.0 SCOPE

This specification covers the design, manufacturing, inspection and testing at manufacturer's work, proper packing, delivery to site, supervision of erection and commissioning, final painting & carrying out acceptance tests at site of compressed air system as mentioned in the different section of this specification for 2X800 MW GADARWARA STPP.

2.0 GENERAL TECHNICAL INSTRUCTIONS

2.1 This volume covers requirements of design, engineering, manufacturing and delivery to site, supervision of erection and commissioning of the complete plant. It is not the intent to specify completely all details of design and construction. However, all the equipment shall conform, in all respect, to high standard of engineering, design and workmanship and be capable of performing the required duties in a manner acceptable to the owner who will interpret the meaning of drawings and specifications and shall be entitled to reject any work or material which in his judgement is not in full accordance herewith.

2.2 The bidder may offer optionally the standard design of equipment indicating the deviations from the specification. However, feedback reports must be furnished of equipment performance. The acceptance of optional equipment shall not be binding on Purchaser.

2.3 In case of conflict between the various clauses of specification, stringent of the conditions as per owner interpretation shall prevail.

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SECTION B

PROJECT INFORMATION

INTRODUCTION

1.00.00 BACKGROUND

Gadarwara Thermal Power Project (Gadarwara TPP) is being set up as a regional power project for the benefit of States/UTs of Western Region. This project is being set up in two stages. Each stage shall comprise of two units of 800 MW.

1.01.00 **Location and**

The site is located near villages Gangai & Umaraiya (about 9 Kms from Gadarwara town in Narsingpur district of Madhya Pradesh.The major cities Bhopal & Jabalpur are located at about 210 Kms & about 140 kms respectively from proposed project site. The nearest BG Railway Station, Gadarwara, on Jabalpur- Itarsi Section on central railway main Line is about 9 Kms from proposed project site.

The nearest commercial airport, Bhopal and Jabalpur are located about 240 Kms and about 155 Kms respectively from site. The plant latitude and longitude are 22° 51' 42" N and 78° 52' 08" respectively.

Vicinity plan of the proposed project is placed at **Annexure –A-I**

1.02.00 **Land**

About 1844 acres of land (Private Land- about 1480 acres nd Govt. Land- about 364 acres) has been envisaged for the project. In-principle land availability clearance has been obtained from Govt. of Madhya Pradesh vide letter dated 19.05.08.

1.03.00 **Water**

The make-up water requirement is estimated as 4680 Cubic Meter/Hr with ash circulation system and about 5980 Cubic Meter/Hr with once through ash water system. The source of water for the Project is Narmada River at a distance of about 30 Kms from the project site.

Govt. of Madhya Pradesh vide dated 19.05.08.has accorded water commitment from Narmada river for the project. CWC vide letter dated 27.07.12 have concurred water availability confirmation accorded by State Govt.

1.04.00 **Capacity**

2 x 800 MW - Present proposal

2 x 800 MW - In Future

1.05.00 **Meteorological data**

Important meteorological data from nearest observatory at Narsinghpur is placed at **Annexure-A-II.**

1.06.00 **Plant Water Scheme**

The Plant water scheme is described below.

1.06.01 **Condenser Cooling (CW) Water System**

It is proposed to provide recirculating type CW system with induced draft type cooling towers. For the recirculating type CW system it is proposed to supply clarified water as make up. Raw water from the make-up water pump house shall be pumped to a Water Pretreatment Plant (PT - CW system). The treated clarified water shall be led to the cold water channel of CW system. Designed Clarified Water Analysis is given in this subsection.CW system shall be operated at a C.O.C of about 4.0. Chemical treatment programme (using acid dosing and scale cum corrosion inhibitors dosing) may be employed in addition to blow down of CW water to control the CW system chemistry in case CW system is required to be operated beyond 4.0 COC. CW blow down shall be drawn from the discharge of CW pumps and the same shall be led to a Service water Tank. For carrying circulating water from CW pump house to TG-area and from TG area to cooling tower, steel lined concrete encased duct would be provided. For interconnecting CW duct with CW pump, condenser and cooling towers, steel pipes would be used. Cooled water from cooling tower will be led to CW pump house through the cold water channel by gravity.

1.06.02 **Equipment Cooling Water (ECW) System (Unit Auxiliaries)**

The plant auxiliaries of Steam Generator and Turbine Generator shall be cooled by Demineralised (DM) water in a closed circuit. The primary circuit DM water shall be cooled through plate type heat exchangers by Circulating Water tapped from CW system in a closed secondary circuit. The hot secondary circuit cooling water shall be cooled in the cooling towers and shall be returned back to the system. It is proposed to provide independent primary cooling water circuit for Steam Generator & auxiliaries and TG & its auxiliaries.

1.06.03 **Station Auxiliaries Cooling Water System**

The station auxiliaries such as Air compressors, Compressors of ash handling plant, Cooling water circuit of Air Conditioning system, compressor of mill reject system etc. shall be cooled by separate cooling water System using separate set of pumps and cooling towers.

1.06.04 **Ash Water System**

It is proposed to operate ash water system in a closed circuit. The ash water from the ash dyke shall be recirculated after treating a part of the quantity in a side stream lime softening plant as the case may be. Make up to the ash water system (to compensate for the ash water system blow down and evaporation loss in ash dyke) shall be supplied from excess CW blow down water (Service water) and raw water supply from water source of the plant. In addition, provision shall be kept to supply treated water from Central Monitoring Basin of Liquid Effluent Treatment Plant.

1.06.05 **Other Miscellaneous Water Systems**

a) CW system blow down water shall be used for the plant service water requirement, dust suppression system of coal handling plant, makeup to the Ventilation system, ash slurry pumps sealing, sealing of Vacuum pumps (if applicable) of Ash Handling plant, make-up to fire water storage tanks and cooling water requirement of hydrogen generation plant. The service (wash water) water collected from various areas shall be treated using oil water separators, tube settlers, coal settling pits etc. as per requirement and treated water from liquid effluent treatment plant shall be recycled back to the service water system for re-use. The excess service water shall be led to central monitoring basin for disposal.

b) Separate water Pre-treatment plants are proposed for Circulating Water (PT-CW) system, Demineralisation Plant (PT-DM) plant and potable (PT-Pot) water systems.

c) The drinking water requirement of the plant and colony shall be provided from the above mentioned Water (PT-Pot) pretreatment plant.

d) Steam Cycle make-up water, makeup to the primary circuit of ECW (unit auxiliaries) system, boiler fill water and makeup to the hydrogen generation plant shall be provided from Demineralising plant.

e) The quality of clarified water & DM water is given in this sub-section at **Annexure-A-III**.

1.07.00 **Criteria for Earthquake Resistant Design of Structures and Equipment**

All power plant structures and equipment, including plant auxiliary structures and equipment shall be designed as per the criteria specified in sub-section-D1 of Section-VI (Part-A).

In case the acceleration criteria considered by the Bidder for the design of anchorage bolts of Steam Turbine and Generator with TG Deck in his bid is different with respect to above criteria, he shall indicate the same in his bid. The same will be discussed with the Bidder and finalized considering the following:

a) The earthquake design acceleration for the steam turbine and generator acting at the centre of gravity depends upon the layout/configuration/size of TG deck supporting columns and beams which are to be jointly decided by NTPC and the bidder.

b) As the data regarding Foundation GA & loading data to be furnished by Bidder may not be available at tender stage, the acceleration criteria proposed by the bidder can not be confirmed for acceptance at the award stage. The same can be confirmed after jointly finalizing the TG substructure arrangement by NTPC and Bidder.

c) TG deck acceleration values will be limited to the design values adopted by Bidder by suitably increasing the size of the TG supporting columns/beams during detailed engineering.

Accordingly Bidder has to make equipment/piping layout clearing the TG column/beams.

1.08.00 **Criteria for Wind Resistant Design of Structures and Equipment**

All structures and equipment of the power plant, including plant auxiliary structures and equipment, shall be designed for wind forces as given as given in sub-section-D1 of Section-VI (Part-A).

EXHIBIT - 1

जलवायवी सारणी
CLIMATOLOGICAL TABLE

स्टेशन : नरसिंहपुर
STATION : Narsinghpur

अक्षांश LAT 22° 57' N देशांतर LONG 79° 11' E समुद्री तल सतह से ऊँचाई HEIGHT ABOVE M. S. L. 358 METRES

1962 से 1980 तक के आंकड़ों पर आधारित
BASED ON OBSERVATIONS FROM 1962 TO 1980

महीने MONTH		स्टेशन का स्तर दाब STATION LEVEL PRESSURE hPa	वायु तापमान AIR TEMPERATURE: औसत MEAN: शुष्क मान DRY BULB °C	औसत MEAN: आर्द्र मान WET BULB °C	औसत MEAN: दैनिक अधिकतम DAILY MAX °C	औसत MEAN: दैनिक न्यूनतम DAILY MIN °C	औसत MEAN: माह में उच्चतम HIGHEST IN THE MONTH °C	औसत MEAN: माह में निम्नतम LOWEST IN THE MONTH °C	चरम EXTREMES: उच्चतम HIGHEST °C	चरम EXTREMES: दिनांक और वर्ष DATE AND YEAR	चरम EXTREMES: निम्नतम LOWEST °C	चरम EXTREMES: दिनांक और वर्ष DATE AND YEAR	आर्द्रता HUMIDITY: सापेक्ष आर्द्रता RELATIVE HUMIDITY %	आर्द्रता HUMIDITY: वाष्प दाब VAPOUR PRESSURE hPa	मेघ CLOUD AMOUNT: समस्त मेघ ALL CLOUDS Eighths of sky	मेघ CLOUD AMOUNT: निम्न मेघ LOW CLOUDS Eighths of sky	वर्षा RAINFALL: मासिक योग MONTHLY TOTAL mm	वर्षा: वर्षा के दिनों की संख्या NO. OF RAINY DAYS	वर्षा: अधिकतम समस्त जल महीने का योग TOTAL IN WETTEST MONTH WITH YEAR mm	वर्षा: अधिकतम शुष्कतम महीने का योग TOTAL IN DRIEST MONTH WITH YEAR mm	वर्षा: 24 घंटों की सबसे भारी वर्षा HEAVIEST FALL IN 24 HOURS mm	वर्षा: दिनांक और वर्ष DATE AND YEAR	औसत पवन गति MEAN WIND SPEED Knots
जनवरी JAN	I	976.0	12.0	9.0	20.8	8.2	30.0	3.0	34.0	08 1973	1.2	23 1963	74	10.6	1.6	0.6	11.0	1.2	46.0 1970	0.0	27.8	05 1969	2.4
	II	972.4	24.8	16.6									40	12.3	1.3	0.4							
फरवरी FEB	I	974.2	15.7	12.2	30.3	11.1	34.6	4.9	37.8	25 1960	1.4	07 1974	64	11.3	1.4	0.7	17.3	1.2	106.4 1973	0.0	71.0	04 1973	3.0
	II	970.3	26.5	18.3									35	13.3	1.3	0.4							
मार्च MAR	I	972.1	21.7	15.5	35.3	15.6	40.0	9.9	42.8	31 1977	6.0	02 1971	50	12.8	1.3	0.5	12.1	1.1	38.8 1969	0.0	27.8	14 1968	3.3
	II	967.7	33.6	21.0									30	16.2	2.0	0.7							
अप्रैल APR	I	968.6	27.9	19.0	40.3	21.4	43.5	15.8	47.4	09 1960	10.0	03 1958	40	15.1	1.3	0.5	6.2	0.8	35.0 1963	0.0	24.4	06 1973	4.4
	II	964.1	38.3	23.1									25	16.0	2.5	0.9							
मई MAY	I	965.0	33.2	23.1	42.5	25.8	45.1	20.5	47.0	29 1973	17.0	13 1968	39	18.9	1.3	0.4	7.0	0.8	39.8 1976	0.0	13.4	25 1976	5.3
	II	960.5	40.3	24.4									24	17.7	2.8	1.0							
जून JUN	I	961.8	29.7	24.6	36.1	26.1	43.9	21.8	47.2	08 1970	18.0	09 1971	66	26.7	4.2	2.6	168.9	7.4	432.6 1977	24.2 1980	217.6	27 1977	8.0
	II	957.9	35.0	25.6									69	25.3	5.4	3.8							
जुलाई JUL	I	961.1	29.1	24.3	31.4	23.9	38.7	21.4	42.4	01 1963	18.8	12 1973	85	25.8	6.2	5.0	334.8	14.4	600.4 1966	123.7 1962	154.9	08 1970	5.8
	II	958.2	29.0	25.2									74	26.8	6.8	5.7							
अगस्त AUG	I	962.3	29.2	24.9	29.7	23.1	34.2	21.3	36.0	03 1972	17.0	10 1969	90	25.8	6.4	5.4	423.6	15.7	774.0 1972	181.0 1962	224.2	20 1972	6.0
	II	959.4	27.7	24.3									80	25.2	6.7	5.8							
सितम्बर SEP	I	966.3	25.5	23.4	31.8	22.5	35.1	20.0	36.8	18 1974	18.4	23 1972	84	27.3	3.8	2.8	160.8	8.4	318.7 1962	17.2 1979	133.4	05 1973	3.8
	II	962.8	29.4	24.3									88	28.1	5.0	3.8							
अक्टूबर OCT	I	971.7	23.1	19.8	33.5	17.8	36.1	12.8	38.4	07 1980	5.8	31 1968	70	20.0	1.3	0.8	23.5	1.4	188.5 1971	0.0	188.5	04 1977	2.2
	II	968.0	36.7	21.5									42	18.3	2.0	0.8							
नवम्बर NOV	I	975.0	17.4	14.3	30.7	12.4	33.9	7.8	37.6	25 1979	2.2	30 1970	70	14.1	1.3	0.7	14.3	0.8	125.2 1977	0.0	75.8	24 1977	2.2
	II	971.5	27.7	18.1									41	15.2	1.7	0.7							
दिसम्बर DEC	I	976.6	12.8	10.8	27.5	8.8	30.7	-3.8	33.0	01 1969	-1.4	28 1968	76	11.4	1.4	0.7	12.0	0.9	130.4 1967	0.0	62.0	11 1967	2.0
	II	973.1	24.8	17.1									43	13.0	1.8	0.8							
वार्षिक योग या माध्य ANNUAL TOTAL OR MEAN	I	969.2	22.4	18.3	33.2	18.1	45.4	2.5	47.4		-1.4		67	18.8	2.8	1.7	1195.3	53.9	1902.8 1977	646.2 1966	224.2		4.2
	II	965.5	30.8	21.8									48	19.3	3.3	2.0							
वर्षों की संख्या NUMBER OF YEARS	I	19	19	19	19	19	19	19	19		19		19	19	19	19	19	19	19	19	19		19
	II	19	19	19									19	19	19	19							

ANNEXURE-A-III

DESIGN CLARIFIED WATER ANALYSIS

Sl. No.	Constituent	as	mg per litre
1.	Calcium	$CaCO_3$	102
2.	Magnesium	$CaCO_3$	41
3.	Sodium	$CaCO_3$	35
4.	Potassium	$CaCO_3$	3
5.	Total Alkalinity	$CaCO_3$	113
6.	P-Alkalinity	$CaCO_3$	Nil
7.	Chloride	$CaCO_3$	43
8.	Sulphate	$CaCO_3$	25
9.	Silica (Reactive)	SiO_2	16
10.	Iron	Fe	0.3 mg/l
11.	pH Value	-	6.8 - 8.5
12.	Turbidity	NTU	10

Note- Clarified water shall be used as make up water for cooling water system.

ANNEXURE – A-III

ANALYSIS OF DM WATER TO BE USED FOR MAKE-UP WATER TO CONDENSER

Sl.No.	Characteristics	Value
1.	Silica (Max.)	0.01 ppm as Sio2
2.	Iron as Fe	Nil
3.	Total hardness	Nil
4.	pH value	6.8 -7.3
5.	Conductivity	Not more than 0.1micro mho/cm excluding the effects of free CO2

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SECTION C.1

SCOPE OF SUPPLY,TERMINAL POINTS AND EXCLUSIONS

1. SCOPE OF SUPPLY AND SERVICES:

The scope of work under this specification shall be as below.

Items not specifically mentioned but deemed necessary by the Tenderer for making the system completely reliable and efficient shall also be considered as if included.

1.1 Total lump sum firm prices for Equipment & Services as specified, comprising of design & engineering, manufacture, inspection & testing at manufacturer's works, painting at manufacturer's works, duly packed for transportation, delivery to site, unloading storage & handling at site, erection & commissioning, carrying out performance/acceptance tests at site & final painting of complete Compressed Air System consisting of following equipments:

1.1.1 Three (3) Nos. Instrument Air Compressors (Oil Free Screw / Centrifugal type) each of minimum 60 NM3/Min capacity at 8 Kg/sqcm (min) discharge pressure with electric motor drive, suction filter with silencer, inter cooler and after cooler with moisture separators, automatic drain traps, instruments, control system and other accessories.

1.1.2 Three (3) Nos. Air Drying Plants Heat of compression (HOC) Rotary type/Dual Tower Type of min. 60 NM3/min. capacity connected to above IA compressors with all instruments, control panels and other accessories as specified.

1.1.3 Four (4) Nos. Service Air Compressors (Oil Free Screw/Centrifugal type) each of minimum 60 NM3/Min capacity at 8 Kg/sqcm (min) discharge pressure with electric motor drive, suction filter with silencer, inter cooler and after cooler with moisture separators, automatic drain traps, instruments, control system and other accessories.

1.1.4 Nine (9) Nos. Air Receivers (Seven (7) nos adjacent to compressor house and two (2) nos in TG Hall B-C Bay) of minimum ten (10) Cu.M capacity each with instruments, relief valve, drain connection with automatic trap stations and other accessories as specified.

1.1.5 One (1) No Air Receiver of minimum two (2) Cu.M capacity near DM plant with instruments, relief valve, drain connection with automatic trap stations and other accessories as specified.

1.1.6 Three (3) Nos. Electronic Dew point meters.

1.1.6.1 Pipes for compressed air line & interconnecting airline shall be galvanized as per IS-4736 and shall conform to IS-1239 Part-1 Heavy Grade Size up to 150 NB and IS-3589 for sizes greater than 150 mm NB. Fittings for air piping shall be conforming to IS-1239 Part-II, cooling water piping will be M.S. conforming to IS: 1239 (Part-I) (Heavy Grade). Fittings for cooling water line ASTM A-234 Gr. WPB for sizing including 65 mm NB and above and ASTM A 105 or as compatible with IS 1239 for size up to 50 NB. including hanger/supports, auxiliary structural members etc. inclusive of all cu-tubing for control air piping, fittings, valves, Counter flanges, bolts, nuts, gaskets etc. at all piping terminals, base plates, support plates, anchor bolts, nuts, sleeves, inserts, lifting lugs, eye bolts etc and other accessories as required including drain piping - Lot .

1.1.7 All airline valves shall be ball valve type. Valves for airline shall be Cast Steel body above 50 NB and Forged Steel Body up to 50 NB with SS internals. Valve size 65 Nb and above with flanged end, valve size 50 Nb and below with screwed. For water service, cast iron valves with GM internals as per relevant IS/equivalent and other applicable standards above 50 mm size. Gunmetal valves as per IS-778/equivalent up to size 50mm– Lot

1.1.8 Field instruments as specified (with itemwise unit rates), all instruments necessary for performance testing of compressors as well as air drying plants.

1.1.9 Control and Instrumentation – Individual compressor control shall be through compressor mounted PLC / microprocessor based control panel. Each compressor shall be interfaced with DCS through gateway / convertor for start, stop, load and unload from common control room (CCR)

including giving input for developing software at DCS (by BHEL EDN) and hardware link for status monitoring, start/stop, load/unload from CCR.

1.1.10 Control cable from Compressor House to HT Switch Gear & Signal cable between Compressor House & DDCMIS (SG C&I) as specified else where in the technical specification - Lot

The Bidder shall also provide Vibration monitoring system for all compressors and their motors. The bidder to provide 4-20mA signal for each vibration monitoring instrument which will be hooked-up to DCS for necessary interlock and protection.

1.1.11 Maintenance tools and tackles, start up and commissioning spares, consumables, first fill of lubricants inclusive of packing – Lot

1.1.12 Any other item not included above or in specification but required for Compressed Air System.

1.1.13 The maximum velocity to be considered in compressed air shall be 15.0 m/s(under Average pr. & Temp. conditions).

1.1.14 Civil works:-Minor dressings of foundation blocks, equipment grouting, supply and fixing of supports etc. on walls, foundations; floor and trenches will be done by successful bidder.

1.1.15 Basis of design, all calculations, equipment selection criterion, layout drawings/schemes/G.A. drg and documents like data sheet/Technical particulars etc. are subject to Customer & BHEL approval during detail engineering stage.

1.1.15 All drawings and documents shall be computer based.

1.1.16 All commissioning spares & consumables for trouble free operation shall be provided.

1.1.17 Bidder to clearly note that the instruments, valves etc as shown in the P&I Diagram is the bare minimum and any additional instruments/valves required to complete the system in line with Technical Specification shall be supplied by the bidder without any commercial implication.

1.1.18 Quality Plans attached are indicating minimum requirements for inspection and testing. Bidder shall note that quality plan is subject to Customer & BHEL approval during detail engineering stage.

1.1.19 Compressed air plant supplier to furnish drawings/documents as per the drgs./documents distribution as per project requirement.

1.1.20 List of Makes is enclosed in the Technical Specification. Compressed air plant supplier to note that Makes of equipments/items shall be subject to BHEL & Customer approval during detail engineering stage.

1.1.21 Bidder to confirm that there is no deviation from the tech specification and furnish signed no deviation certificate enclosed as Annexure-I of the Technical Specification .

1.1.22 If any deviation is there then same to be indicated separately under the heading "**Schedule of Technical Deviation**" enclosed as per Annexure II of the Technical Specification alongwith Cost of Withdrawal. Incase nothing is mentioned under the column Cost of withdrawal then during bid evaluation no price implication will be admissible for withdrawal of deviations. Bidders shall also note that the deviation in any other form except above is not acceptable (i.e. in data sheet or other Annexure or elsewhere in the offer) and same shall not be considered for review/evaluation purpose/comments and it would be assumed that the system/material/equipment has been offered strictly in line with specifications/requirements.

2.0 TERMINAL POINTS :

2.1 Bidder will terminate compressed air piping at common IA header and common SA header downstream of air receiver with isolation valve as per enclosed tender drawing.

2.2 Cooling water supply pipeline connection will be provided by the purchaser outside the compressor house (at 5.0 m from compressor house building).The return hot water shall be terminated by the contractor at the same location. Further interconnection from these terminal points shall be in bidder's scope.

3.0 EXCLUSIONS :

3.1 MCC/Switchgear for power supply to Air Compressors and other drives and panels :

3.1.1 Civil works including construction of compressor house, foundation of all compressor, air dryer and air receiver, pipe / cable trenches.

3.1.2 Lighting and ventilation of compressor house.

3.1.3 Monorail hoists/Cranes as necessary for handling of equipment after erection.

3.1.4 Compressed Air Distribution Piping running from isolation valve of the IA & SA header after the air receivers outside the compressor house.

4.0 BIDDER TO NOTE THE FOLLOWING INFORMATION :

4.0.0 Bidders to indicate offered model in their offer and to submit backup document (e.g. performance test, etc.) matching FAD calculation along with the catalogue of the offered model to justify selection.

4.1.0 Compressor and air dryer shall be designed for cooling water (Station Aux. Cooling Water) with inlet temp of thermal 36 deg C with terminal pressure 6 kg/sqcm(g) and rise in temp shall be limited to 10 deg C and pressure drop across Compressed Air System within terminal point shall be limited to 10 mwc. Qty of cooling water shall be 560 cum/hr (minimum) considering working equipments only.

4.2.0 Design Inlet conditions for Compressor
a) Temp : 45.0 Deg C
b) Relative humidity : 75%
c) Altitude : 358.5 m above MSL

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SECTION C.1

SPECIFIC TECHNICAL REQUIREMENTS (MECHANICAL)

1.00.00 FUNCTION

The purpose of this system is the supply of Instrument / service air through the distribution system to the different areas of GADARWARA TPP (2x800 MW) Power Plant as indicated in this specification.

2.00.00 SYSTEM DESCRIPTION

2.01.01 Compressed air system includes the following: Three (3) no. (2W + 1S) Instrument air compressors and Four (4) no. Service air compressor (2W+2S), including drives, intercoolers, after coolers, step up gearbox, silencer and other accessories.

In addition, the service air compressor may be used for instrument air system connecting ADP with plant air compressor in case of instrument air compressor failure.

Two nos. of standby service air compressors will remain in operation as per requirement to cater the enhanced service air during **"start-up & flame stabilisation"** of boiler, where in LDO will be fired till 30% of BMCR. In addition to, instrument air compressor can also be utilised to cater the service air requirements for LDO Firing during **"start-up & flame stabilisation"** of boiler.

Refer P & I diagram attached for detailed arrangement.

2.01.02 Three (3) nos. (2W+1S) Heat of Compression type air-drying plants (Conventional Twin Tower type / single rotary drum type) suitable for connecting to individual instrument air compressor.

2.01.03 Intake air filters.

2.01.04 Ten (10) nos. air receivers, (i.e. one for each compressor near compressor house & 2 nos. unit air receiver of $10m^3$ capacity and 1 no. Air receiver of capacity $2M^3$ for DM Plant).

2.01.05 All interconnecting piping, valves, fittings, supports/hangers, control air tubing (complete with valves and fittings between air receiver, compressor and local panel for each compressor), cooling water piping & valves for safe and satisfactory operation of air compressors.

2.01.06 All instruments including the electronic on line dew point meter with suitable sampling connection.

2.01.07 The lifting capacity of EOT crane (Electrically operated, Pendent controlled, overhead travelling type) of compressor house shall be 125% of the weight of the heaviest part to be lifted during erection or operation or maintenance inside the compressor house. The minimum capacity shall be 8 Tonnes.

3.00.00 EQUIPMENT DESIGN CRITERIA

3.01.00 Equipment Description:

3.01.01 The minimum requirements of design and construction features of various components of Compressed air system (screw /Centrifugal type air compressor ,air dryer ,air receiver etc.) are described below.

3.01.02 The motor drives shall be as per relevant Electrical sub-section of this Technical Specification.

3.02.00 Screw Air Compressors

3.02.01 **CODES AND STANDARDS**

3.02.02 The design, manufacture, testing and performance of the various components of the Rotary Screw type Air Compressors shall comply with the requirements of one or more of the following codes, as applicable :

3.02.03 IS-5456 : Code of Practice for testing of positive displacement type air compressors and exhausters.

3.02.04 IS-10431 [part -1] : Measurement of Air Flow of Compressors and Exhausters.

3.02.05 ASME PTC-9 : Performance Test Codes for Displacement Compressors, Vacuum Pumps and Blowers.

3.02.06 IS-6206 : Guide for selection, installation and maintenance of Air compressor plants with operating pressure up to 10 bars.

3.02.07 IS-5727 : Glossary of terms relating to compressors and Exhausters

3.02.08 CAGI : Compressed Air & Gas Institute

3.02.09 Other International Standards like American/BS/DIN etc. equivalent or superior to above mentioned standards are acceptable. Where IS specification is not available, the equipment shall conform to one such International Standard, which shall be indicated in the proposal.

3.02.10 The materials of the various components shall conform to the applicable IS/BS/ASTM/DIN Standards.

3.02.11 In case of any contradiction with the aforesaid standards and the stipulations as per this Technical Specification and Technical Data Sheets, the stipulations of the Technical Specification and Technical Data Sheets shall prevail. In case of any contradiction between Technical Specification and Technical Data Sheet, stipulations of the later shall prevail.

3.03.00 PERFORMANCE REQUIREMENT

3.03.01 Air Compressors shall be designed for continuous operation with high efficiency to satisfy the performance requirement as specified by the bidder in the Technical Data Sheet.

3.03.02 The power rating of the driver shall be selected such that a minimum margin of 10% is available over the power required to deliver rated capacity against rated pressure at all the operating ambient specified in the data sheet. When the driver is not directly coupled to the compressor, due account should be made for losses in power transmission, in addition to the above margin. However, the power rating of the driver thus selected shall have sufficient margin to run the compressor under relief valve discharge condition considering that the compressor is operating at its rated capacity and discharge pressure corresponding to set pressure of relief valve.

3.03.03 As more than one compressor with drive is specified, satisfactory operation in parallel shall be ensured without any uneven load sharing, undue vibration, keeping noise level within permissible limits for a number of compressors working simultaneously in the same room.

3.03.04 The Contractor under this specification shall assume full responsibility in the operation of the compressor and the drive as a unit.

3.04.00 DESIGN AND CONSTRUCTION

3.04.01 The design shall be such as to ensure trouble free operation with least vibration and noise. Different parts of the compressor and accessories shall be arranged neatly in a compact manner. Due consideration shall be given for easy accessibility and maintenance of the compressors.

3.04.02 Unless inconsistent with this specification equipment from the standard range of manufacture of the bidder shall be preferred.

3.04.03 The compressor shall be oil free multistage, horizontal, water cooled, rotary screw type, heavy duty, rugged construction. Their speed shall be so selected as to result in low maintenance and trouble-free operation under specified conditions.

3.04.04 Compressor elements shall be completely removable as independent parts. Materials of construction shall be suitable for the service.

3.04.05 Rotors shall be supported on both sides by suitable antifriction type bearings. The rotors shall not touch each other so that there shall be no metal to metal contact between them. The rotors shall have profile that keeps leakage losses to a minimum to ensure high efficiency.

3.04.06 The rotor and shaft shall be of single piece construction, made of forged steel (AISI C1141 or equivalent). The stator (casing) shall be of Cast-Iron (IS-210 grade) Construction with integral jacket cooling. The rotors shall be dynamically balanced to reduce vibration.

3.04.07 The seal rings and retainers shall be of stainless steel construction and be free for radial self adjustment along the rotor shafts. The seals shall prevent air and oil leakage along the shaft. Air vented from second stage discharge end seals shall provide buffer air to the other seals to prevent migration of oil towards the compression chamber under all operating conditions.

3.04.08 Bearings shall be high precision antifriction type IS- 25 grade 84). The axial thrust load shall be minimized by dividing the axial load of compression on the main and auxiliary bearings through suitable balancing arrangement.

3.05.00 Lubrication system

3.05.01 The compressor package shall include a lubricant management system which shall lubricate the compressor rotors, bearings and seal and also cool the air.

3.05.02 A thermostatically controlled valve shall modulate lubricant around and through the cooler to maintain a constant oil temperature. Bidder shall be responsible for selecting proper oil temperature.

3.05.03 The lubricant pump shall be shaft driven. An auxiliary motor driven pump shall be provided if required by the manufacturer to supply pre-start and shut down system. All lube oil pumps shall be of rotary positive displacement type, having stainless steel rotors and steel casing. The pump discharge system will be protected by a relief valve.

3.05.04 All tapered roller – type antifriction bearing shall have a L10 rated life of at least 50,000 hours with continuous operation at rated conditions.

3.05.05 The lubrication system shall be designed to prevent oil leakage or discharge of oil mist to the compressed air chamber.

3.05.06 All instrumentation and accessories in the lubrication circuit, namely discharge pressure gauge, pressure switch, relief valve etc. shall be included in the scope of supply. Suitable time delay relay or equivalent device to bypass low oil pressure switch during start-up shall be provided.

3.06.00 Gear Box

Speed increasing gears between the motor and compressor stages shall consist of a common helical gear driving the pinion of each stage. Helical timing gears shall be mounted on the rotor shafts to maintain accurate relative rotor position. Gears shall have a rating of AGMA-12 or equivalent.

3.07.00 Centrifugal Air Compressors

3.07.01 **CODES AND STANDARDS**

3.07.02 The design, manufacture, testing and performance of air compressors and accessories shall comply with the requirements of one or more of the following codes as applicable:

IS-2825: Code for unfired pressure vessels.

IS-4503: Shell and Tube Type Heat Exchanger.

CAGI: Compressed air and gas institute

IS-5727: Glossary of terms relating to compressors and exhausters.

IS-1239 [Part-I & II]: Mild Steel tube and fittings.

IS-6206: Guide for selection, installation and maintenance of air compressor plants with operating pressure upto 10 bars.

ANSI-B16.5: Steel Pipes Flanges and Fittings.

IS-7938: Air Receivers for Compressed Air Installations.

BS-487: Fusion Welded Steel Air Receiver.

IS-10431 [Part-I]: Measurement of Air Flow of Compressors and Exhausters.

IS-4736: Hot dip zinc coating for steel tubes.

IS-11989: Specification for compressed air dryers.

IS-14875: Compressed air filters – evaluation parameters.

IS-11727: Measurement and evaluation of vibration severity in situ of large rotating machines with speed ranging from 10 to 200 rev/sec.

ASME-PTC-10: Code for testing of Air-Compressors.

3.07.03 International Standards like American/BS/DIN etc. equivalent or superior to above mentioned standards are acceptable. When IS specification is not available the equipment shall conform to one such International Standard, which shall be indicated in the proposal. All codes and standards used/ referred to shall be to their latest edition/ version as on the date of the acceptance of the tender.

3.07.04 Standard of TEMA.

3.07.05 All equipment as may be necessary shall conform to the provision of statutory and other regulations in force, such as Indian Explosive Act, Indian Factories Act, Indian Petroleum Act and also those of State Government.

3.07.06 All electrical equipment supplied shall comply with the latest revision of Indian Electricity

Rules and within the statutory requirement of the Government of India and State Government as regards safety, earthing and provision specified therein for installation and operation of electrical equipment.

3.07.07 The materials of the various components shall conform to those specified in the Data specification Sheet.

3.07.08 In case of any contradiction with the aforesaid standards and the stipulations as per this Technical Specification and Data Specification Sheets, the stipulations of this Technical Specification and Data Specification Sheets shall prevail. In case of any contradiction between technical specification and Data Specification Sheets, stipulations of data specification sheets shall prevail.

3.08.00 PERFORMANCE REQUIREMENT

3.08.01 Air Compressors shall be designed for continuous operation with high efficiency to satisfy the performance requirement as specified in the Data Specification Sheet.

3.08.02 The power rating of the driver shall be selected such that a minimum margin of **10%** is available over the power required to deliver rated capacity against rated pressure. When the driver is not directly coupled to the compressor, due account should be made for losses inpower transmission, in addition to the above margin. However, the power rating of the driver thus selected shall have sufficient margin to run the compressor under relief valve discharge condition considering that the compressor is operating at its rated capacity and discharge pressure corresponding to set pressure of relief valve.

3.08.02 As more than one compressor with drive is specified, satisfactory operation in parallel shall be ensured without any uneven load sharing, undue vibration, keeping noise level within permissible limits for a number of compressors working simultaneously in the same room.

3.08.03 The Contractor under this specification shall assume full responsibility in the operation of the compressor and the drive as a unit.

3.08.04 Compressor frame shall have minimum 10% extra capacity. Compressor shall have 25% minimum turndown capability (at 45 deg C & 75% RH). Compressor shall be provided with IGV at the suction flange.

3.09.00 DESIGN AND CONSTRUCTION

3.09.01 The design shall be such as to ensure trouble free operation with least vibration and noise. Different parts of the compressor and accessories shall be arranged neatly in a compact manner. Due consideration shall be given for easy accessibility and maintenance of the compressors.

3.09.02 Each compressor unit shall be complete with HT electric motor drive of suitable capacity. Driving motor shall have adequate margin over rated capacity of compressor not less than 10%.

3.09.03 Unless inconsistent with this specification equipment from the standard range of manufacture of the bidder shall be preferred.

3.09.04 Compressor components shall be interchangeable as far as possible.

3.09.05 Air Compressors shall be oil free centrifugal air compressors with non-contact air/oil seals, each capable of delivering continuously rated volume flows at rated delivery pressure.

3.09.06 Compressor elements shall be completely removable as independent parts. Materials of construction shall be suitable for the service.

3.09.07 Rotors shall be supported on both sides by suitable self aligning tilting pad bearings/ equivalent proven self aligning bearings. The rotors shall not touch each other so that there shall be no metal-to-metal contact between them. The rotors shall have profile that keeps leakage losses to a minimum to ensure high efficiency.

3.09.08 The rotor shaft shall be of single piece construction, made of Stainless Steel (or equivalent). The stator (casing) shall be of Cast-Iron Construction with integral jacket cooling. The rotors shall be dynamically balanced to reduce vibration.

3.09.09 Bearings shall be high precision self aligning tilting pad bearings/ equivalent proven self aligning bearings. The axial thrust load shall be minimized by dividing the axial load of compression on the main and auxiliary bearings through suitable balancing arrangement.

3.09.10 The gaskets shall be of asbestos free material.

3.10.00 Lubrication system

Suitable lubrication systems for bearings, gear box etc. for the compressors and other moving parts shall be provided. Lubrication system shall be complete with shaft driven main oil pump, Electric motor driven auxiliary oil pump, strainers, full flow oil coolers, full flow duplex type oil filters regenerative mist eliminator, level indicators, oil temperature control valve with regulating by pass, mixing valves, pressure transducers, air ejectors, oil reservoirs of suitable capacity, pipes, fittings and valves etc. Hand pump/oil pump priming system shall be provided to ensure that all parts are sufficiently lubricated before starting the compressors. Lubricating oil pipes shall be of stainless steel. The Tenderer for each Air ejector shall provide separate air drying unit. Lub. Oil pressure should be more than water pressure.

3.10.01 Each compressor shall be provided with Inlet Guide Vane (IGV) control for suction air volume control.

3.10.02 Each compressor shall be provided with coupling guard with fixing arrangement.

3.10.02 Proper and robust supporting arrangement shall be provided from foundation/ floor for overhang casing, oil coolers, air piping, cooling water piping, oil piping, etc.

3.10.03 Noise level must not exceed 90 dB (A) at a distance of 1 m from source.

3.10.04 Compressors shall be provided with adequate safety, protection control system including antisurge protection with bypass valve etc. and auto dual control (either; controlled for constant pressure or constant volume flow). The duty points shall be at least 15% away from the antisurge line.

3.10.05 The compressors with all accessories shall be designed and tested as per API 672.

3.11.00 Intercooler, After cooler& Oil Coolers(for Screw/Centrifugal)

3.11.01 Intercoolers, After coolers and Oil coolers shall be of water cooled & shell-and-tube type with water on the tube side. Intercoolers & after coolers shall be designed in accordance with Section VIII, Division 1 of ASME Code or equivalent.

3.11.02 Outlet temperature of air from intercooler shall be suitable to suit the equipment and outlet temperature of air from the compressor house outlet header shall be limited to 45 deg.C. However, the instruments or the pneumatic devices requires air temperature less than 45 deg.C., the same shall be achieved at the outlet header.

3.11.03 Coolers shall be provided with removable tube bundle design in accordance with design

code TEMA Class C and shall be constructed with removable shell cover.

3.11.04 The coolers shall be constructed and arranged to allow removal of tube bundles without dismantling piping or compressor components.

3.11.05 Oil Coolers shall be equipped with vent & drain connections on oil and water sides. Oil temperature control valve with manual override feature or bypass construction shall be provided to maintain constant temperature. Vent & drain connections for intercoolers and after coolers shall be provided.

3.11.06 Design pressure shall be 8 Kg/cm2 (g) based on shut-off head of cooling water pumps.

3.11.07 The coolers shall be designed for maximum heat load and atleast 10 percent design margin shall be provided in the number of tubes.

3.11.08 Adequately sized safety valves shall be provided for both intercoolers and after coolers.

3.11.09 Each intercooler and after cooler shall be provided with moisture separator units with suitable baffling. Moisture separator units shall be equipped with a level gauge glass with isolatingcock.

3.11.10 Electrically operated automatic drain trap stations with bypass and isolating valves shall be provided for moisture separators for automatically draining of condensed moisture. The drain trap may be of full bore ball valve operated by capacitance type level switch. Manual draining facility shall also be provided in the drain trap.

3.11.11 Cooler shells, channels and covers shall be of carbon steel (SA 285 Gr C or equivalent).Tube sheet shall be of Brass or SS and the tubes shall be of Admiralty brass or Aluminum brass or Copper or SS 304.

3.11.12 For the instrument air compressors offered with "Heat of compression" type air drying plants, the after coolers shall also be provided at downstream of Air Drying Plant.

3.12.00 Air Receivers

3.12.01 There shall one air receiver for each compressor near compressor house, one receiver for DM plant (2 M3) capacity and one Unit Instrument air receiver for each unit.

3.12.02 Capacity of each of the air receivers in the compressor house shall be of minimum 10 M3 (nominal). The capacity of the Unit air receivers shall be minimum 10 M3 (nominal) or to suit the emergency storage requirement if any for any of the Bidder's requirement whichever is higher.

3.12.03 Receivers (other than unit air receivers) shall be outdoor located and vertical cylindrical vessel with dished ends.

3.12.04 The design pressure and temperature shall be minimum 10 Kg/cm^2 (g) and 50 deg.C respectively. Receivers shall be designed in accordance with Section VIII, Division 1 of ASME Code or equivalent.

3.12.05 Air receivers are to be provided with gasketted inspection manhole of minimum 500 mm diameter with cover plate, lifting handle, davit cap etc. Opening shall not pierce any seam &shall be as far as possible away from any welded seam.

3.12.06 Receivers shall be of welded construction with minimum number of joints. Longitudinal seamin adjacent sections shall not be in same line. Welding shall be as per relevant codes. Filler material to have composition & structure as that of material welded. Welding electrodes to be approved by Employer. Electrodes to be dried before use.

3.12.07 Relief valves shall be provided to suit compressor capacity and set pressure of the same shall be atleast 10% above working pressure. The spring in relief valve shall not reset for any pressure more than 10% above or below the design set pressure.

3.12.08 Each receiver shall be provided with drain connection with electrically operated automatic drain trap arrangement with isolation and bypass valves.

3.12.09 The material of construction of shell, dished ends, flanges, etc of the air receivers shall be of Boiler quality carbon steel as per IS:2002 or equivalent.

3.13.00 INTAKE AIR FILTER AND SILENCER

3.13.01 Filters with multiple elements quick removal type for easy cleaning shall be provided at suction of each air compressor and also be of heavy-duty dry type.

3.13.02 The filters shall be complete with integral silencers. Separate silencers, if specified, shall be provided. The filtering elements shall be easily removable for cleaning.

3.13.03 The filters shall be designed for an efficiency of not less than 99% for particles 2 microns and larger.

3.13.04 If filter after receiver is specified in the data specification sheet, the same shall be provided to remove the bulk of moisture and other contaminants entrained in the air stream.

3.14.00 AIR DRYING PLANTS

3.14.01 One number Air drying plant shall be provided for each Instrument air compressor. Drying shall be by adsorption process through a desiccant medium.

3.14.02 Air Drying (ADP) Plant may be of "Open Through type (Blower reactivated)" OR "Heat of (HOC) Compression type".

3.14.03 Regeneration of desiccant shall be achieved by "open through" or "Heat of compression" method without any air purge loss.

3.14.04 Hot unsaturated compressed air shall be used for regeneration of exhausted desiccant in case of "Heat of compression type ADP" and air from blower shall be used for regeneration after heating by electrical heater in case of "Open through type ADP".

3.14.05 Each ADP shall be provided with two absorber towers each sized for design drying cycle of minimum 8 hours. After this period, the absorber tower which was under drying mode shall be put under regeneration/reactivation mode while the other tower will take over the drying duty. The change of drying mode to reactivation mode or vice-versa shall be automatic with provision for manual operation also. The change over from one mode to another shall be through automatic solenoid operated valves.

3.14.06 In "Open Through" type ADP, for regeneration of desiccant, atmospheric air shall be filtered, heated through an electric heater and passed through the desiccant before exhausted to atmosphere The reactivated desiccant shall be cooled through same atmospheric air without heater in operation.

In case of HOC type drier, the reactivation shall be achieved by the heat of the compressed air itself. The hot unsaturated compressed air from the outlet of last stage of compressor shall be passed through the absorber tower. The moist air shall be cooled in dehumidifier and passed through the second absorber for final drying.

The design reactivation cycle/period of the tower shall be less than 8 hours including cooling period for desiccant for both the types of ADP.

3.14.07 Each ADP shall be provided with 2 numbers of 100 percent capacity pre-filters and 2 numbers of 100 percent capacity after-filters at the upstream & downstream of towers. The filtering media shall be of ceramic candle type elements designed to withstand at least 50% of static pressure as differential pressure. The pre-filters shall be provided with automatic electrically operated drain trap arrangement with isolation and bypass valves.

3.14.08 The electric heaters (2x100% capacity for each ADP) shall be provided with thermostatic control for heater and relief valve for safety and shall be flanged type to facilitate easy replacement of element.

3.14.09 Each electric motor driven blower (2x100% capacity for each ADP) shall be provided with individual dry type filters at inlet.

3.14.10 The absorber tower shall be designed with sufficient cross sectional area resulting low air velocity and pressure drop. Minimum 20% of desiccant depth shall be provided as free board in absorber vessels. Absorber vessels to be provided with suitable number of inspection/sight windows of "Persplex" for observation of adsorbent condition. Desiccant filling and removal connections shall be provided for the absorber vessels.

3.14.11 The coolers/heat exchangers/ dehumidifiers of ADP shall be designed & constructed as per the requirements specified for “Intercoolers, After coolers & Oil coolers" above.

3.14.12 All pressure vessels such as pre-filters, after-filters, absorber vessels, heaters, heat exchangers/de-humidifiers / coolers etc associated with ADP shall be designed in accordance with Section VIII, Division 1, of ASME Code or equivalent. The pressure vessels shall be provided with air tight gasketted manholes/handholes and relief valves.

3.14.13 Quantity of desiccant to be calculated shall take into account residual moisture content at the end of regeneration cycle. Design calculation with curves shall be submitted for approval of Employer.

3.14.14 Adsorption capacity and density to be considered for silica gel shall not be more than 10% and 550 kg/M3 respectively. In case of activated alumina the same shall be 8% (max) and 900 kg/M3 (max.) respectively.

3.14.15 In case of Heat of compression type, absorbers shall be sized so that even when the compressor is operating at part load, complete regeneration shall be achieved within the cycle time and quality of air (dew point) shall be maintained throughout the design cycle period.

3.14.16 Complete ADP equipments shall preferably be mounted on a skid.

3.14.17 Required sample connections in piping be provided for sampling of air at desired locations.

3.14.18 Non-lubricated two way / three way / four way valves ball valves with pneumatic actuators be provided.

3.14.19 The material of Construction for various components of ADP shall be as follows:-

(a) Absorber vessel Carbon steel

(b) All internals of absorber vessels SS 304

(c) Cooler shells, channels and covers, Same as that in intercoolers/Cooler Tube sheet & tubes after coolers

(d) Blower casing Carbon steel

(e) Blower blades & shaft Stainless steel

(f) Relief valves Brass or SS

(g) Desiccant Silica gel or Activated Alumina

(h) Air piping Galvanized steel

(i) Valves in Air Line CI or Cast steel or Forged steel body with stainless steel trim

(j) Valves in water pipelines SS / Bronze / Gunmetal

3.14.20 HOC dryers of single rotating drum type design using packed dessicant with in-built regeneration and adsorption compartments are also acceptable in place of specified twin tower type dryers, if the design ensures specified performance guarantee. In case, the Contractor offers such a type, the same shall be of proven design and shall meet the conditions stipulated under "EQUIPMENT SOURCING CRITERIA FOR BOUGHT OUT ITEMS" in relevant sub-section of Part-B, of Technical Specification. The control & instrumentation requirements specified is applicable for such design also. Further for such design of HOC dryer, the contractor shall supply two sets of spare drum (with required bearings) assembly packed with desiccant and one set of spare drive assembly (for dryer) consisting of motor, gear boxes, drive shaft & couplings in addition to the applicable items specified under "Mandatory Spares" elsewhere in Technical Specification within the contract price.

4.00.00 INTERCONNECTING PIPING, FITTING AND VALVES

4.01.01 All interconnecting compressed air piping shall conform to IS: 1239 (Heavy Grade) or IS: 3589 Gr. 410 and galvanised as per IS: 4736.

4.01.02 Fittings for air piping shall be conforming to IS: 1239/IS: 1879 and Grade equivalent that of parent pipe Grade.

4.01.03 Compressed air piping from air compressor to after cooler and other lines handling hot air will be suitably insulated so as to restrict surface temperature to 60deg.C. The pipe joints will be screwed coupling type for sizes upto 50 NB and above 50 NB the same will be flanged.

4.01.04 All cooling water piping will be M.S. conforming to IS: 1239 (Part-I) (Heavy Grade).

4.01.05 Air pipe sizing shall be done by considering compressed air velocity not exceeding 15 m/s.

4.01.06 Water pipe sizing shall be done by considering water velocity in pipes 1.2-1.8 m/s for pipe sizes below 50 Nb, 1.8-2.4 m/s for pipe sizes 50 Nb to 150 Nb and 2.1-2.5 m/s for pipe sizes of 200 Nb and above.

4.02.00 **VALVES**

a) Compressed Air Services:

- All airline valves shall be ball valve type. Cast steel body with Stainless steel internals shall be provided for valve size 65 Nb and above with flanged end. Forged carbon steel body with Stainless steel internals shall be provided for valve size 50 Nb and below with screwed.

b) Water Service:

- Cast iron valves with GM internals as per IS-780/equivalent and other applicable standards above 50 mm size. Gunmetal valves as per IS-778/equivalent up to size 50mm.

c) Auto drain trap for each air receiver shall be provided.

5.00.00 CONTROL PHILOSPHY

5.01.00 GENERAL

5.01.01 The minimum requirements are specified herein and the same shall be elaborated by contractor. The Contractor shall include controls & instrumentation to facilitate safe, reliable and efficient operation for the system. The controls, protection, interlock and instrumentation system offered by the contractor shall be subjected to approval of the Employer during post award engineering stage.

5.01.02 Any of the compressor and Air drying Plant may be selectable for "shutdown", "working" or "standby" duty.

5.01.03 On tripping of working equipment, the standby equipment shall come into operation automatically in case of very low air pressure in the system.

5.01.04 All abnormal conditions used for tripping the compressor or any other equipment shall be provided with pre-trip audio-visual indication/annunciation in the control panel.

5.01.05 An electrically operated automatic valve shall be provided on cooling water supply line of each compressor & dryer (if applicable) which will automatically shut off the cooling water supply, in case any of the compressor/dryer is not running for more than set time duration. Suitable interlock shall also be provided for opening the valve before starting of any of the compressor.

5.01.06 The following indications shall be made available in the control panels for repeating the same in main plant Control System / Panels.

(a) Status of each compressor

(b) Instrument air pressure low/high

(c) Service air pressure low/high

(d) Dew point of instrument air

(e) Status of each ADP

5.01.07 Lube oil pressure and temperature in the oil circuit of compressor shall be automatically controlled.

5.01.08 Unless otherwise mentioned in the relevant electrical sub-section, automatic motor overload control system shall be included to permit continuous operation of compressors at minimum ambient air without exceeding the name plate rating of the motor.

5.02.00 Screw Compressors

5.02.01 Each compressor shall be in the control panel to operate either in Base duty (Auto Load-Unload) or Standby duty (Auto On-Off) mode.

5.02.02 In "Base duty" mode, whenever air supply from compressors exceeds the demand, control system shall operate the load-unload circuit at a predetermined set pressure, throttle the inlet valve and open the blow off valve. The compressor shall run in unloaded condition. When system pressure drops due to more demand, the load-unload circuit shall operate again to bring the compressor to 100% load after closing the blow -off valve.

5.02.03 In "Stand-by" mode the compressor shall automatically assist base load compressors during periods of peak air demand. When air pressure in the system reaches a pre-set lower limit, compressor shall be started in unloaded condition and the compressor shall be fully loaded.
When the pressure in the system rises to pre-set high value, the compressor shall be unloaded and shall run in idling mode for a specific period (set by a timer). The compressor may be loaded to full load in case of drop in system pressure or compressor may be stopped in case the system pressure does not drop and compressor continues to idle for more than apre-set time.

5.02.04 The control system shall provide warning to the operator that a hot-start condition exists forth motor driver and adequate cool-down period has not occurred after the motor was shutdown.

5.02.05 The alarms and shutdown scheme mentioned below are suggestive and shall be provided as per manufacturer's standard practice meeting the safe operational requirement of the equipment/system each compressor:-

(a) "Air temperature high" at inlet to last stage Alarm & trip

(b) "Low lube oil pressure" Alarm & trip

(c) "High Lube oil supply temperature" Alarm & trip

(d) "High oil filter differential pressure" Alarm

(e) "Low lube oil level in lube oil sump" Alarm
(f) "High inlet air filter differential pressure" Alarm & trip

(g) "Low cooling water flow to air compressor" Alarm

5.03.00 Centrifugal compressor

5.03.01 Each compressor shall be in the control panel to operate either in unload/modulate/energy optimization (Auto Dual Mode).

5.03.02 In "Base duty" mode, whenever air supply from compressors exceeds the demand, control system shall operate the load-unload circuit at a predetermined set pressure, throttle the inlet valve and open the blow off valve. The compressor shall run in unloaded condition. When system pressure drops due to more demand, the load-unload circuit shall operate again to bring the compressor to 100% load after closing the blow -off valve.

5.03.03 In "Stand-by" mode the compressor shall automatically assist base load compressors during periods of peak air demand. When air pressure in the system reaches a pre-set lower limit, compressor shall be started in unloaded condition and the compressor shall be fully loaded.
When the pressure in the system rises to pre-set high value, the compressor shall be unloaded and shall run in idling mode for a specific period (set by a timer). The compressor may be loaded to full load in case of drop in system pressure or compressor may be stopped in case the system pressure does not drop and compressor continues to idle for more than apre-set time.

5.03.04 The control system shall provide warning to the operator that a hot-start condition exists forthe motor driver and adequate cool-down period has not occurred after the motor was shutdown.

5.03.05 The alarms and shutdown scheme mentioned below are suggestive and shall be provided as per manufacturer's standard practice meeting the safe operational requirement of the equipment/system each compressor:-

(a) "Air temperature high" at inlet to last stage Alarm & trip

(b) "Low lube oil pressure" Alarm & trip

(c) "High Lube oil supply temperature" Alarm & trip

(d) "High oil filter differential pressure" Alarm

(e) "Low lube oil level in lube oil sump" Alarm

(f) "High inlet air filter differential pressure" Alarm & trip

(g) "Low cooling water flow to air compressor" Alarm

5.04.00 Air Drying Plant

5.04.01 Sequential operation of the absorber towers & air compressors shall be controlled automatically with a provision for manual take over.

5.04.02 Change over of tower from drying mode to regeneration mode shall happen automatically if the dew point is high at the outlet of ADP sensed by the dew point (using aluminum oxide probe) meter/sensor. Automatic operation during regeneration, starting and stopping of blowers, starting and stopping of heaters, etc shall be timer controlled. During the process, incase, operation is taken over manually from the panel through push button or selector switch, the sequential operation shall start with the manual initiation for each of the steps.

5.04.03 The control system shall provide the (as minimum) alarms, "High Reactivation air temperature", "Low Reactivation air temperature", "Low cooling water flow", "Low air pressure at the outlet of ADP" and "High dew point at the outlet of ADP". Adequate number of temperature elements etc. shall be provided for measurement and monitoring of the same.

5.04.04 For rotary drum type Air drying plant, control philosophy as per manufacture's standard and proven practice is also acceptable.

6.00.00 PAINTING

6.01.01 All the Equipments shall be protected against external corrosion by providing suitable painting.

6.01.02 The surfaces of stainless steel, Galvanized steel, Gunmetal, brass, bronze and non-metallic components shall not be applied with any painting.

6.01.03 The steel surface to be applied with painting shall be thoroughly cleaned before applying painting by brushing, shot blasting etc as per the agreed procedure.

7.00.00 LAYOUT CONSIDERATIONS

Air compressors will be located indoor in a separate compressor room .The air receivers will be located outdoors adjacent to the compressor room. Other receiver necessary maintenance access will be provided in the layout. Unit air receiver shall be located suitably in BC Bay of powerhouse area. Complete ADP equipment shall be preferably mounted on a skid and located indoor.

8.00.00 POWER SUPPLY ARRANGEMENT

The power supply (rated voltage, frequency, phase) of the equipments will be 3.3 KV, 415 V +/- 10%, 3ph, 50 Hz +3% to -5%.

9.00.00 REFERENCE DRAWINGS/DOCUMENTS

- P & I Diagram for IA and SA System within Compressor House, BHEL Drawing No.PE-DG-395-555-A501 Rev 00.
- Annexure-1, IA & SA compressor sizing calculation.

PAINTING SPECIFICATION TO BE FOLLOWED BY BIDDERS FOR COMPRESSED AIR SYSTEM

14.00.00	**SPECIFICATION FOR SURFACE PREPARATION & PAINTING**
14.01.00	Surface preparation methods and paint/primer materials shall be of the type specified herein. If the contractor desires to use any paint/primer materials other than that specified, specific approval shall be obtained by the contractor in writing from the employer for using the substitute material.
14.02.00	All paints shall be delivered to job site in manufacturers sealed containers. Each container shall be labelled by the manufacturer with the manuacturer's name, type of paint, batch number and colour.
14.03.00	Unless specified otherwise, paint shall not be applied to surfaces of insulation, surfaces of stainless steel/nickel/ copper/brass/ monel/ aluminum/ hastelloy/lead/ galvanized steel items, valve stem, pump rods, shafts, gauges, bearing and contact surfaces, lined or clad surfaces.
14.04.00	All pipelines shall be Colour coded for identification as per the NTPC Colour-coding scheme, which will be furnished to the contractor during detailed engineering..
14.05.00	**SURFACE PREPARATION**
14.05.01	All surfaces to be painted shall be thoroughly cleaned of oil, grease and other foreign matter. Surfaces shall be free of moisture and contamination from chemicals and solvents.
14.05.02	The following surface schemes are envisaged here. Depending upon requirement any one or a combination of these schemes may be used for surface preparation before application of primer.

SP1	Solvent cleaning
SP2	Application of rust converter (Ruskil or equivalent grade)
SP3	Power tool cleaning
SP4	Shot blasting (shot blasting shall be used as surface preparation method for hot worked pipes prior to application of primer)
SP4*	Shot blast cleaning/ abrasive blast cleaning to SA21/2 (near white metal) 35-50 microns
SP5	Phosphating
SP6	Emery sheet cleaning/Manual wire brush cleaning.

14.06.00 APPLICATION OF PRIMER/PAINT

14.06.01 The paint/primer manuacturer's instructions covering thinning, mixing, method of application, handling and drying time shall be strictly followed and considered as part of this specification. The Dry film thickness (DFT) of primer/paint shall be as specified herein.

14.06.02 Surfaces prepared as per the surface preparation scheme indicated herein shall be applied with primer paint within 6 hours after preparation of surfaces.

14.06.03 Where primer coat has been applied in the shop, the primer coat shall be carefully examined, cleaned and spot primed with one coat of the primer before applying intermediate and finish coats. When the primer coat has not been applied in the shop, primer coat shall be applied by brushing, rolling or spraying on the same day as the surface is prepared. Primer coat shall be applied prior to intermediate and finish coats.

14.06.04 Steel surfaces that will be concealed by building walls shall be primed and finish painted before the floor is erected. Tops of structural steel members that will be covered by grating shall be primed and finish painted before the grating is permanently secured.

14.06.05 Following are the Primer/painting schemes envisaged herein:

PS3	-	Zinc Chrome Primer (Alkyd base) by brush/Spray to IS104.
PS3*	-	Zinc Chrome primer (Alkyd base) by dip coat.
PS4	-	Synthetic Enamel (long oil alkyd) to IS2932.
PS5	-	Red oxide zinc phosphate to IS-12744.
PS9	-	Aluminum paint to IS 2339.
PS9*	-	Heat resistant Aluminum paint to IS-13183 Gr.-I (for temperature 400 ^{o}C - 600 ^{o}C) , IS-13183 Gr.-II (for temperature 200 ^{o}C - 400 ^{o}C) and IS-13183 Gr.-III (for temperature upto 200 ^{o}C)
PS13	-	Rust preventive fluid by spray, dip or brush.
PS14	-	weldable primer-Deoxaluminate or equivalent.
PS16	-	High Build Epoxy CDC mastic `15' .
PS17	-	Aliphatic Acrylic Polyurethane CDE134 ,%V=40.0(min.)
PS18	-	Epoxy based TiO2 pigmented coat
PS19	-	Epoxy based Zinc phosphate primer (92% zinc in dry film (min.), %VS=35.0(min.).
PS20	-	Epoxy based finish paint.

14.06.06 All weld edge preparation for site welding shall be applied with one coat of weldable primer.

14.06.07 For internal protection of pipes/tubes, VCI pellets shall be used at both ends after sponge testing and ends capped. VCI pellets shall not be used for SS components and composite assemblies.

14.07.00 Primer/Painting Schedule

Sl.No	Description		Surface Preparation	Primer Coat			Intermediate Coat			Finish Coats			Total Min. Painting DFT (Microns)	Colour Shade
				System	Coat	Min. DFT / coat (Microns)	System	Coat	Min. DFT/ Coat (Microns)	System	Coat	Min. DFT/ Coat (Microns)		
1.	All **insulated** Pipings, fittings/ components, Pipe clamps, Vessels/Tanks, Equipments etc.		SP3/SP4	PS 9*	1	20	-	-	-	PS9*	1	20	40	As per NTPC Colour shade/ coding scheme
2.	All uninsulated Piping, fittings/ components, Pipe clamps, Vessels/Tanks, Equipments etc.	Design temperature <60 ^{o}C	SP3/SP4	PS 5	2	25	-	-	-	PS 4	3 $	35 $	155 $	
		Design temperature 60 ^{o}C-200 ^{o}C	SP3/SP4	PS 9*	1	20				PS 9*	1	20	40	
		Design temperature > 200 ^{o}C	SP3/SP4	PS9*	1	20	-	-	-	PS9*	1	20	40	
3	Constant Load **Hanger** (CLH), Variable Load Hanger (VLH) and other supports		SP4*	PS19	1	40	-	-	-	PS17	1	30	70	
4.	**Valves**													

	Cast /Forged	Design temperature <60°C	SP1/SP2/ SP3	PS9	1	20				PS 9	1	20	40	
		Design temperature 60 °C-200 °C	SP1/SP2/ SP3	PS9*	1	20	-	-	-	PS9*	1	20	40	
		Design temperature > 200 °C	SP1/SP2/ SP3	PS9*	1	20				PS9*	1	20	40	
5.	All Structural Steel components	Outside TG building and in SG envelope	SP4*	Inorganic Ethyl Zinc Silicate	1	75	PS18	1	75	a))Epoxy coat b)Final coat of paint PS17	2 1	35 30	250	
		Within TG building	SP4*	-do-	1	35	PS18	1	35	a))Epoxy coat b)Final coat of paint PS17	2 1	25 30	150	
6.	Weld Edges		SP6 (Hand cleaning by wire brushing)	PS13 (Weldable primer)	1	25	-	-	-	-	-	-	-	

$ The first 2 finished coats (total min.DFT of 70 microns) shall be done at shop and the 3rd finish coat (min.DFT 35 Microns) shall be applied at site.

COMPRESSED AIR SYSTEM

1.00.00 **SYSTEM DESCRIPTION**

1.01.00 The compressed air system shall consist of Instrument Air compressors & their motor drives, Air Drying (ADPs) Plants, Service Air compressors & their motor drives, air receivers for each Air compressor, instrumentation and control, control panels, interconnecting compressed air piping in the compressor house, Instrument Air Piping network, service air piping network and Unit Instrument Air receivers (One for each unit).

1.02.00 The Air compressors & Drives, instruments, control panels and ADPs shall be located indoor inside the compressor house and the air receivers shall be located outside the compressor house. The compressor house shall be provided with an electrically (with pendent control for long travel, cross travel and lifting) operated, overhead travelling type (EOT) crane.

1.03.00 In addition to the air receivers mentioned above, Unit Air receivers for instrument air system shall be provided, one for each Unit of the main plant systems to cater to the requirements of Instrument air requirement of respective SG (Steam generator) & auxiliaries and TG (Turbine Generator) and its auxiliaries. The Unit Air receivers shall be located in "BC" bay of TG building area.

1.04.00 Further a dedicated air receiver shall be provided near Demineralising Plant to meet the instrument air requirement of Water Treatment plant if included in the scope of works in Part-A of technical specification, Section-VI.

1.05.00 Air from Instrument air compressors shall be dried in respective Air Drying Plants in compressor house and delivered to the Air receivers. From the Compressed air piping header at the downstream of Air receivers, one instrument air piping header for each unit of main plant and one for balance of plant shall be provided. Distribution of instrument air network shall be provided as per the tender drawing and as detailed out under "Terminal Points" in Part-A of technical Specification, Section-VI.

1.06.00 A separate service air header shall be tapped off from the pipe header at Service Air receiver outlet and distributed as per the tender drawing and as detailed out under "Terminal Points" in Part-A of technical Specification, Section-VI .

1.07.00 The compressors shall be arranged such that all the service air compressors shall be able to supply air at upstream of each ADP through an isolation and a non-return valve so that in the event of failure of instrument air compressor, instrument air is ensured continuously from service air compressor. The instrument air header piping & valves at ADP outlet in compressor house shall be provided such that all the instrument air compressors may be interconnected and the entire system can be used as a station facility.

2.00.00 **DESIGN CRITERIA / BASIS AND PERFORMANCE GUARANTEE**

2.01.00 All the equipments shall be designed for continuous duty and as well as for intermittent operation. Frequent start/stop of the system shall not result deterioration in performance nor damage to the equipment.

2.02.00 The compressors and Air Drying plants shall operate under the following ambient conditions.

(i)	Minimum temperature	10 deg.C
(ii)	Maximum temperature	50 deg. C

(iii) Design condition (temperature & Relative humidity) — 45 deg.C & 75% RH

(iv) Height above MSL (m) — Refer Chapter "Project Information"

2.03.00 The design ambient conditions for the motors shall be as mentioned in relevant Electrical sub-sections.

2.04.00 Selection of Capacity of Air Compressor

2.04.01 Instrument Air Compressor

a) Instrument air Compressor shall be designed to meet the Instrument air requirement of all the equipments/plant/systems to be supplied by the Contractor and as well as to meet instrument air requirement of Employer's systems /plant as follows:-

Sl. no.	Continuous Requirement	Quantity (in NM^3/min)
1.	For each Unit of Steam Generator & its auxiliaries (Continuous)	**A**
2.	For each Unit of Employer's TG & its auxiliaries (Continuous)	**B**
3.	For Employer's Water Treatment Plant (Continuous)	**C**
4.	For Station C&I System (Employer's)	**D**
5.	**Instrument air requirement for 1 unit (X)**	**= [2x(A+B)]+C+D NM^3/min Where B = 5 NM^3/min C = 1.5 NM^3/min D = Nil**
6.	**Total instrument air requirement for 2 units**	**= 2X**
7.	**Capacity of instrument air compressor**	**= 2X/N(*) Where N=Nos. of instrument Air Compressor (working) as specified**

Notes: While calculating the air requirement of Bidder's equipments/plant/systems, for continuous requirements of instrument air, no diversity factor shall be considered and they are to be assumed to be of “Simultaneous Requirements”. The intermittent requirement of instrument air, if any shall be converted into continuous requirement by considering frequency of such requirements or selecting an appropriate diversity factor and such diversity factor shall not be less than 0.4.

2.04.02 **Service Air Compressor**

a) Service air Compressor shall be designed to meet the Service air requirement of all the equipments/plant/systems to be supplied by the Contractor and as well as to meet service air requirement of Employer's systems /plant as follows:-

Sl. no.	Continuous Requirement		Quantity (in NM^3/min)
1.	For each Unit Steam Generator & its auxiliaries (Continuous)		**E**
2.	For each unit Employer's TG & its auxiliaries (Continuous)		**F**
3.	For Employer's Water Treatment Plant (Continuous)		**G**
4.	**Service air requirement for 1 unit (Y)**	**=**	**[2x(E+F)]+G NM^3/min Where F= 2.5 NM^3/min G = 1.5 NM^3/min**
5.	**Total service air requirement for 2 units**	**=**	**2Y**
6.	**Capacity of service air compressor**	**=**	**2Y/M(*) Where M=Nos. of service Air Compressor (working) as specified**

Note: (1) While calculating the air requirement of Bidder's equipments/plant/systems, for continuous requirement of service air, no diversity factor shall be considered and they are to be assumed to be of "Simultaneous Requirements". The intermittent requirement of service air if any shall be converted into continuous requirement by considering frequency of such requirements or selecting an appropriate diversity factor and such diversity factor shall not be less than 0.4. The Service air requirement of mill reject shall not be included while sizing the compressor capacity, as separate & dedicated compressors are to be provided for the same.

2.04.03 The compressor capacity & discharge pressure of instrument air system and service air system shall be identical.

2.05.00 The capacity of air drying plant shall be equal to the capacity of the individual air compressors. The Air drying plant, at its rated capacity, shall be designed to deliver continuously air at dew point of minus (-) 40 deg C at atmospheric pressure and the Quality of dry outlet air to conform to Instrument Society of American Standard S7.3 "Quality Standard for Instrument Air".

2.06.00 Discharge pressure available at the outlet of Air drying Plant shall be minimum 7.5 Kg/cm2 (g) or more as per the requirement of Contractor.

2.07.00 The discharge pressure of compressor shall be minimum 8 Kg/cm2(g).

2.08.00 The heat exchangers are to be designed considering maximum Cooling water temperature of 36 deg C. The cooling water quality shall be same as that of Cooling water for condensers of main plant TG unit.

2.09.00 The temperature rise of cooling water in the heat exchangers of the Compressed air system shall be limited to 5-10 deg C.

2.10.00	Noise level shall not exceed 90 dBA to a reference level of 0.0002 microbar when measured at a distance of 1.5 meter above the floor. Required acoustic enclosures may be provided to meet the above condition. The discharge blow-off silencer and intake silencers shall be designed to meet the above noise limitation level.
2.11.00	Parallel operation of compressors shall be possible without any undue vibration and noise.
2.12.00	The flow in compressed air piping shall be designed for the design capacity of each compressor and the flow in header and ring mains to be designed for the total capacity of working compressors.
2.13.00	The maximum velocity to be considered in compressed air and cooling water piping shall be as mentioned elsewhere in Subsection titled "Low Pressure Piping" in Part-B of this Technical Specification. .
2.14.00	The lifting capacity of EOT crane of Compressor house shall be 125 percent (%) of the weight of the heaviest part to be lifted during erection or operation or maintenance inside the compressor house. The minimum capacity shall be 8 Tones.
2.15.00	All hot vessels/pipelines/ valves shall be insulated to restrict the outside temperature within 60 deg.C or less with mineral wool (or equivalent), GI wire netting and aluminum cladding/cover.
3.00.00	**Equipment Description:**
3.01.00	The minimum requirements of design and construction features of various components of Compressed air system (screw /Centrifugal type air compressor ,air dryer ,air receiver ,etc.) are described below.
3.02.00	The motor drives shall be as per relevant Electrical sub-section of this Technical Specification.
4.00.00	**Screw Air Compressors**
4.01.00	**CODES AND STANDARDS**
4.01.00	The design, manufacture, testing and performance of the various components of the Rotary Screw type Air Compressors shall comply with the requirements of one or more of the following codes, as applicable :
4.01.01	IS-5456 : Code of Practice for testing of positive displacement type air compressors and exhausters.
4.01.02	IS-10431 [part -1] : Measurement of Air Flow of Compressors and Exhausters.
4.01.03	ASME PTC-9 : Performance Test Codes for Displacement Compressors, Vacuum Pumps and Blowers.
4.01.05	IS-6206 : Guide for selection, installation and maintenance of Air compressor plants with operating pressure up to 10 bars.
4.01.06	IS-5727 : Glossary of terms relating to compressors and Exhausters
4.01.07	CAGI : Compressed Air & Gas Institute

4.01.08	Other International Standards like American/BS/DIN etc. equivalent or superior to above mentioned standards are acceptable. Where IS specification is not available, the equipment shall conform to one such International Standard, which shall be indicated in the proposal.
4.01.09	The materials of the various components shall conform to the applicable IS/BS/ASTM/DIN Standards.
4.01.10	In case of any contradiction with the aforesaid standards and the stipulations as per this Technical Specification and Technical Data Sheets, the stipulations of the Technical Specification and Technical Data Sheets shall prevail. In case of any contradiction between Technical Specification and Technical Data Sheet, stipulations of the later shall prevail.
4.02.00	PERFORMANCE REQUIREMENT
4.02.01	Air Compressors shall be designed for continuous operation with high efficiency to satisfy the performance requirement as specified by the bidder in the Technical Data Sheet.
4.02.02	The power rating of the driver shall be selected such that a minimum margin of 10% is available over the power required to deliver rated capacity against rated pressure at all the operating ambient specified in the data sheet. When the driver is not directly coupled to the compressor, due account should be made for losses in power transmission, in addition to the above margin. However, the power rating of the driver thus selected shall have sufficient margin to run the compressor under relief valve discharge condition considering that the compressor is operating at its rated capacity and discharge pressure corresponding to set pressure of relief valve.
4.02.03	As more than one compressor with drive is specified, satisfactory operation in parallel shall be ensured without any uneven load sharing, undue vibration, keeping noise level within permissible limits for a number of compressors working simultaneously in the same room.
4.02.04	The Contractor under this specification shall assume full responsibility in the operation of the compressor and the drive as a unit.
4.03.00	**DESIGN AND CONSTRUCTION**
4.03.01	The design shall be such as to ensure trouble free operation with least vibration and noise. Different parts of the compressor and accessories shall be arranged neatly in a compact manner. Due consideration shall be given for easy accessibility and maintenance of the compressors.
4.03.02	Unless inconsistent with this specification equipment from the standard range of manufacture of the bidder shall be preferred.
4.03.03	The compressor shall be oil free multistage, horizontal, water cooled, rotary screw type, heavy duty, rugged construction. Their speed shall be so selected as to result in low maintenance and trouble-free operation under specified conditions.
4.03.04	Compressor elements shall be completely removable as independent parts. Materials of construction shall be suitable for the service.
4.03.05	Rotors shall be supported on both sides by suitable antifriction type bearings. The rotors shall not touch each other so that there shall be no metal to metal contact between them. The rotors shall have profile that keeps leakage losses to a minimum to ensure high efficiency.
4.03.06	The rotor and shaft shall be of single piece construction, made of forged steel (AISI C1141 or equivalent). The stator (casing) shall be of Cast-Iron (IS-210 grade) Construction with integral jacket cooling.

The rotors shall be dynamically balanced to reduce vibration.

4.03.07 The seal rings and retainers shall be of stainless steel construction and be free for radial self adjustment along the rotor shafts. The seals shall prevent air and oil leakage along the shaft. Air vented from second stage discharge end seals shall provide buffer air to the other seals to prevent migration of oil towards the compression chamber under all operating conditions.

4.03.08 Bearings shall be high precision antifriction type IS- 25 grade 84). The axial thrust load shall be minimized by dividing the axial load of compression on the main and auxiliary bearings through suitable balancing arrangement.

4.04.00 Lubrication system

4.04.01 The compressor package shall include a lubricant management system which shall lubricate the compressor rotors, bearings and seal and also cool the air.

4.04.02 A thermostatically controlled valve shall modulate lubricant around and through the cooler to maintain a constant oil temperature. Bidder shall be responsible for selecting proper oil temperature.

4.04.03 The lubricant pump shall be shaft driven. An auxiliary motor driven pump shall be provided if required by the manufacturer to supply pre-start and shut down system. All lube oil pumps shall be of rotary positive displacement type, having stainless steel rotors and steel casing. The pump discharge system will be protected by a relief valve.

4.04.04 All tapered roller – type antifriction bearing shall have a L10 rated life of at least 50,000 hours with continuous operation at rated conditions.

4.04.05 The lubrication system shall be designed to prevent oil leakage or discharge of oil mist to the compressed air chamber.

4.04.06 All instrumentation and accessories in the lubrication circuit, namely discharge pressure gauge, pressure switch, relief valve etc. shall be included in the scope of supply. Suitable time delay relay or equivalent device to bypass low oil pressure switch during start-up shall be provided.

4.05.00 Gear Box

4.05.01 Speed increasing gears between the motor and compressor stages shall consist of a common helical gear driving the pinion of each stage. Helical timing gears shall be mounted on the rotor shafts to maintain accurate relative rotor position. Gears shall have a rating of AGMA-12 or equivalent.

5.00.00 **Centrifugal Air Compressors**

5.01.00 **CODES AND STANDARDS**

5.01.01 The design, manufacture, testing and performance of air compressors and accessories shall comply with the requirements of one or more of the following codes as applicable:

IS-2825:	Code for unfired pressure vessels.
IS-4503:	Shell and Tube Type Heat Exchanger.
CAGI:	Compressed air and gas institute
IS-5727:	Glossary of terms relating to compressors and exhausters.
IS-1239 [Part-I & II]:	Mild Steel tube and fittings.

	IS-6206:	Guide for selection, installation and maintenance of air compressor plants with operating pressure upto 10 bars.
	ANSI-B16.5:	Steel Pipes Flanges and Fittings.
	IS-7938:	Air Receivers for Compressed Air Installations.
	BS-487:	Fusion Welded Steel Air Receiver.
	IS-10431 [Part-I]:	Measurement of Air Flow of Compressors and Exhausters.
	IS-4736:	Hot dip zinc coating for steel tubes.
	IS-11989:	Specification for compressed air dryers.
	IS-14875:	Compressed air filters – evaluation parameters.
	IS-11727:	Measurement and evaluation of vibration severity in situ of large rotating machines with speed ranging from 10 to 200 rev/sec.

ASME-PTC-10: Code for testing of Air-Compressors.

5.01.02 International Standards like American/BS/DIN etc. equivalent or superior to abovementioned standards are acceptable. When IS specification is not available the equipment shall conform to one such International Standard, which shall be indicated in the proposal. All codes and standards used/ referred to shall be to their latest edition/ version as on the date of the acceptance of the tender.

5.01.03 Standard of TEMA.

5.01.04 All equipment as may be necessary shall conform to the provision of statutory and other regulations in force, such as Indian Explosive Act, Indian Factories Act, Indian Petroleum Act and also those of State Government.

5.01.05 All electrical equipment supplied shall comply with the latest revision of Indian Electricity Rules and within the statutory requirement of the Government of India and State Government as regards safety, earthing and provision specified therein for installation and operation of electrical equipment.

5.01.06 The materials of the various components shall conform to those specified in the Data specification Sheet.

5.01.07 In case of any contradiction with the aforesaid standards and the stipulations as per this Technical Specification and Data Specification Sheets, the stipulations of this Technical Specification and Data Specification Sheets shall prevail. In case of any contradiction between technical specification and Data Specification Sheets, stipulations of data specification sheets shall prevail.

5.02.00 PERFORMANCE REQUIREMENT

5.02.01 Air Compressors shall be designed for continuous operation with high efficiency to satisfy the performance requirement as specified in the Data Specification Sheet.

5.02.02 The power rating of the driver shall be selected such that a minimum margin of **10%** is available over the power required to deliver rated capacity against rated pressure. When the driver is not directly coupled to the compressor, due account should be made for losses in

power transmission, in addition to the above margin. However, the power rating of the driver thus selected shall have sufficient margin to run the compressor under relief valve discharge condition considering that the compressor is operating at its rated capacity and discharge pressure corresponding to set pressure of relief valve.

5.02.03 As more than one compressor with drive is specified, satisfactory operation in parallel shall be ensured without any uneven load sharing, undue vibration, keeping noise level within permissible limits for a number of compressors working simultaneously in the same room.

5.02.04 The Contractor under this specification shall assume full responsibility in the operation of the compressor and the drive as a unit.

5.02.05 Compressor frame shall have minimum 10% extra capacity. Compressor shall have 25% minimum turndown capability (at 45 deg C & 75% RH). Compressor shall be provided with IGV at the suction flange.

5.03.00 DESIGN AND CONSTRUCTION

5.03.01 The design shall be such as to ensure trouble free operation with least vibration and noise. Different parts of the compressor and accessories shall be arranged neatly in a compact manner. Due consideration shall be given for easy accessibility and maintenance of the compressors.

5.03.02 Each compressor unit shall be complete with HT electric motor drive of suitable capacity. Driving motor shall have adequate margin over rated capacity of compressor not less than 10%.

5.03.03 Unless inconsistent with this specification equipment from the standard range of manufacture of the bidder shall be preferred.

5.03.04 Compressor components shall be interchangeable as far as possible.

5.03.05 Air Compressors shall be oil free centrifugal air compressors with non-contact air/oil seals, each capable of delivering continuously rated volume flows at rated delivery pressure.

5.03.06 Compressor elements shall be completely removable as independent parts. Materials of construction shall be suitable for the service.

5.03.07 Rotors shall be supported on both sides by suitable self aligning tilting pad bearings/ equivalent proven self aligning bearings. The rotors shall not touch each other so that there shall be no metal-to-metal contact between them. The rotors shall have profile that keeps leakage losses to a minimum to ensure high efficiency.

5.03.08 The rotor shaft shall be of single piece construction, made of Stainless Steel (or equivalent). The stator (casing) shall be of Cast-Iron Construction with integral jacket cooling. The rotors shall be dynamically balanced to reduce vibration.

5.03.09 Bearings shall be high precision self aligning tilting pad bearings/ equivalent proven self aligning bearings. The axial thrust load shall be minimized by dividing the axial load of compression on the main and auxiliary bearings through suitable balancing arrangement.

5.03.10 The gaskets shall be of asbestos free material.

5.04.00 Lubrication system

Suitable lubrication systems for bearings, gear box etc. for the compressors and other moving parts shall be provided. Lubrication system shall be complete with shaft driven main

	oil pump, Electric motor driven auxiliary oil pump, strainers, full flow oil coolers, full flow duplex type oil filters regenerative mist eliminator, level indicators, oil temperature control valve with regulating by pass, mixing valves, pressure transducers, air ejectors, oil reservoirs of suitable capacity, pipes, fittings and valves etc. Hand pump/oil pump priming system shall be provided to ensure that all parts are sufficiently lubricated before starting the compressors. Lubricating oil pipes shall be of stainless steel. The Tenderer for each Air ejector shall provide separate air drying unit. Lub. Oil pressure should be more than water pressure.
5.05.00	Each compressor shall be provided with Inlet Guide Vane (IGV) control for suction air volume control.
5.06.00	Each compressor shall be provided with coupling guard with fixing arrangement.
5.07.00	Proper and robust supporting arrangement shall be provided from foundation/ floor for overhang casing, oil coolers, air piping, cooling water piping, oil piping, etc.
5.08.00	Noise level must not exceed 90 dB (A) at a distance of 1 m from source.
5.09.00	Compressors shall be provided with adequate safety, protection control system including anti surge protection with bypass valve etc. and auto dual control (either; controlled for constant pressure or constant volume flow). The duty points shall be at least 15% away from the anti surge line.
5.10.00	The compressors with all accessories shall be designed and tested as per API 672.
6.00.00	**Intercooler, Aftercooler & Oil Coolers(for Screw/Centrifugal)**
6.01.00	Intercoolers, After coolers and Oil coolers shall be of water cooled & shell-and-tube type with water on the tube side. Intercoolers & after coolers shall be designed in accordance with Section VIII, Division 1 of ASME Code or equivalent.
6.02.00	Outlet temperature of air from intercooler shall be suitable to suit the equipment and outlet temperature of air from the compressor house outlet header shall be limited to 45 deg.C. However, the instruments or the pneumatic devices requires air temperature less than 45 deg.C., the same shall be achieved at the outlet header.
6.03.00	Coolers shall be provided with removable tube bundle design in accordance with design code TEMA Class C and shall be constructed with removable shell cover.
6.04.00	The coolers shall be constructed and arranged to allow removal of tube bundles without dismantling piping or compressor components.
6.05.00	Oil Coolers shall be equipped with vent & drain connections on oil and water sides. Oil temperature control valve with manual override feature or bypass construction shall be provided to maintain constant temperature. Vent & drain connections for intercoolers and aftercoolers shall be provided.
6.06.00	Design pressure shall be 8 Kg/cm2 (g) based on shut-off head of cooling water pumps.
6.07.00	The coolers shall be designed for maximum heat load and atleast 10 percent design margin shall be provided in the number of tubes.
6.08.00	Adequately sized safety valves shall be provided for both intercoolers and after coolers.

6.09.00	Each intercooler and aftercooler shall be provided with moisture separator units with suitable baffling. Moisture separator units shall be equipped with a level gauge glass with isolating cock.
6.10.00	Electrically operated automatic drain trap stations with bypass and isolating valves shall be provided for moisture separators for automatically draining of condensed moisture. The drain trap may be of full bore ball valve operated by capacitance type level switch. Manual draining facility shall also be provided in the drain trap.
6.11.00	Cooler shells, channels and covers shall be of carbon steel (SA 285 Gr C or equivalent).Tube sheet shall be of Brass or SS and the tubes shall be of Admiralty brass or Aluminium brass or Copper or SS 304.
6.12.00	For the instrument air compressors offered with "Heat of compression" type air drying plants, the after coolers shall also be provided at downstream of Air Drying Plant.
7.00.00	**Air Receivers**
7.01.00	There shall one air receiver for each compressor near compressor house, one receiver for DM plant (2 M^3) capacity and one Unit Instrument air receiver for each unit.
7.02.00	Capacity of each of the air receivers in the compressor house shall be of minimum 10 M^3 (nominal). The capacity of the Unit air receivers shall be minimum 10 M3 (nominal) or to suit the emergency storage requirement if any for any of the Bidder's requirement whichever is higher.
7.03.00	Receivers (other than unit air receivers) shall be outdoor located and vertical cylindrical vessel with dished ends.
7.04.00	The design pressure and temperature shall be minimum 10 Kg/cm^2 (g) and 50 deg.C respectively. Receivers shall be designed in accordance with Section VIII, Division 1 of ASME Code or equivalent.
7.05.00	Air receivers are to be provided with gasketted inspection manhole of minimum 500 mm diameter with cover plate, lifting handle, davit cap etc. Opening shall not pierce any seam & shall be as far as possible away from any welded seam.
7.06.00	Receivers shall be of welded construction with minimum number of joints. Longitudinal seam in adjacent sections shall not be in same line. Welding shall be as per relevant codes. Filler material to have composition & structure as that of material welded. Welding electrodes to be approved by Employer. Electrodes to be dried before use.
7.07.00	Relief valves shall be provided to suit compressor capacity and set pressure of the same shall be atleast 10% above working pressure. The spring in relief valve shall not reset for any pressure more than 10% above or below the design set pressure.
7.08.00	Each receiver shall be provided with drain connection with electrically operated automatic drain trap arrangement with isolation and bypass valves.
7.09.00	The material of construction of shell, dished ends, flanges, etc of the air receivers shall be of carbon steel as per IS:2062 or equivalent.
8.00.00	**INTAKE AIR FILTER AND SILENCER**
8.01.00	Filters with multiple elements quick removal type for easy cleaning shall be provided at suction of each air compressor and also be of heavy-duty dry type.

8.02.00	The filters shall be complete with integral silencers. Separate silencers, if specified, shall be provided. The filtering elements shall be easily removable for cleaning.
8.03.00	The filters shall be designed for an efficiency of not less than 99% for particles 2 microns and larger.
8.04.00	If filter after receiver is specified in the data specification sheet, the same shall be provided to remove the bulk of moisture and other contaminants entrained in the air stream.
9.00.00	**AIR DRYING PLANTS**
9.01.00	One number Air drying plant shall be provided for each Instrument air compressor. Drying shall be by adsorption process through a desiccant medium.
9.02.00	Air Drying (ADP) Plant may be of "Open Through type (Blower reactivated)" OR "Heat of (HOC) Compression type".
9.03.00	Regeneration of desiccant shall be achieved by "open through" or "Heat of compression" method without any air purge loss.
9.04.00	Hot unsaturated compressed air shall be used for regeneration of exhausted desiccant in case of "Heat of compression type ADP" and air from blower shall be used for regeneration after heating by electrical heater in case of "Open through type ADP".
9.05.00	Each ADP shall be provided with two adsorber towers each sized for design drying cycle of minimum 8 hours. After this period, the adsorber tower which was under drying mode shall be put under regeneration/reactivation mode while the other tower will take over the drying duty. The change of drying mode to reactivation mode or vice-versa shall be automatic with provision for manual operation also. The change over from one mode to another shall be through automatic solenoid operated valves.
9.06.00	In "Open Through" type ADP, for regeneration of desiccant, atmospheric air shall be filtered, heated through an electric heater and passed through the desiccant before exhausted to atmosphere The reactivated desiccant shall be cooled through same atmospheric air without heater in operation. In case of HOC type drier, the reactivation shall be achieved by the heat of the compressed air itself. The hot unsaturated compressed air from the outlet of last stage of compressor shall be passed through the adsorber tower. The moist air shall be cooled in dehumidifier and passed through the second adsorber for final drying. The design reactivation cycle/period of the tower shall be less than 8 hours including cooling period for desiccant for both the types of ADP.
9.07.00	Each ADP shall be provided with 2 numbers of 100 percent capacity pre-filters and 2 numbers of 100 percent capacity after-filters at the upstream & downstream of towers. The filtering media shall be of ceramic candle type elements designed to withstand atleast 50% of static pressure as differential pressure. The pre-filters shall be provided with automatic electrically operated drain trap arrangement with isolation and bypass valves.
9.08.00	The electric heaters (2x100% capacity for each ADP) shall be provided with thermostatic control for heater and relief valve for safety and shall be flanged type to facilitate easy replacement of element.
9.09.00	Each electric motor driven blower (2x100% capacity for each ADP) shall be provided with individual dry type filters at inlet.

9.10.00 The adsorber tower shall be designed with sufficient cross sectional area resulting low air velocity and pressure drop. Minimum 20% of desiccant depth shall be provided as free board in adsorber vessels. Adsorber vessels to be provided with suitable number of inspection/sight windows of "Persplex" for observation of adsorbent condition. Desiccant filling and removal connections shall be provided for the adsorber vessels.

9.11.00 The coolers/heat exchangers/ dehumidifiers of ADP shall be designed & constructed as per the requirements specified for “Intercoolers, After coolers & Oil coolers" above.

9.12.00 All pressure vessels such as pre-filters, after-filters, adsorber vessels, heaters, heat exchangers/de-humidifiers / coolers etc associated with ADP shall be designed in accordance with Section VIII, Division 1, of ASME Code or equivalent. The pressure vessels shall be provided with air tight gasketted manholes/handholes and relief valves.

9.13.00 Quantity of desiccant to be calculated shall take into account residual moisture content at the end of regeneration cycle. Design calculation with curves shall be submitted for approval of Employer.

9.14.00 Adsorption capacity and density to be considered for silica gel shall not be more than 10% and 550 kg/M3 respectively. In case of activated alumina the same shall be 8% (max) and 900 kg/M3 (max.) respectively.

9.15.00 In case of Heat of compression type, adsorbers shall be sized so that even when the compressor is operating at part load, complete regeneration shall be achieved within the cycle time and quality of air (dew point) shall be maintained throughout the design cycle period.

9.16.00 Complete ADP equipments shall preferably be mounted on a skid.

9.17.00 Required sample connections in piping be provided for sampling of air at desired locations.

9.18.00 Non-lubricated two way / three way / four way valves ball valves with pneumatic actuators be provided.

9.19.00 The material of Construction for various components of ADP shall be as follows:-

(a)	Adsorber vessel	Carbon steel
(b)	All internals of adsorber vessels	SS 304
(c)	Cooler shells, channels and covers, Cooler Tube sheet & tubes	Same as that in intercoolers/ after coolers
(d)	Blower casing	Carbon steel
(e)	Blower blades & shaft	Stainless steel
(f)	Relief valves	Brass or SS
(g)	Desiccant	Silica gel or Activated Alumina
(h)	Air piping	Galvanized steel
(i)	Valves in Air Line	CI or Cast steel or Forged steel body with stainless steel trim

(j) Valves in water pipelines SS / Bronze / Gunmetal

9.20.00 HOC dryers of single rotating drum type design using packed dessicant with in-built regeneration and adsorption compartments are also acceptable in place of specified twin-tower type dryers, if the design ensures specified performance guarantee. In case, the Contractor offers such a type, the same shall be of proven design and shall meet the conditions stipulated under "EQUIPMENT SOURCING CRITERIA FOR BOUGHT OUT ITEMS" in relevant sub-section of Part-B, of Technical Specification. The control & instrumentation requirements specified is applicable for such design also. Further for such design of HOC dryer, the contractor shall supply two sets of spare drum (with required bearings) assembly packed with desiccant and one set of spare drive assembly (for dryer) consisting of motor, gear boxes, drive shaft & couplings in addition to the applicable items specified under "Mandatory Spares" elsewhere in Technical Specification within the contract price.

10.00.00 INTERCONNECTING PIPING, FITTING AND VALVES

The interconnecting piping & valves within compressor house for compressed air & cooling water etc shall be designed in line with the specification furnished in subsection titled "Low Pressure Piping" of Part-B of this Technical Specification.

11.00.00 E.O.T. CRANE

11.01.00 The crane shall be of electrically operated, pendant controlled, overhead travelling type. The Span and runway length shall suit the compressor house building.

11.02.00 The design and construction features of crane shall be as described Annexure-I of this sub-section.

12.00.00 CONTROL PHILOSPHY

12.01.00 GENERAL

12.01.01 The minimum requirements are specified herein and the same shall be elaborated by contractor. The Contractor shall include controls & instrumentation to facilitate safe, reliable and efficient operation for the system. The controls, protection, interlock and instrumentation system offered by the contractor shall be subjected to approval of the Employer during post award engineering stage.

12.01.02 Any of the compressor and Air drying Plant may be selectable for "shutdown", "working" or "standby" duty.

12.01.03 On tripping of working equipment, the standby equipment shall come into operation automatically in case of very low air pressure in the system.

12.01.04 All abnormal conditions used for tripping the compressor or any other equipment shall be provided with pre-trip audio-visual indication/annunciation in the control panel.

12.01.05 An electrically operated automatic valve shall be provided on cooling water supply line of each compressor & dryer (if applicable) which will automatically shut off the cooling water supply, in case any of the compressor/dryer is not running for more than set time duration. Suitable interlock shall also be provided for opening the valve before starting of any of the compressor.

12.01.06 The following indications shall be made available in the control panels for repeating the same in main plant Control System / Panels.

(a) Status of each compressor

(b) Instrument air pressure low/high

(c) Service air pressure low/high

(d) Dew point of instrument air

(e) Status of each ADP

12.01.07 Lube oil pressure and temperature in the oil circuit of compressor shall be automatically controlled.

12.01.08 Unless otherwise mentioned in the relevant electrical sub-section, automatic motor overload control system shall be included to permit continuous operation of compressors at minimum ambient air without exceeding the name plate rating of the motor.

12.02.00 **Screw Compressors**

12.02.01 Each compressor shall be in the control panel to operate either in Base duty (Auto Load-Unload) or Standby duty (Auto On-Off) mode.

12.02.02 In "Base duty" mode, whenever air supply from compressors exceeds the demand, control system shall operate the load-unload circuit at a predetermined set pressure, throttle the inlet valve and open the blow off valve. The compressor shall run in unloaded condition. When system pressure drops due to more demand, the load-unload circuit shall operate again to bring the compressor to 100% load after closing the blow -off valve.

12.02.03 In "Stand-by" mode the compressor shall automatically assist base load compressors during periods of peak air demand. When air pressure in the system reaches a pre-set lower limit, compressor shall be started in unloaded condition and the compressor shall be fully loaded. When the pressure in the system rises to pre-set high value, the compressor shall be unloaded and shall run in idling mode for a specific period (set by a timer). The compressor may be loaded to full load in case of drop in system pressure or compressor may be stopped in case the system pressure does not drop and compressor continues to idle for more than a pre-set time.

12.02.04 The control system shall provide warning to the operator that a hot-start condition exists for the motor driver and adequate cool-down period has not occurred after the motor was shut down.

12.02.05 The alarms and shutdown scheme mentioned below are suggestive and shall be provided as per manufacturer's standard practice meeting the safe operational requirement of the equipment/system each compressor:-

(a)	"Air temperature high" at inlet to last stage	Alarm & trip
(b)	"Low lube oil pressure"	Alarm & trip
(c)	"High Lube oil supply temperature"	Alarm & trip
(d)	"High oil filter differential pressure"	Alarm
(e)	"Low lube oil level in lube oil sump"	Alarm

	(f)	"High inlet air filter differential pressure"	Alarm & trip
	(g)	"Low cooling water flow to air compressor"	Alarm

12.03.00 **Centrifugal compressor**

12.03.01 Each compressor shall be in the control panel to operate either in unload/modulate/energy optimization (Auto Dual Mode).

12.03.02 In "Base duty" mode, whenever air supply from compressors exceeds the demand, control system shall operate the load-unload circuit at a predetermined set pressure, throttle the inlet valve and open the blow off valve. The compressor shall run in unloaded condition. When system pressure drops due to more demand, the load-unload circuit shall operate again to bring the compressor to 100% load after closing the blow -off valve.

12.03.03 In "Stand-by" mode the compressor shall automatically assist base load compressors during periods of peak air demand. When air pressure in the system reaches a pre-set lower limit, compressor shall be started in unloaded condition and the compressor shall be fully loaded. When the pressure in the system rises to pre-set high value, the compressor shall be unloaded and shall run in idling mode for a specific period (set by a timer). The compressor may be loaded to full load in case of drop in system pressure or compressor may be stopped in case the system pressure does not drop and compressor continues to idle for more than a pre-set time.

12.03.04 The control system shall provide warning to the operator that a hot-start condition exists for the motor driver and adequate cool-down period has not occurred after the motor was shut down.

12.03.05 The alarms and shutdown scheme mentioned below are suggestive and shall be provided as per manufacturer's standard practice meeting the safe operational requirement of the equipment/system each compressor:-

(a)	"Air temperature high" at inlet to last stage	Alarm & trip
(b)	"Low lube oil pressure"	Alarm & trip
(c)	"High Lube oil supply temperature"	Alarm & trip
(d)	"High oil filter differential pressure"	Alarm
(e)	"Low lube oil level in lube oil sump"	Alarm
(f)	"High inlet air filter differential pressure"	Alarm & trip
(g)	"Low cooling water flow to air compressor"	Alarm

12.04.00 **Air Drying Plant**

12.04.01 Sequential operation of the adsorber towers & air compressors shall be controlled automatically with a provision for manual take over.

12.04.01 Change over of tower from drying mode to regeneration mode shall happen automatically if the dew point is high at the outlet of ADP sensed by the dew point (using aluminium oxide probe) meter/sensor. Automatic operation during regeneration, starting and stopping of blowers, starting and stopping of heaters, etc shall be timer controlled. During the process, in case, operation is taken over manually from the panel through push button or selector switch, the sequential operation shall start with the manual initiation for each of the steps.

12.04.01	The control system shall provide the (as minimum) alarms, "High Reactivation air temperature", "Low Reactivation air temperature", "Low cooling water flow", "Low air pressure at the outlet of ADP" and "High dew point at the outlet of ADP". Adequate number of temperature elements etc. shall be provided for measurement and monitoring of the same.
12.04.01	For rotary drum type Air drying plant, control philosophy as per manufacture's standard and proven practice is also acceptable.
13.00.00	**PAINTING**
13.01.00	All the Equipments shall be protected against external corrosion by providing suitable painting.
13.02.00	The surfaces of stainless steel, Galvanized steel, Gunmetal, brass, bronze and non-metallic components shall not be applied with any painting.
13.03.00	The steel surface to be applied with painting shall be thoroughly cleaned before applying painting by brushing, shot blasting etc as per the agreed procedure.

Annexure-1

E.O.T CRANE

1.00.00 INTENT OF SPECIFICATION

1.01.00 This specification is intended to cover design, engineering manufacture, assembly, inspection, testing at manufacturer's, works, painting & forwarding duly packed for transportation, and performance testing at site of Electrically operated overhead Traveling crane (EOT) and mono-rail hoists complete with all accessories as specified herein.

2.00.00 EOT CRANES

2.01.00 Electric Overhead Traveling (EOT) crane shall take care of erection/ maintenance requirement of pumps/blowers/machines and their associated auxiliaries for which these are being installed. The capacity of the crane shall not be less than that indicated elsewhere or 25% above the weight of the heaviest item envisaged to be lifted during erection and maintenance.

2.02.00 The EOT crane shall be pendent operated. The power shall be supplied from a single electrical power supply point at a suitable location on the operation floor of pump house/compressor house as the case may be.

2.03.00 The design code for EOT crane shall be IS : 3177 latest edition.

2.04.00 However, the speed for the various motions shall be as follows :

Main hoist	1.6 m/min
Trolley Travel (Cross Travel)	4.0 m/min
Crane Travel (Long Travel)	8.0 m/min

2.05.00 Creep speed arrangement shall be provided for all motions of EOT Crane. This shall be 10% of rated speed.

2.06.00 The crane shall be electrically operated, overhead travelling type. Design and duty of crane structure, main hoist, cross travel. Long travel shall be in accordance with class M5 of IS: 3177 (latest edition) and shall be suitable for indoor operation.

2.07.00 The crane shall be complete with trolley and truck, wheels and axles, Drive mechanisms, Hoisting Drums, Brakes, Creep Speed Arrangement, Lifting tackles, Buffers Electric Motors, Controls, Switch Board and cabling, horns, warning lights, Limit switches etc. Any item not mentioned herein but required to make the system complete for the satisfactory performance of the crane shall also be included.

2.08.00 The main hoist, trolley travel and crane travel for each movement shall be motor driven. Proper allowance shall be made for impact and wear in the design of the crane and in no case shall the factor of safety in any part be less than six (6), as per IS: 3177 based on the ultimate strength of the materials used at design duty. The design duty of crane structure, main hoist, cross travel and long travel shall conform to Class M5 of the Indian Standard IS : 3177 (latest edition) or superior. The crane as a whole shall comply with the Indian Standard IS: 3177/IS: 807 or approved equivalent international standard (latest edition).

2.09.00 Mechanical and Electrical equipment of each crane shall be of simple robust design, easy for correction adjustment, readily accessible for maintenance and elegant in appearance. All steel used in the crane shall be tested to requirements.

2.10.00 The hoist motors shall be provided with electro-magnetic brakes as well as Electro Hydraulic Thrust brakes. Electro - Hydraulic Thrust brakes shall be provided for cross travel & long travel.

2.11.00 Safe means of access shall be provided and to every place of crane where examination/maintenance of any component is involved. A platform shall extend to full length of the crane bridge on both sides of the bridge girder. The platform shall be made of checkered Steel plate.

2.12.00 Necessary access ladders shall be provided for access on to crane bridge platform from the gantry girder level, from crane bridge platform to trolley platform and from operating floor of equipments to gantry girder level.

2.13.00 The lifting tackle shall consist of a safety type lower pulley block, hook, necessary sheave and flexible steel wire ropes. The lower block sheaves and ropes shall be of adequate design and size to handle the specified loads. The hooks shall be of forged steel. The main hook shall be of Ramshorn type conforming to IS: 5749 (latest edition) and the auxiliary hook (if required main Technical Specification/or in Data sheet if enclosed) shall be of shank type conforming to IS :3815 (latest edition). The factor of safety for the rope shall not be less than six (6). The sheaves shall be of heavy duty with deep flanges made of cast steel and shall be properly grooved to fit the rope and adequately guarded.

2.14.00 Each crane shall be equipped with motor of ample capacity for the duties and speeds specified conforming to IS: 325 (latest edition). The motor shall also meet the requirements as specified in IS: 3177 (latest edition). All motors shall be suitable for operations at 415V, 50 cycles, 3 phase, 4 wire system. The motor speed shall not exceed 1000 RPM. The break down torque of the motors shall not be less than 225 percent of the full load torque with rated voltage and frequency applied. The bearings shall have ample strength to withstand the heavy shocks and vibrations to which they will be subjected. Other design and constructional features of the motors shall in general conform to motor specification requirements mentioned elsewhere in the specification.

2.15.00 Each crane shall be controlled individually for all its motions from the control pendent panel.

2.16.00 Each crane shall have a permanent inscription of English on each side, readily visible from the ground level, stating the safe working loads in tones for both the hooks, year of manufacture, crane serial number and manufacturer's name.

2.17.00 The vertical deflection of crane girder shall not exceed 1/800 of the span, as per IS: 807. The girder shall be of box type and construction shall ensure non-accumulation of water/oil inside the box.

2.18.00 **Special Cleaning, Protection & Painting**

Before shipment of the equipment to be supplied under this specification, the necessary cleaning, flushing etc., as per Manufacturer's standard shall be done. Shop coats of rust inhibiting paints, lacquers etc. shall be applied to various parts as necessary as per code and final coat after erection at site. Final coat of all electrical items shall be as per shade 692 (smoke grey) of IS:5.

LOW PRESSURE PIPING

1.00.00 **EQUIPMENT SIZING CRITERIA**

1.01.00 All the piping systems and equipment supplied under this package shall be designed to operate without replacement and with normal maintenance for a plant service life of 30 years, and shall withstand the operating parameter fluctuations and cycling which can be normally expected during this period.

1.02.00 For all L.P. piping system covered under this specification, sizing and system design shall be to the requirements of relevant codes and standard indicated elsewhere. In addition to this, requirements of any statutory code as applicable shall also be taken into consideration.

1.03.00 Inside diameters of piping shall be calculated for the flow requirements of various systems. The velocities for calculating the inside diameters shall be limited to the following:

a) **Water Application**

	Pipe Size	Water Velocity in m/sec Below 50 mm	50-150 mm	200 mm & above
(a)	Pump suction	------	1.2-1.5	1.2-1.8
(b)	Pump discharge and recirculation	1.2-1.8	1.8-2.4	2.1-2.5
(c)	Header	------	1.5-2.4	2.1-2.4

Pipe line under gravity flow shall be restricted to a flow velocity of 1 m/sec generally. Channels under gravity flow shall be sized for a maximum flow velocity of 0.6 m/sec.

WILLIAM & HAZEN formula shall be used for calculating the friction loss in piping systems with the following "C" value:

(i)	Carbon steel pipe	100
(ii)	C.I Pipe/ Ductile Iron.	100
(iii)	Rubber lined steel pipe	120
(iv)	Stainless steel pipe	100

For calculating the required pump head for pump selection, at least 10% margin shall be taken over the pipe friction losses and static head shall be calculated from the minimum water level of the tank/ sump/ reservoir from which the pumps draw water.

(b) **Compressed Air Application**

Compressed air 15.0 m/sec.(under Average Pressure & Temp. conditions)

1.04.00 The pipes shall be sized for the worst (i.e. maximum flow, temp. and pressure values) operating conditions.

1.05.00 Based on the inside dia. so established, thickness calculation shall be made as per ANSI B 31.1 OD and thickness of pipes shall than be selected as per ANSI B 36.10/IS-1239 Heavy grade/IS-3589/ASTM-A-53/API-5L/ANSI B 36.19 as the case may be.

1.06.00 Corrosion allowance of 1.6 mm will be added to the calculated thickness being considered.

1.07.00 Bend thinning allowance/manufacturing allowance etc. shall be as per the requirement of the design code provision.

1.08.00 High points in piping system shall be provided with vents along with valves as per the system requirement. Low points shall be provided with drains along with drain valves as per the system requirement. Drain lines shall be adequately sized so as to clear condensate in the lines. Material for drain and vent lines shall be compatible with that of the parent pipe material.

1.09.00 Material of construction for pipes carrying various fluids shall be as specified elsewhere.

1.10.00 Compressed air pipe work shall be adequately drained to prevent internal moisture accumulation and moisture traps shall be provided at strategic locations in the piping systems.

1.11.00 Depending upon the size and system pressure, joints in compressed air pipe work shall be screwed or flanged. The flange shall be welded with the parent pipe at shop and shall be hot dip galvanized before dispatch to site. Alternatively, the flanges on GI pipes may be screwed-on flanges also.

1.12.00 Threaded joints shall be provided with Teflon sealant tapes.

1.13.00 Following types of valves shall be used for the system/service indicated.

SYSTEM	**TYPES OF VALVES**					
	Butterfly	Gate	Globe	Check	Ball	Plug
Water	x	x	x	x	x	
Air		x	x	x	x	
Drains & vents		x	x	x		
Fuel oil (if any)		x	x	x	x	x

1.14.00 Recirculation pipes along with valves, breakdown orifices etc. shall be provided for important pumping systems as indicated in respective process and instrumentation diagrams (p&ids). The recirculation pipe shall be sized for minimum 30%design flow of single pump operation or the recommended flow of the pump manufacturer whichever is higher.

2.00.00	**TECHNICAL SPECIFICATION**
2.01.00	**GENERAL**
	Specific technical requirements of low-pressure piping, fittings, supports, valves, specialties and tanks etc. have been covered under this Sub-section. It includes details pertaining to design and material of construction for piping, fittings, valves, equipment, etc. cleaning/surface preparation application of primer and painting on over ground piping. It also includes detailed technical requirement of laying underground/buried piping including water proofing/anti corrosive protection. It also covers design, engineering, manufacturing, fabrication, technical details of piping, valves, specialties, piping hangers / supports, tanks etc.
2.02.00	**Pipes and fittings**
2.02.01	All low pressure piping systems shall be capable of withstanding the maximum pressure in the corresponding lines at the relevant temperatures. However, the minimum thickness as specified in the following clauses and or respective codes for pipes and fittings shall be adhered to. The bidder shall furnish the pipe sizing/ thickness calculation as per the criteria mentioned above under LP piping equipment sizing criteria of this Technical Specification.
2.02.02	Piping and fittings coming under the purview of IBR shall be designed satisfying the requirements of IBR as a minimum.
2.02.03	Supporting arrangement of piping systems shall be properly designed for systems where hydraulic shocks and pressure surges may arise in the system during operation. Bidder should provide necessary protective arrangement like anchor blocks/anchor bolt etc. for the safeguard of the piping systems under above mentioned conditions. The requirement will be, however, worked out by the contractor and he will submit the detailed drawings for thrust/anchor block to the Employer. External, and internal, attachments to piping shall be designed so as not to cause flattening of pipes and excessive localized bending stresses.
2.02.04	Bends, loops, off sets, expansion or flexible joints shall be used as required in order to prevent overstressing the piping system and to provide adequate flexibility. Flexibility analysis (using software packages such as Caesar-II etc.) shall be carried out for sufficiently long piping (straight run more than 300M).
2.02.05	Wherever Bidder's piping coming under this specification, terminates at an equipments or terminal point not included in this specification, the reaction and the thermal movement imposed by bidder's piping on equipment terminal point shall be within limits to be approved by the Employer.
2.02.06	The hot lines shall be supported with flexible connections to permit axial and lateral movements. Flexibility analysis shall be carried out for pipelines which have considerable straight run as indicated above and necessary loops/ expansion joint etc. shall be provided as may be necessary depending on layout.
2.02.07	Piping and fittings shall be manufactured by an approved manufacturer of repute. They should be truly cylindrical of clear internal diameter, of uniform thickness, smooth and strong, free from dents, cracks and holes and other defects.
2.02.08	For rubber lined ERW pipes, beads shall be removed.
2.02.09	Inspection holes shall be provided at suitable locations for pipes 800 Nb and above as required for periodic observations and inspection purposes.

2.02.10 At all intersection joints, it is Contractor's responsibility to design and provide suitable reinforcements as per the applicable codes and standards.

2.02.11 For large size pipes/ducts, at high point and bends/change of direction of flow, air release valves shall be provided as dictated by the system requirement and operation philosophy & tripping conditions of pumping system. Sizing criteria for air release valves shall be generally on the basis of valve size to pipe diameter ratio of 1:8. Requirement shall be decided as per relevant code.

Transient analysis /surge analysis where ever specified and required shall be conducted in order to determine the location , number and size of the Air-Release valve on certain long distance/high volume piping systems, if applicable within the scope of work of the package.

2.03.00 **Material**

2.03.01 Alternate materials offered by Bidder against those specified. shall either be equal to or superior to those specified, The responsibility for establishing equality or superiority of the alternate materials offered rests entirely with the Bidder and any standard code required for establishing the same shall be in English language.

2.03.02 No extra credit would be given to offers containing materials superior to those specified. Likewise no extra credit would be given to offers containing pipe thickness more than specified.

2.03.03 All materials shall be new and procured directly from the manufacturers. Materials procured from traders or stockists are not acceptable.

2.03.04 All materials shall be certified by proper material test certificates. All material test certificates shall carry proper heat number or other acceptable references to enable identification of the certificate that certifies the material.

2.03.05 Material of construction for pipes carrying various fluids shall be as follows:

Sl No.	Type of Fluid	Material
1.	i) Ordinary Water (Raw Water, Clarified Water, CW blow down water etc.) ii) Equipment cooling water including Both primary & secondary circuit (DMCW pH-corrected & ACW drain water)	IS-2062 Gr.-B/ASTM A-36/ASTM A-53 type 'E'Gr.B/IS-3589 Gr. 410 /IS-1239 Heavy.
2.	i) Demineralised water, ii)Alkaline solution (ECW system chemical dosing) iii) Equipment cooling water piping from overhead tank to suction header of DMCW pumps.	Stainless Steel to ASTM A312, Gr. 304 welded for sizes 65 mm NB and above. Stainless steel to ASTM A312, Gr. 304 sch.40s seamless for sizes 50mm and below
3.	i) Drinking (potable) water ii)Compressed air (Instrument & service air)	ASTM A-53 type E Gr. B galvanized/ IS 1239 Gr heavy galvanized/IS 3589 Gr 410 galvanized. Galvanized shall be to IS- 4736 or equivalent.
4.	(Condensate) spill water	ASTM A 106 Gr. B

2.03.06	In water lines, pipes upto 150mm Nb shall conform to ANSI B36.10/ASTM-A-53, Type-E Gr.B /IS:1239 Gr. Heavy and minimum selected thickness shall not be less than IS:1239 Grade Heavy except for demineralised water, drinking water and condensate spill lines.
2.03.07	Pipes of above 150mm Nb shall be to AWWA-C200/ANSI B 36.10/ASTM A-53/IS 3589 Gr.410. Pipe to be fabricated by the bidder shall be rolled and butt welded from plates conforming to ASTM A-53 type 'E' Gr. B/IS 2062 Gr.B/ASTM-A-36. However, larger pipes, i.e. 1000mm Nb and above shall be made from plates conforming to ASTM A 36/IS 2062 Gr.B and shall meet the requirements of AWWA-M-11 (for deflection & buckling criteria considering water filled pipe as well as vacuum condition that may prevail during transient/surge conditions, truck-load, rail-load and weight density for compacted soil or any other load as the case may be).
2.03.08	In demineralised water service, the pipes upto 50 Nb shall be of stainless steel ASTM A 312, Gr. 304 sch. 40 Seamless. The size for these pipes shall be to ANSI B 36.19. These shall be socket welded. The material for pipe from 65mm NB upto and including 400 NB shall be to ASTM A 312, Gr. 304 (welded). In no case the thickness of fittings shall be less than parent pipe thickness. Bidder/Contractor shall note that pipes offered as per a particular code shall conform to that code in all respects i.e. Dimension, tolerances, manufacturing methods, material, heat treatment, testing requirements, etc. unless otherwise mentioned elsewhere in the specification.
2.03.09	Instrument air, Plant (service) air lines and Drinking water lines shall be to ASTM A 53 type E grade B/ANSI B 36. 10/IS 3589, Gr. 410 / IS: 1239 Heavy (in case thickness calculated is more than gr. Heavy, ANSI B 36.10 Schedule numbers shall be followed) and galvanized to IS 4736 or any equivalent internationally reputed standard. The material of the pipes shall be to ASTM A 53 type 'E' Gr. B / IS: 3589, Gr. 410 / IS: 1239 Gr. Heavy. The fittings shall be of either same as parent material or malleable iron to IS-1879 (galvanized).
2.03.10	Spiral welded pipes as per API-5L/IS-3589 are also acceptable for pipe of size above 150 NB. However minimum thickness of the pipes shall be as elaborated in above clauses.
2.03.11	Condensate lines shall be to ASTM A 106 Gr. B and dimension to ANSI B 36.10 schedule "standard" as minimum to be maintained.
2.03.12	If carbon steel plates of thickness more than 12 mm are used for manufacture of pipes, fittings and other appurtenances, then the same shall be control-cooled or normalized as the case may be following the guidelines of the governing code.
2.04.00	**Piping layout**
2.04.01	Piping shall be grouped together where practicable and routed to present a neat appearance.
2.04.02	Piping routing shall be such as to provide sufficient clearance for removal and maintenance of equipment, easy access to valves, instruments and other accessories. The piping shall not encroach on the withdrawal space of various equipments.
2.04.03	Over head piping shall have a normal minimum vertical clearance of 2.5 meters above walkways and working areas and 8m above roadways/railways. When several pipe lines are laid parallel, flanged joints must be staggered. Welded and flanged joints should as far as possible be located at one third span from supports. if the support is situated right under the

welded joints this joint must be reinforced with a strap. Flanged and welded joints must be avoided in the middle of the span. Valves should be located in such a manner so as to ensure their convenient operation from the floor or the nearest platform.

2.04.04 Pipe lines of NB 50 size and below are regarded as field run piping. It is Bidder's responsibility to plan suitable layouts for these system insitu. Bidder shall prepare drawings indicating the layout of field run pipe work. These drawings shall be approved by Project Manager to the installation of the field run pipe work. Based on these approved layouts the Bidder shall prepare the BOQ of field run-pipes and submit to Employer for approval.

2.04.05 All piping shall be routed so as to avoid interference with other pipes and their hangers and supports, electrical cable trays, ventilation ducting, structural members, equipment etc. Adequate clearance shall be ensured with respect to the above to accommodate insulation and pipe movements, if any.

2.04.06 Piping shall generally be routed above ground but where specifically indicated/approved by the Project Manager the pipes may be arranged in trenches or buried. Pipes at working temperature above the ambient shall however not be buried.

2.04.07 Sufficient up stream and down stream lengths shall be provided for flow measuring devices, control valves and other specialties.

2.04.08 All local instruments shall be located on pipe lines as to render them observable from the nearest available platforms.

2.04.09 Openings provided in the wall for pipelines must be closed with bricks and mortar with 10-12 mm clearance between brick work and pipe after taking care of insulation and thermal movement, if any. The clear space must be filled with felt or asbestos or approved filling compound.

2.05.00 **Slope/Drains and Vents**

2.05.01 Suitable slope shall be provided for all pipelines towards drain points. It is Bidder responsibility to identify the requirements of drains and vents, and supply the necessary pipe work, valves, fittings, hangers and supports etc. As per the system requirement low points in the pipelines shall be provided with suitable draining arrangement and high points shall be provided with vent connections where air or gas pockets may occur. Vent for use during hydrostatic test shall be plugged after the completion of the test. Vent shall not be less than 15mm size. Drains shall be provided at low points and at pockets in piping such that complete drainage of all systems is possible. Drain shall not be less than 15mm for line size up to 150mm, not less than 20mm up to 300mm and not less than 25mm for 350mm to 600mm pipes and not less than 50mm for 600mm and above pipes.

2.05.02 Air piping shall be sloped so that any part of the system can be drained through the shut-off drain valve or drain plugs.

2.06.00 **Pipe Joints**

In general all water lines 65mm NB and above, are to be joined generally by butt welding except the locations where valves/fittings are to be installed with flanged connections and 50mm and below by socket welding unless mentioned otherwise specifically. All air lines shall be of screwed connection and rubber lined pipes of flanged connections.

2.06.01 **Screwed**

(a) Threading of pipes shall be carried out after bending, heat treatment etc. If not possible, threading may be done prior to these operations but proper care should be taken to protect them from damage. Threads shall be to ANSI B 2.1 (taper) NPT/IS: 554 unless specified otherwise.

(b) Galvanized pipe shall generally be joined by screwing into sockets. The exposed threaded portion on the outside of the pipes shall be given a zinc silicate coating. Galvanized pipes shall not be joined by welding. Screwed ends of GI pipes shall be thoroughly cleaned and painted with a mixture of red and white lead before jointing. For galvanized pipe sizes above 150 mm NB, screw & socket jointing as per ASTM-A-865 shall be employed for both pipe-to-pipe and pipe-to-fitting jointing. For pipe to fitting connection since no direct threading can be done on the fittings (supplied as per ASTM-A-234 Gr. WPB and ANSI B-16.9) necessary straight pipe lengths acting as match pieces shall be welded to the fitting at both ends and subsequently the free ends of the straight lengths shall be threaded as per ASTM A-865 for jointing with main pipe. Once welding of fittings with match pieces and threading of free ends of match pieces are over, the entire fabricated piece shall be galvanized, or in case match pipes and fittings are already galvanized before the above mentioned fabrication then suitable application of Zinc-Silicate paste adequately at the welded surface (both in side & out side) after welding with zinc rich electrode, along with the nascent threaded metal portions at both free ends given the same application of Zinc Silicate paste. Alternatively flanged jointing may be employed for pipe sizes 100 NB and above. However, the bidder shall ensure the galvanized pipe joints do not fail during hydro test.

(c) Teflon tapes shall be used to seal out screwed joints and shall be applied to the male threads only. Threaded parts shall be wiped clean of oil or grease with appropriate solvent if necessary and allowing proper time for drying before applying the sealant. Pipe ends shall be reamed and all chips shall be removed. Screwed flanges shall be attached by screwing the pipe through the flange and the pipe and flange shall be refaced accurately.

(d) For pipe sizes from 350 mm NB to 550 mm NB (including 350 NB & 550 NB) the GI pipes shall be of flanged connection. However, the pipes after welding of flanges shall be completely galvanized. Any site welding done on galvanized pipes shall be done with zinc-rich special electrodes and the welded surfaces whether inside or outside shall be coated with zinc-silicate paste. Seal welding of flanges with zinc-rich electrode will be permitted only when any flange is leak-prone during hydro testing.

(e) For pipe sizes 600 mm NB and above, the GI pipes shall be of welded connection (with zinc-rich special electrodes) followed by application of zinc silicate coating at welded surfaces both inside and outside the pipe, except for the last blank/blind flange, or, equipment connection where application of zinc-silicate paste after welding cannot be done due to inaccessibility of the inside welded surface and where galvanic protection has been impaired due to welding of pipe-to-pipe joint. Thus the last erection joint shall be flanged joint.

2.06.02 **Welded**

(a) For making up welded joints (butt weld or socket weld) the welding shall be performed by manual shielded metal arc process in accordance with the requirements specified elsewhere in the spec. Any welder employed for carrying butt welding shall be qualified as per ASME section IX for the type of joints he is going to

weld. Jointing by butt weld, or socket weld shall depend upon the respective piping material specifications.

2.06.03 **Flanged**

(a) Flanged connections for pipes are to be kept to the minimum and used only for connections to vessel, equipments, flanged valves and other fittings like strainer/traps/orifices etc. for ease of connection and maintenance etc. Rubber lined pipes shall be flange joined only.

(b) All flanged valves intended for installation on steel piping system, shall have their flanges drilled to ANSI B 16.5 (or equivalent) and according to the pressure class stated in their respective piping material specification.

(c) Drilling on flanges of flanged valves must correspond to the drilling of flanges on the piping system on which the valves are installed.

2.07.00 **Bends/elbows/mitre bends/ Tees/ Reducers & other fittings**

2.07.01 For pipe fittings such as elbows (long radius), reducers, tees, etc. the material shall be to ASTM-A-234 Gr. WPB/ASTM-105 up to 300 NB. For pipe fittings above 300 NB, the fittings may be fabricated conforming to parent pipe material. Provision of compensation pads shall be kept as per ANSI B 31.1. The fitting shall conform to the dimensional standard of ANSI B-16.9/ 16.11.Further branching in pipes for sizes 65nb and above is also acceptable (ANSI B 31.1).

However, for pipes up to 150 NB, pipe fittings may be supplied with material and dimension conforming to IS 1239 in case parent pipes also conform to IS 1239.

2.07.02 For pipe size 350Nb and above mitre bends may be used for all pipes except rubber lined pipes. The bend radius shall be 1½ times the nominal pipe diameter. 90 deg. bends (mitre) shall be in 4 pieces (3 cuts) and 45 deg. mitre bends shall be in 3 pieces 22½ deg. Fabrication of mitre bends shall be as detailed in BS 2633/BS534.

2.07.03 For pipes, above 1200 NB, reducer and tees shall be to dimensional standard of AWWA-C-208.

2.07.04 Stainless steel fittings shall conform to either ASTM-A-182 Gr. 304 or ASTM-A-403 Grade WP. 304 Class-S, for sizes upto and including 50 mm NB, i.e. the fittings shall be of seamless construction. However, for stainless fittings above 50 mm NB, the same shall conform to ASTM-A-403 Gr. WP 304 Class W i.e. the fittings shall be of welded construction strictly in accordance with ASTM-A-403.

2.07.07 In no case, the thickness of fittings shall be less than the thickness of parent pipe, irrespective of material of construction.

2.08.00 **Flanges**

2.08.01 Flanges shall be slip on type. Welding of flanges in tension is not permitted.,

2.08.02 All flanges and-flanged drilling shall be to ANSI B 16.5/BS EN-1092 of relevant pressure/temperature class. Flanges shall be fabricated from steel plates conforming to ASTM A 105/IS 2062 Gr. B. However stainless steel flanges shall be fabricated from SS plates to ASTM-A-240, Gr. 304 (316 for Sea water application, if any) or equivalent.

2.09.00 **Specific technical requirement of laying buried pipe with anti corrosive treatment**

The pipe in general shall be laid with the top of the pipe minimum 1.0 (one) meter below finished general ground level.

2.09.01 **Trenching**

(a) The trench shall be cut true to the line and level and shall follow the gradient of the pipeline. The width of the trench shall be sufficient to give free working space on each side of the pipe. Trenches shall conform to IS 5822.

(b) Free access shall be provided for the welding of the circumferential joints by increasing the width and depth of the trench at these points. There should be no obstruction to the welder from any side so that good welded joint is obtained.

(c) The free working space shall conform to IS: 5822. The trench shall be excavated so as to provide minimum cover of 1000mm between the top of the pipe and finished grade.

(d) Prior to lowering and laying pipe in any trench, the bidder shall backfill and compact the bottom of the trench or excavation in accordance with is: 5822 to provide an acceptable bed for placing the pipe.

(e) Coating and Wrapping shall be done as under

2.09.02 **Preparation and cleaning of piping**

(a) The pipeline shall be thoroughly cleaned of all rust, grease, dirt, weld scales and weld burrs etc. moisture or other foreign matter by power cleaning method such as sand blasting, power tool cleaning, etc. Grease or heavy oil shall be removed by washing with a volatile solvent such as gasoline. Kerosene will not be permitted for cleaning. This cleaning operation shall be immediately followed by priming with the mechanical priming machine.

(b) Certain inaccessible portions of the pipeline (which otherwise not possible to be cleaned by power cleaning methods) may be scrubbed manually with a stiff wire brush and scrapped where necessary with specific permission of the Project Manager.

(c) The cleaning and priming operation shall be carried out at site. The entire pipe length shall be cleaned but the ends of the pipes shall be left without coating for a distance of 230mm for joints, which shall be coated manually at site after laying, welding and testing the pipe.

(d) On the internal surface for pipes 1000 Nb and above, a coat of primer followed by a hot coal-tar enamel or coal tar epoxy painting (cold) shall be applied.

2.09.03 **Coating and wrapping**

(a) Buried piping shall be coated and wrapped, as per specification, after completion of welded and/or flanged connections, and after completion and approval of Hydro testing. Materials to be used for coating and wrapping of underground pipelines are:

(1) Coating primer (coal tar primer)

(2) Coating enamel (coal tar enamel)

(3) Wrapping materials.

(b) All primer/coating/wrapping materials and methods of application shall conform to IS: 10221 except asphalt/bitumen material. Materials (primer/coating/wrapping) as per AWWA-C-203 are also acceptable.

(c) Protective coating shall consist of coal tar primer, coal tar enamel coating, glass fiber, tissue inner wrap followed by glass fiber or coal tar impregnated Kraft outer wrap or finish coat

(d) Number of coats and wraps, minimum thickness for each layer of application shall be as per IS-10221. Number of. Coats and wraps shall be decided based on soil corrosivity/resistivity as indicated in IS-10221. Soil data-for this purpose shall be made available.

(e) Total thickness of completed coating shall not be less than 4.0 mm.

(f) Alternatively, the anti-corrosive protection can consist of anti-corrosive protection Coal-tar tapes. Material and application of tapes shall conform to IS 15337 or equivalent. These-tapes shall be applied hot over the cold coal tar primer preferably in steps of 2mm thickness so as to cover the spiral edges of the first tape by the application of second tape. The total thickness of the finished protective coating shall be 4.0 mm minimum.

2.09.04 **Trench bed preparation and back filling**

Prior to lowering and laying pipe in any excavated trench, the bottom of the trench may require to be back filled and compacted (or as the case may be) to provide an acceptable bed for placing the pipe. Bed preparation in general shall be as per IS: 5822.

2.09.05 **Laying of galvanized steel (GI) pipes**

All the joints shall be screwed with socket or flanged. Screwed ends of GI pipes shall be thoroughly cleaned and painted with a mixture of red and white lead before jointing Threaded portion on either side of the socket joint shall be applied with Zinc silicate paste.

All the provisions for trenching' bed preparation' laying the pipe application of primer' coating' wrapping with tapes and back filling etc. as indicated for "laying of buried piping" and " anti corrosive protection for buried piping" are applicable for buried galvanized steel (GI) pipes also.

2.10.00 **Cleaning and flushing**

2.10.01 All piping shall be cleaned by the Bidder before and after erection to remove grease, dirt, dust, scale and welding slag.

2.10.02 Before erection all pipe work, assemblies, sub-assemblies, fittings, and components, etc. shall be thoroughly cleaned internally and externally by blast cleaning or by power driven wire brushes and followed by air-blowing. The brushes shall be of the same or similar material as the metal being cleaned. Cleaning of Galvanized pipes shall be done in such a manner that the coating on MS pipe is not affected.

2.10.03 After erection, all water lines shall be mass flushed with water. The cleaning velocities in water lines shall be 1.2-1.5 times the operating velocities in the pipelines.

2.10.04 All compressed air pipe work shall be cleaned by blowing compressed air.

2.11.00 **Surface preparation and painting**

Pipes shall be cleaned both internally and externally thoroughly by blast-cleaning or power tool cleaning method as indicated above.. In case of oil piping, cleaning will have to be done by pickling. No painting is required on stainless steel pipe / equipment surface, galvanized pipe surface or galvanized steel surface. However, necessary color banding for identification as per color code shall be done. External surface of piping shall be cleaned and prepared as indicated below.

2.11.01 **Primer painting**

(a) After the surface is prepared two coats of red oxide (zinc chromate/zinc phosphate) primer conforming to IS-2074/IS-12744 or equivalent shall be applied. Primer coat shall be immediately applied without any time lag after the surface preparation.

(b) Any equipment which has been given the shop coat of primer shall be carefully examined after its erection in the field and shall be treated with a touch up coat of primer wherever the shop coat has been abraded, removed or damaged during transit/erection, or defaced during welding.

2.11.02 **Finish painting**

(a) Paint to be used shall be synthetic enamel paint conforming to IS-2932 or equivalent. Finish painting shall be carried out in three coats consisting of one intermediate coat and two finishing coats. Dry film thickness (DFT) of painting inclusive of primer thickness shall be at least 150 micron.

(b) The primed surface shall be cleaned of dust/dirt/grease etc. without scratching or in any way damaging the primer coat. The intermediate coat shall be allowed to dry before applying the finish coat or as recommended by paint manufacturer.

(c) Paint shall be applied by brushing. It shall be ensured that brush marks are a minimum and the requirements of workmanship is as specified in IS-1477.

(d) Paint used shall be stirred frequently to keep the pigment in suspension. Paint shall be of the ready mix type in original sealed containers as packed by the paint manufacturer. No thinners shall be permitted.

(e) No painting shall be done in frost/foggy weather or when the humidity is high to cause-condensation on the surface to be painted.

(f) The dry film thickness (DFT) after the painting shall not be less than 150 microns.

2.11.03 **Other requirements**

(a) Paint manufacturers instructions shall be followed in method of application, handling, drying time etc.

(b) The color of the finish paint shall be as per approved color-coding.

(c) If finish paint was applied in shop, one coat of finish paint shall be applied at site.

(d) The dry film thickness of paint shall not be less than 0.15 mm.

2.11.04 Color code for identification

The pipes shall be color painted/banded for identification as per the approved color-coding scheme and shall be generally as per IS-9404.

2.12.00 **Specification for hangers and supports**

2.12.01 All supports and parts shall conform to the requirement of power piping code ANSI B 31.1 or approved equivalent.

2.12.02 While designing supports for rubber lined pipes special consideration should be given. Any kind of welding on these pipes is not allowed after rubber lining.

2.12.03 Hanger for piping 65mm Nb and larger and all spring support assemblies regardless of size shall be completely engineered in conformance with the provisions of power piping code ANSI B 31.1.

2.12.04 Hangers, saddles, supports etc. shall be fabricated from plates/pipes sections conforming to ASTM A 53/IS: 2062/IS: 226/or equivalent. They shall be designed to provide the required supporting effects and allow pipe line movements as necessary. The structural steel work shall be as per IS: 800/BS: 4360. Insulation protection saddles shall be used at support point of all insulated piping.

2.12.05 The support shall be so interspaced as to minimize sagging of the pipes and to keep them with in permissible limits where pipes are full with the conveying media.

2.12.06 The maximum spans of the supports of straight length shall not exceed the recommended values indicated in ANSI B 31.1.

2.12.07 All pipe supports shall be designed to provide an absolute minimum head room of 2.5 m from floor in passages/walkways.

2.12.08 At all sliding surfaces of supports suitable arrangement is to be provided to minimize sliding friction.

2.12.09 All components of hangers/supports shall be provided with two coats of primer (red oxide paint) at shop before dispatch to site. After erection they shall be given finish coat of Long Oil Synthetic enamel to IS: 2932 of total DFT 100 to 140 microns. CLH & VLH will be primed with Epoxy Zinc rich primer of 50 micron followed by finish painting of Aliphatic Acrylic Polyurethane or equivalent of DFT 65 microns.

2.13.00 **Design/Construction/Material Particulars of Gate/ Globe/Check Valves/ Globe Stop Valve/Butterfly valve**

2.13.01 **GENERAL**

(a) All valves shall be suitable for the service conditions i.e flow, temperature and pressure, at which they are required to operate.

(b) The valves as well as all accessories shall be designed for easy disassembly and maintenance.

(c) Valves to be installed outside shall be required to have the stem properly protected against atmospheric corrosion.

(d) All rising stem valves shall be provided with back seat to permit repacking (of glands) with valves in operation. All valves shall preferably be of outside screw and yoke type.

(e) All valves shall be closed by rotating the hand wheel in the clockwise direction when looking at the face of the hand wheel. In case where the hand wheel is not directly attached to the valve spindle suitable gearing shall be introduced.

(f) All valves shall have indicators or direction clearly marked on the hand-wheel so that the valves opening/closing can be readily determined.

(g) Special attention shall be given to operating mechanism for large size valves with a view to obtaining quick and easy operation ensuring that a minimum of maintenance is required. For valves of size 350mm and above either bevel or spur gearing shall be provided to facilitate manual operation.

(h) The valves coming in vacuum lines shall be of extended gland type and/or water sealed.

(i) The actuator-operated valves shall be designed on the basis of the following:

(1) The internal parts shall be suitable to support the pressure caused by the actuators;

(2) The valve-actuator unit shall be suitably stiff so as not to cause vibrations, misalignments, etc.

(3) All actuator-operated valves shall be provided with hand operated gearing mechanism also.

(4) All actuators operated valves shall open/ close fully within time required by the process.

(j) Valves coming under the purview of IBR shall meet IBR requirements.

(k) Gate/sluice valves shall be used for isolation of flow. Gate valves shall be provided with the following accessories in addition to other standard items:

(1) Hand wheel

(2) Position indicator (for above 50 mm NB valve size)

(3) Draining arrangement wherever required.

(l) Globe valves shall be used for regulation purposes. They shall be provided with hand wheel, position indicator, draining arrangement (wherever required) and arrow indicating flow direction.

(m) Check valves shall be used for non-return service. They shall be swing. check type or double door (Dual plate)check type with a permanent arrow inscription on the valve body indicating the fluid flow direction. In long distance pipes lines with possibility of surge-occurrence, dual plate check valves are preferable for its spring controlled opening /closing of flaps/doors against flow reversals. However, dual plate check valves shall not be used for sizes more than 600mm NB

(n) All gate and globe valves shall be provided with back seating arrangement to enable on line changing of gland packing.

(o) All gate and globe valves shall be rising stem type and shall have limit switches for full OPEN and full CLOSED indication wherever required. This will include motor-operated valves also wherever required. In such cases the limit switches shall form an integral part of the valve. Stop-gap arrangement in this respect is not acceptable.

(p) All valves shall be provided with embossed name plate giving details such as tag number, type, size etc.

(q) Wherever required valves shall be provided with chain operator, extension spindles and floor stands or any other arrangement approved by employer so that they can be operated with ease from the nearest operating floor. Wherever necessary for safety purpose locking device shall be provided. Further, necessary small platforms for facilitating easy valve operation shall be provided by the contractor wherever necessary in consultation with project manager within the bid price at no extra cost to employer.

(r) All valves except those with rising stems shall be provided with continuous mechanical position indicators; rising stem valves shall have only visual indication through plastic/metallic stem cover for sizes above 50 mm nominal bore.

(s) For CI gate, globe and check valves wherever thickness of body/bonnet is not mentioned in the valves standards, thickness mentioned in IS- 1538 for fitting shall be applicable.

2.13.02 **VALVE BODY MATERIAL**

Valve body material for various services shall be as follows:

Valve body material for water application like circulating water, Secondary circuit auxiliary cooling water of ECW system, Raw water, Ash water make-up, service water, clarified water, DM cooling water (pH corrected) & drinking water shall be cast iron for sizes 65NB and above; gun-metal for sizes 50 Nb and below.

For compressed air application, valve body material shall be cast carbon steel or forged carbon steel for sizes 65 mm NB & above and Gun metal for sizes 50 NB and below.

DM water: SS body and disc along with SS internals.

Condensate: Cast Carbon Steel / Forged Carbon Steel.

2.13.03 The design, material, construction, manufacture, inspection, testing and performance of valves shall comply with all currently applicable statutes, regulations and safety codes in the locality where the valves will be installed. The valves shall conform to the latest editions of applicable codes and standards as mentioned elsewhere. Nothing in this specification shall

be construed to relieve the Bidder of his responsibility. Valves in general shall conform to the requirements of the following standards.

Standards and Codes

AWWA-C-504	Rubber seated butterfly valves.
BS-5155/EN-593	Cast iron and steel body butterfly valves for general purpose.
IS-778	Gun-metal gate, globe and check valves for general purpose.
BS-5154	Copper alloy globe/globe stop and check and gate valves for general purpose.
IS-780	Sluice valves for water works purpose (50-300 mm size)
IS-2906	Sluice valves for water works purpose (350-1200 mm size)
IS-5150	Cast iron wedge and double disc gate for general purpose.
BS-5152	Specification for cast iron globe valves.
BS-5153	Cast iron check valves for general purpose.
IS-5312	Swing check type reflux (non-return) valves.
ANSI B 16.34	Standard for valves.
API-594	Standard for Dual-check valves.
API-600	Steel gate valves.
ANSI-B-16.10	Valves face to face and other relevant dimension.
API-598	Valves inspection test.

2.13.04 **End Connections**

The end connections, shall comply with the following:

Socket welding (SW) - ANSI B 16.11

Butt Welding (BW) - ANSI B 16.25.

Threaded (SC) - ANSI B 2.1

Flanged (FL) - ANSI B 16.5& AWWA-C-207(steel flanges), ANSI B 16.1 (Cast Iron flanges)

2.13.05 All cast iron body valves (gate, globe and non-return) shall have flanged end connections; (screwed ends for Ductile D.2NI body valves are not acceptable).

2.13.06	All steel and stainless steel body valves of sizes 65 mm and above shall have flanged or butt welding ends. Valves of sizes below 65mm shall have flanged or socket welded ends. Compatibility of welding between valve body material and connecting pipe material is a pre-requisite in case of butt-welded joints.
2.13.07	All gun metal body valves shall have screwed ends.
2.13.08	All flanged end valves/specialties. shall be furnished along with matching counter flanges, fasteners, gaskets etc. as required to complete the joints.
2.14.00	**Check Valves**
2.14.01	Check valves shall comply with the following characteristics: (a) For bore greater than 2" the valves must be swing check type or dual plate check type suitable for installation in all positions (vertical and horizontal); (b) For bore smaller than or equal to 2" the valves must be of the piston type to be installed, in horizontal position. (c) In the case of swing check valves, the body seat shall be inclined at such an angle from the vertical as will facilitate closing and prevent chatter.
2.14.02	Drilling on flanges of flanged valves must correspond to the drilling on flanges of the piping system on which the valves are to be installed.
2.14.03	All flanged valves intended for installation in steel piping systems shall have their flanges drilled to ANSI B 16.5 (or equivalent) and according to the pressure class.
2.14.04	Counter flanges to be installed on air pipes shall be screwed-on type irrespective of size.
2.15.00	**Globe Valves**
2.15.01	The globe valves shall have the following characteristics: Straight conveyed flow. Right angle Preferably, the valves shall be of the vertical stem type.
2.15.02	Globe valves shall preferably have radiused or spherical seating and discs shall be free to revolve on the spindle.
2.15.03	The pressure shall preferably be under the disc of the valve. However, globe valves, with pressure over the disc shall also be accepted provided (i) no possibility exists that flow from above the disc can remove either the disc from stem or component from disc (ii) manual globe valves can easily be operated by hand. If the fluid load on the top of the disc is higher than 40-60 KN, bypass valve shall be provided which permits the downstream system to be pressurized before the globe valve is opened.
2.15.04	For the regulating valves, valves with regulating plug & parabolic outline disc type is preferred.

2.15.05 All motorized globe valves with regulating plug for which indication of percentage (%) opening are required in the control room shall be provided with necessary position transmitter.

2.16.00 **Gate valves**

All gate valves shall be of the full-way type, and when in the full open position the bore of the valve shall not be constricted by any part of the gate.

Gate valves shall be of the solid/elastic or articulated wedge disc and rising stem type.

2.17.00 **Air Release Valve**

(a) The air release valves shall be of automatic double air valve with two orifices and two floats. The float shall not close the valve at higher air velocities. The orifice contact joint with the float shall be leak tight joint.

(b) The valve shall efficiently discharge the displaced air automatically from ducts/pipes while filling them and admit air automatically into the ducts/pipes while they are being emptied. The valve shall also automatically release trapped air from ducts/pipes during operation at the normal working pressure.

(c) Body material of automatic air release valves shall comply generally with BS 1452 Gr. 14/IS: 210 Gr. FG 260. and spindle shall conform to high tensile brass.

(d) Air release valves shall not have any integral isolation device within them. Each Air release valve shall be mounted, preceded by a separate isolation gate/ butterfly valve.

2.18.00 **Butterfly valves**

2.18.01 **Design/Construction**

(a) The valves shall be designed for the design pressure/temperature of the system on which it is installed and in accordance with AWWA-C-504, EN-593 or any other approved equivalent standard latest edition. Fabricated steel (IS: 2062 GR. B) butterfly valves instead of cast iron body valves are also acceptable for size above 300 mm nb diameter. In such a case, however, the bidder will have to necessarily submit thickness calculations, in order to establish the integrity of the fabricated valve body under the system operating pressure condition.

(1) The valves shall be suitable for installation in any position (horizontal/vertical etc.) and shall be generally of double-flanged construction. However for sizes 600 NB and below the valves of Wafer construction are also acceptable.

(2) The seals, both on the body (sleeve) and on the disc shall be of the material specified. Necessary shaft seal shall be provided and adequately designed to ensure no leakage across the seal. This seal shall be designed so that they will allow replacement without removal of the valve shaft. The sealing ring on the disk shall be continuous type and easily replaceable.

(3) For all types of valves, the design with shaft eccentric to the disc is preferred. The shaft shall be solid type and shall pivot on bushings.

Bushings/sleeve type bearings shall be contained in the hub of valve body. The bearing shall be self-lubricated type with low coefficient of friction and should not have any harmful effect on water and on valve components.

(4) The design of the shaft shall be such that it will safely sustain maximum differential pressure across the closed valve. The shaft and any key (taper pin etc.) for transmitting the torque between shaft and disc shall be capable of withstanding the maximum torque required to operate the valve. However, the shaft diameter shall not be less than the minimum shaft diameter specified in relevant code. Necessary Torque Calculation and the torque class selected on the basis of the same shall be furnished to the Employer for information.

(5) The disc shall rotate from the full open to the tight shut position. The disc shall be contoured to ensure the least possible resistance to flow and shall be suitable for throttling operation. While the disc is in the throttled position, valve shall not create any noise or vibration.

(6) The operating mechanism shall be mounted directly on or supported from the valve body.

(7) All valves shall be complete with:

Position indicator (located in a visible place)

Arrow indicating the flow direction;

Adjustable mechanical stop limiting devices to prevent over

Travel of valve disc in open/close position.

All valves shall be "tight shut off"

(8) Hand operated valves shall have the following

Local hand controls

The hand controls shall close the valve with clockwise rotation.

The hand controls shall be dimensioned to guarantee an easy maneuver under most severe conditions.

The hand controls shall be provided with locking systems suitable to avoid the disc assuming a non-desirable position during the operation.

Hand wheel shall be made of malleable iron with arms and rims of adequate strength. The hand wheel of diameters 300mm or less shall be provided with handles for ease of operation.

Valves-350Nb and above shall have pressure equalizing bypass valves, wherever system parameters warrant the same.

Valves-200Nb and above shall also be provided with gear operator arrangement as a standard practice suitable for manual operation. Manual operation of valve shall be through gear arrangement having totally enclosed

gearing with hand wheel diameter and gear ratio designed to meet the required operating torque It shall be designed to hold the valve disc in intermediate position between full open and full closed position without creeping or fluttering. Adjustable stops shall be provided to prevent over travel in either direction.

Limit and torque switches (if applicable) shall be enclosed in water tight enclosures along with suitable space heaters for motor actuated valves, which may be either for On-Off operation or inching operation with position transmitter.

2.18.02 **Material of Construction (Butterfly Valves)**

Materials and other design details shall be as indicated below :

(a) **Cast Iron Butterfly Valves**

Body & Disc	ASTM A48, Gr. 40 with 2% Ni/ IS: 210. Gr. FG-260, with 2% Ni and epoxy coated
Shaft	BS 970 431 S: 291 / EN 57, or AISI-410 or AWWA-permitted shaft material equivalent to EN-57/AISI-410 or better.
Seat ring	18-8 Stainless steel
Seal	Nitrile Rubber

(b) **Stainless Steel Butterfly Valves**

Body & Disc	ASTM A 351, Gr. CF8M / ASTM-A-182-Gr.304.
Shaft	ASTM A 182, Gr. 316 / ASTM-A-479 Gr.316/Equivalent
Disc & Seat Rings	EPT/BUNA-N/Neoprene

(c) **Carbon steel Butterfly Valves**

Body & Disc	ASTM A 216, Gr. WCB
Shaft	ASTM A 182, Gr. 304 / ASTM-A-479 Gr.304/Equivalent
Disc & Seat Rings	EPT/BUNA-N/Neoprene

2.18.03 **Proof of Design Test (Type Test) for Butterfly Valves**

Proof of Design (P.O.D.) test certificates shall be furnished by the bidder for all applicable size-ranges and classes of Butterfly valves supplied by him, in the absence of which actual P.O.D. test shall be conducted by the bidder in the presence of Employer's representative.

All valves that are designed and manufactured as per AWWA-C-504 shall be governed by the relevant clauses of P.O.D test in AWWA-C-504. For Butterfly valves designed and manufactured to EN-593 or equivalent, the P.O.D. test methods and procedures shall

generally follow the guidelines of AWWA-C-504 in all respect except that Body & seat hydro test and disc-strength test shall be conducted at the pressures specified in EN-593 or the applicable code. Actuators shall also meet requirements of P.O.D. test of AWWA-C-504.

2.19.00 **MATERIAL OF CONSTRUCTION (GATE/GLOBE/CHECK VALVE)**

(a) The materials shall generally comply with the following:

(1) **Cast Steel Valves**

Body & bonnet	ASTM A 216 Gr. WCB/ ASTM A 105
Disc for non-return Valves	ASTM A 216 Gr. WCB/ ASTM A 105
Trim.	ASTM A 182 Gr. F6 or Equivalent

(2) **Stainless steel valves**

Body & Bonnet	ASTM A 351 Gr. CF 8M/ ASTM A 182 Gr. 304
Disc	-do-
Trim.	ASTM 182 Gr. F. 316 /ASTM-A-479Gr.316 / ASTM A 351 Gr. CF 8M

(3) **Cast iron valves**

Body & bonnet	BS 1452 Gr. 14/ IS-210 Gr. FG 260
Seating surfaces and rings	13% chromium steel/ 13% Chrome overlay
Disc for non-return valves	BS 1452 Gr. 14/IS-210 Gr FG 260
Hinge pin for non-return valves	AISI 316
Stem for gate globe valves	13% chromium steel or Equivalent
Back seat	13 % chromium steel / 13% Chrome overlay

(4) **Gun Metal valves**

Body and bonnet	IS 318 Gr. 2/ Equivalent Standard
Trim.	-do-

(b) Cast iron body valves shall have high alloy steel stem and seat.

(c) Material for counter flanges shall be the same as for the piping.

2.20.00 **Float operated valves**

(a) Valve shall automatically control the rate of filling and will shut off when a predetermined level is reached and close to prevent over flow on pre-set maximum water level. Valve shall also open and close in direct proportion to rise or fall of water level.

(b) DESIGN AND CONSTRUCTION FEATURES

The following design and construction feature of the valve shall be the minimum acceptable.

(c) Valves shall be right-angled or globe pattern.

(d) Valves shall be balance piston type with float ball.

(e) Leather liner shall not be provided.

(f) The body and cover material shall be cast iron conforming to ASTM-A 126 Grade 'B' or IS: 210 Grade 200 or equivalent, and Float shall be of copper with epoxy painting of two (2) coats.

(g) Valves shall be suitable for flow velocities of 2 to 2.5m/sec.

(h) The valves shall have flanged connections.

2.21.00 **PAINTING OF VALVES:**

Two (2) coats of primer followed by three (3) coats of enamel of approved color code/shade (usually same as that of connected piping) shall be applied to all exposed surfaces except stainless steel surface, Galvanized steel surface and gun metal surface at shop as required to prevent corrosion, before dispatch. The use of grease/oil other than light grade mineral oil, for corrosion protection is prohibited. The total DFT of paining shall be 150 micron (minimum). If during transport, unloading/unpacking or erection at site any part of the painted surface gets damaged, the same shall be made good by the contractor by repainting with compatible painting primer and enamel to the satisfaction of the project manager.

2.22.00 **Tanks and Accessories**

2.22.01 The designer and manufacturer of storage tanks shall comply with and obtain approval of all currently applicable statutory regulations and safety codes in the locality where the equipment will be installed. The tanks shall conform to IS 803/IS804/IS 805/ IS 2825/ API 650/ IS 4049/ IS 4682 (part-I) and IS 4864 to 4870/ ASME B & PV code Sec.-VIII as the case may be.

2.22.02 **DESIGN AND CONSTRUCTION**

(a) Design of all vertical atmospheric storage tanks containing water, acid, alkali and other chemical shall conform to IS:803 & API 650.

(b) Design of all horizontal atmospheric storage tanks containing water, acid, alkali and other chemicals shall generally conform to IS:2825 as regards to fabrication and general construction taking care of combined bending, shear & hoop stresses developed due to supporting arrangement.

(c) Design temperature of vessels shall be 10 deg.C higher than the maximum temperature that any part of the vessel is likely to attain during the course of operation.

(d) Tank shall be made from mild steel plates to BS 4360/IS-2062 Gr.B (or equivalent).

(e) The joint efficiency factors to be adopted for design calculations shall be in accordance with the specified design code.

(f) Tank shall be provided with suitable supporting joints. All vessels shall be provided with lifting lugs, eye bolts etc. for effective handling during erection.

(g) The material for flanges shall be of ASTM A 105/ IS-2062 Gr.B.

(h) For cylindrical tanks, the plates shall be cold rolled through plate bending machine by several number of passes to true curvature.

(i) Vessel seams shall be so positioned that they do not pass through vessel connections. For cylindrical vessel consisting of more than two sections longitudinal seams shall be offset.

(j) Tanks shall be provided with float operated level indicators/level gauges/level transmitters and level switches, as required, with complete assembly. Suitable flanged pads for level switches mounting shall also be provided. The level indicator can be top or side mounted as the case may be.

(k) In addition to inlet and outlet nozzles, the tanks shall be provided with vents, overflow, drain nozzles complete for various connections on tanks. Overflow lines from storage tanks is to be routed to the nearest surface drains. For tanks containing dm water, alkaline water or power cycle water the vent to atmosphere shall be through carbon-di-oxide absorber vessel suitably mounted on the tank. CO2 absorber vessel shall be provided with the initial fill of chemicals. Similarly for equipment cooling water overhead tank, the overflow & drain from tank shall be combined together and shall be led to nearest drain (at zero level) via. a seal-trough so as not to come directly in contact with atmosphere.

(l) Tanks shall have suitable stairs/ladders on inside and outside of the tanks, manholes/inspection covers as required and also platform suitably located.

(m) Tank supporting arrangement as approved by Employer shall be provided with all plates/angles/joints/flats and supporting attachment including lugs, saddles, legs etc.

(n) Piercing nozzles/pipes from tank body / dish ends shall be adequately compensated as per relevant code.

(o) Tank fabrication drg. and design calculations shall be approved by the Project Manager.

2.22.03 **Corrosion protection**

(a) A corrosion allowance, applicable to surface in contact with corrosive media, when required, shall be taken into consideration.

(b) Manholes shall be provided for easy access into the vessels. The size shall be minimum 500 mm and will be with cover plate, nuts bolts, etc. to ensure leak tightness at the test pressure.

(c) Each tank shall be provided with drilled cleats welded to the tank for electrical grounding. Material of cleats shall be same as that of the shell.

(d) Epoxy-coating shall be provided on the inside of vessel in three coats (minimum) resulting in total thickness of not less than 200 micron in which ever case required, such as equipment cooling water overhead tank, sodium hydroxide tank, condensate surge tank etc.

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2.22.04 **Cleaning & Painting**

(a) Inside surface of all tanks shall be protected by anti-corrosive paints as required.

(b) For tanks/vessel requiring epoxy painting, all inside surface shall be blast cleaned using non-siliceous abrasive after usual wire brushing.

(c) Outside surfaces of all vessels shall be provided with two coats of primer with three (3) coats of epoxy minimum 100mm DFT resin based paint of approved color.

2.23.00 **RUBBER EXPANSION JOINTS**

2.23.01 All parts of expansion joints shall be suitably designed for all stresses that may occur during continuous operation and for any additional stresses that may occur during installation and also during transient condition.

2.23.02 The expansion joints shall be single bellow rubber expansion joints. The arches of the expansion joints shall be filled with soft rubber.

2.23.03 The tube (i.e. inner cover) and the cover (outer) shall be made of natural or synthetic rubber of adequate hardness. The shore hardness shall not be less than 60 deg. A for outer and 50 deg. A for inner cover.

2.23.04 The carcass between the tube and the cover shall be made of high quality cotton duck, preferably, square woven to provide equal strength in both directions of the weave. The fabric plies shall be impregnated with age resistant rubber or synthetic compound and laminated into a unit.

2.23.05 Reinforcement, consisting of solid metal rings embedded in carcass shall be provided.

2.23.06 Expansion joints shall be complete with stretcher bolt assembly. The expansion joints shall be suitable to absorb piping movements and accommodate mismatch between pipe lines.

2.23.07 The expansion joints shall be of heavy duty construction made of high grade abrasion-resistant natural or synthetic rubber compound. The basic fabric for the' duck' shall be either a superior quality braided cotton or synthetic fibre having maximum flexibility and non-set characteristic.

2.23.08 The expansion joints shall be adequately reinforced, with solid steel rings, to meet the service conditions under which they are to operate.

2.23.09 All expansion joints shall be provided with stainless steel retaining rings for DM water application and IS 2062 Gr B galvanized steel retaining rings for ordinary water for use on the inner face of the rubber flanges, to prevent any possibility of damage to the rubber when the bolts are tightened. These rings shall be split and beveled type for easy installation and replacement and shall be drilled to match the drilling on the end rubber flanges and shall be in two or more pieces.

2.23.10 The expansion joints shall have integral fabric reinforced full-face rubber flanges. The bolt on one flange shall have no eccentricity in relation to the corresponding bolt hole on the flange on the other face. The end rubber flanges shall be drilled to suit the companion pipe flanges.

2.23.11 All exposed surfaces of the expansion joint shall be given a 3 mm thick coating of neoprene. This surface shall be reasonably uniform and free from any blisters, porosity and other surface defects.

2.23.12 Each control unit shall consist of two (2) numbers of triangular stretcher bolt plates, a stretcher bolt with washers, nuts, and lock nuts. Each plate shall be drilled with three holes, two for fixing the plate on to the companion steel flange and the third for fixing the stretcher bolt.

2.23.13 Each joint shall have a permanently attached brass or stainless steel metal tag indicating the tag numbers and other salient design features.

2.23.14 Bidder to note that any metallic part which comes in contact with DM /corrosive water shall be of Stainless Steel material.

2.24.00 **STRAINERS**

2.24.01 **Simplex type**

The strainers shall be basket type and of simplex construction. The strainer shall be provided with plugged drain/blow off and vent connections. The free area of the strainer element shall be at least four (4) times the internal area of the connecting pipe lines. The strainer element shall be 20 mesh. Pressure drop across the strainers in new condition shall not exceed 1.5 MCW at full flow. Wire mesh of the strainers shall be suitably reinforced, to avoid buckling under operation. Strainer shall have screwed blow off connection fitted with a removable plug. The material of construction of various parts shall be as follows:

(a)	Body	IS: 318, Gr. 2 up to 50 mm Nb, and IS: 210 Gr. FG 260 above 50 mm Nb. (For DM water/ -Body: AISI 316 or equivalent)
(b)	Strainer Element	Stainless steel (AISI 316)
(c)	End connection	Screwed upto 50 mm Nb, and Flanged above 50 mm Nb

2.24.02 **Duplex type**

(a) The strainers shall be basket type and of duplex construction. The strainer shall be provided with plugged drain/blow off and vent connections. The free area of the strainer element shall be at least four (4) times the internal area of the connecting pipe. The mesh of strainer element shall be commensurate with the actual service required. Pressure drop across the strainer in new condition shall not exceed 4.0 MWC at full flow.

(b) Wire mesh (if applicable) of the strainers shall be suitably reinforced. The material of construction of various parts shall be as follows.

Body	IS: 318, Gr. 2 up to 50 mm Nb, and IS:210, Gr. FG 260 or ASTM-A-515 Gr. 75/IS-2062 Gr. B and internally epoxy-painted above 50 mm NB.
Strainer element	Stainless steel (AISI 316)
End connection	Screwed up to 50mm Nb, and Flanged above 50 mm Nb. Gasket shall be of full face type

(c) The strainer will have a permanent stainless steel tag fixed on the strainer body indicating the strainer tag number and service and other salient data.

(d) The size of the strainer and the flow direction will be indicated on the strainer body casting.

(e) Thickness of the strainer element should be designed to withstand the pressure developed within the strainer due to 100% clogged condition exerting shut-off pressure on the element.

2.24.03 Three shop coats of paint preceded by two coats of primer shall be applied to all exposed surfaces as required to prevent corrosion.. All parts shall be adequately protected for rust prevention. The use of grease or oil other than light grade mineral oils for corrosion protection is prohibited.

TECHNICAL SPECIFICATION

FOR

COMPRESSED AIR SYSTEM

(ELECTRICAL PORTION)

1.0 EQUIPMENT & SERVICES TO BE PROVIDED BY BIDDER:

a) Services and equipment as per "Electrical Scope between BHEL and Vendor".
b) Any item/work either supply of equipment or erection material which have not been specifically mentioned but are necessary to complete the work for trouble free and efficient operation of the plant shall be deemed to be included within the scope of this specification. The same shall be provided by the bidder without any extra charge.
c) Supply of mandatory spares as specified in the specifications of mechanical equipments.
d) Erection and Commissioning spares.
e) Erection & Maintenance tools & tackles.
f) Electrical load requirement for mill reject system.
g) All equipment shall be suitable for the power supply fault levels and other climatic conditions mentioned in the enclosed project information.
h) Bidder to furnish list of makes for each equipment at contract stage, which shall be subject to customer /BHEL approval without any commercial and delivery implications to BHEL
i) Various drawings, data sheets as per required format, Quality plans, calculations, test reports, test certificates, operation and maintenance manuals etc shall be furnished as specified at contract stage. All documents shall be subject to customer/BHEL approval without any commercial implication to BHEL.
j) Motor shall meet minimum requirement of motor specification.
k) LT power & control cables shall meet minimum requirement of LT power & control cables specification.
l) Cabling, earthing & lightning protection shall meet minimum requirement of cabling, earthing & lightning protection specification.

2.0 EQUIPMENT & SERVICES TO BE PROVIDED BY PURCHASER FOR ELECTRICAL & TERMINAL POINTS:

Refer "Electrical Scope between BHEL and Vendor".

3.0 DOCUMENTS TO BE SUBMITTED ALONG WITH BID

3.1 Bidder shall confirm total compliance to the electrical specification without any deviation from the technical/quality assurance requirements stipulated. In line with this two signed and stamped copies of the following shall be furnished by the bidder as technical offer:

a) A copy of this sheet "Electrical equipment Specification for Condensate Polishing Unit" and sheet "Electrical Scope between BHEL and Vendor" with bidder's signature and company stamp.
b) List of Erection and Commissioning spares.
c) List of Erection & Maintenance tools & tackles.
d) Electrical load requirement

3.2 No technical submittal such as copies of data sheets, drawings, write-up, quality plans, type test certificates, technical literature, etc, is required during tender stage. Any such submission even if made, shall not be considered as part of offer.

4.0 List of enclosures :

a) Electrical scope between NTPC & vendor.
b) Technical specification, datasheets & quality plans for 415V Electric motors.
c) Technical Specification, datasheets & quality plans for LT power & control cables.
d) Technical Specification, datasheets & quality plans for cabling, earthing & lightning protection.
e) Electrical Load data format.

5.0 In case of conflict between any requirement mentioned in case of “General technical requirements for LV motors”(Doc No. - PE-SS-999-506-E101 Rev 00) / Technical Datasheet-A & “NTPC specification of motor”, mentioned clause in NTPC specification shall prevail.

ANNEXURE – I TO SECTION – C : STANDARD ELECTRICAL SCOPE BETWEEN BHEL AND VENDOR

PACKAGE : COMPRESSED AIR SYSTEM

PROJECT:

S.NO	DETAILS	SCOPE SUPPLY	SCOPE E&C	REMARKS
1	6.6 KV / 3.3 KV / 415 V Switchgear	NTPC	NTPC	1.6.6 kV / 3.3 kV / 415 V AC/240 V AC supply shall be provided by NTPC based on load data provided by vendor at contract stage for all equipment supplied by vendor as part of contract. DC supply (battery bank, charger etc) and any other supply as required for PLC/control panel (as applicable) shall be provided by vendor. 2. Interposing relays (RE 302 of Jyoti make or equivalent), if required for PLC and microprocessor based systems, shall be provided by NTPC in MCCs/switchgear. Requirement of these relays shall be furnished by vendor during detailed engineering stage
2	Local Push Button Station (for motors)	Vendor	Vendor	Located near the motors.
3	Power cables, control cables and screened control cables a) both end equipment in vendor's scope b) one end equipment in vendor's scope & one end in NTPC scope. c) one end equipment in Vendor's scope & one end in BHEL scope.	 Vendor NTPC Vendor	 Vendor NTPC Vendor	Sizes and quantity of cables required shall be informed by vendor at contract stage (based on inputs provided by NTPC). Finalisation of cable sizes shall be done by NTPC. Vendor shall provide lugs & glands accordingly.
4	Any special type of cable like compensating, co-axial, prefab, MICC, fibre optical etc	Vendor	Vendor	
5	Cable trays, accessories & cable trays supporting system	NTPC (Main tray) Vendor (Branch Tray)	NTPC/ BHEL site	NTPC will supply and erect the cable trays and its supporting structure in the Main cable routes both for their & vendor's cable. Vendor shall provide tray and support arrangements for his cables in the branch routes (i.e. route to each eqp, instruments, JB's, etc from the nearest main route).
6	Cable glands and lugs for equipments supplied by Vendor	Vendor	Vendor	1. Double compression Ni-Cr plated brass cable glands 2. Solder less crimping type heavy duty tinned copper lugs for power cables 3. solder less crimping type heavy duty copper lugs for control cables.
7	Conduit and conduit accessories for cabling between equipments supplied by vendor	Vendor	Vendor	Cabling shall be through conduits. However vendor can use the trunk route where available for laying of cables. Conduits shall be supplied by vendor and shall be medium duty, hot dip galvanised cold rolled mild steel rigid conduit as per IS: 9537. Makes of conduits shall be subject to NTPC/ BHEL approval at contract stage.
8	Lighting	NTPC	NTPC	

ANNEXURE – I TO SECTION – C : STANDARD ELECTRICAL SCOPE BETWEEN BHEL AND VENDOR

PACKAGE : COMPRESSED AIR SYSTEM

9	Equipment grounding & lightning protection	NTPC	NTPC	
10	Below grade grounding	NTPC	NTPC	
11	LT Motors with base plate and foundation hardware	Vendor	Vendor	Makes shall be subject to NTPC/ BHEL approval at contract stage.
12	Mandatory spares	Vendor	-	Vendor to quote as per specification.
13	Recommended O & M spares, E & C spares, erection & maintenance tools & tackle	Vendor	-	As per specification
14	Any other equipment/material/service required for completeness of system but not specified above (to ensure trouble free and efficient operation of the system).	Vendor	NTPC/ BHEL site	
15	a) Input cable schedules (C & I) b) Cable interconnection detail for the above c) Cable block diagram	Vendor Vendor Vendor	- - -	Cable listing for control cables for vendor supplied equipment (soft copies in the BHEL cable schedule format) shall be furnished during detail engineering by vendor.
16	Equipment layout drawings	Vendor	-	For ensuring cabling requirements are met, vendor shall furnish layout drawings (both in print form as well as in AUTOCAD) of the complete plant (including electrical area) indicating location and identification of all equipments requiring cabling, and shall incorporate cable routing details marked on the drawing as per PEM interface comments. Electrical equipment layout drawing shall be to BHEL approval.
17	Electrical equipment GA drawing	Vendor	-	For necessary interface review.

NOTES:

1. Make of all electrical equipments/items supplied shall be reputed make & shall be subject to approval of BHEL/NTPC after award of contract.
2. All QPs shall be subject to approval of BHEL/NTPC after award of contract without any commercial implication.
3. For skid mounted system, 2 nos. (1W+1S) supply of 415 V, 3 phase, 3 wire AC shall be provided by BHEL. Complete skid including changeover between feeder/starters/LCP/inter-locks/protection devices / any other supply etc. shall be in bidder's scope only.

B - 3

L.T. POWER CABLES

LT POWER CABLES

1.00.00 CODES & STANDARDS

1.01.00 All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions. In case of conflict between this specification and those (IS : codes, standards, etc.) referred to herein, the former shall prevail. All the cables shall conform to the requirements of the following standards and codes:

IS :1554 - I	PVC insulated (heavy duty) electric cables for working voltages upto and including 1100V.
IS : 3961	Recommended current ratings for cables
IS : 3975	Low carbon galvanised steel wires, formed wires and tapes for armouring of cables.
IS : 5831	PVC insulation and sheath of electrical cables.
IS:7098 (Part -I)	Cross linked polyethylene insulated PVC sheathed cables for working voltages upto and including 1100V.
IS : 8130	Conductors for insulated electrical cables and flexible cords.
IS : 10418	Specification for drums for electric cables.
IS : 10810	Methods of tests for cables.
ASTM-D -2843	Standard test method for density of smoke from the burning or decomposition of plastics.
IEC-754 (Part-I)	Tests on gases evolved during combustion of electric cables.
IEC-332	Tests on electric cables under fire conditions. Part-3: Tests on bunched wires or cables (Category-B).

2.00.00 TECHNICAL REQUIREMENTS

2.01.00 The cables shall be suitable for laying on racks, in ducts, trenches, conduits and under ground buried installation with chances of flooding by water.

2.02.00 Cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses developed under steady state and transient operating conditions as specified elsewhere in this specification.

2.03.00 Aluminium conductor used in power cables shall have tensile strength of more than 100 N/ sq.mm. Conductors shall be stranded.

2.04.00 XLPE insulation shall be suitable for a continuous conductor temperature of 90 deg. C and short circuit conductor temperature of 250 deg C. PVC insulation shall be suitable for continuous conductor temperature of 70 deg C and short circuit conductor temperature of 160 deg. C.

2.05.00 The cable cores shall be laid up with fillers between the cores wherever necessary. It shall not stick to insulation and inner sheath. All the cables, other than single core unarmoured cables, shall have distinct extruded PVC inner sheath of black colour as per IS : 5831.

2.06.00 For single core armoured cables, armouring shall be of aluminium wires/ formed wires. For multicore armoured cables, armouring shall be of galvanised steel as follows :

Calculated nominal dia. of cable under armour	Size and Type of armour
Upto 13 mm	1.4mm dia GS wire
Above 13 & upto 25mm	0.8 mm thick GS formed wire / 1.6 mm dia GS wire
Above 25 & upto 40 mm	0.8mm thick GS formed wire / 2.0mm dia GS wire
Above 40 & upto 55mm	1.4 mm thick GS formed wire /2.5mm dia GS wire
Above 55 & upto 70 mm	1.4mm thick GS formed wire / 3.15mm dia GS wire
Above 70mm	1.4 mm thick GS formed wire / 4.0 mm dia GS wire

2.06.01	The aluminium used for armouring shall be of H4 grade as per IS: 8130 with maximum resistivity of 0.028264 ohm mm^2 per meter at 20 deg C. The sizes of aluminium armouring shall be same as indicated above for galvanized steel.
2.06.02	The gap between armour wires / formed wires shall not exceed one armour wire / formed wire space and there shall be no cross over / over-riding of armour wire / formed wire. The minimum area of coverage of armouring shall be 90%. The breaking load of armour joint shall not be less than 95% of that of armour wire / formed wire. Zinc rich paint shall be applied on armour joint surface of G.S.wire/ formed wire.
2.07.00	Outer sheath shall be of PVC as per IS: 5831 & black in colour. In addition to meeting all the requirements of Indian standards referred to, outer sheath of all the cables shall have the following FRLS properties. (a.) Oxygen index of min. 29 (as per IS 10810 Part-58). (b.) Acid gas emission of max. 20% (as per IEC-754-I). (c.) Smoke density rating shall not be more than 60 % (as per ASTMD-2843).
2.08.00	Cores of the cables shall be identified by colouring of insulation. Following colour scheme shall be adopted: 1 core - Red, Black, Yellow or Blue 2 core - Red & Black 3 core - Red, Yellow & Blue 4 core - Red, Yellow, Blue and Black
2.09.00	For reduced neutral conductors, the core shall be black.
2.10.00	In addition to manufacturer's identification on cables as per IS, following marking shall also be provided over outer sheath. (a.) Cable size and voltage grade - To be embossed (b.) Word 'FRLS' at every 5 metre - To be embossed (c.) Sequential marking of length of the cable in metres at every one metre -To be embossed / printed The embossing shall be progressive, automatic, in line and marking shall be legible and indelible.

2.11.00	All cables shall meet the fire resistance requirement as per Category-B of IEC 332 Part-3.
2.12.00	Allowable tolerances on the overall diameter of the cables shall be +\-2 mm maximum, over the declared value in the technical data sheets.
2.13.00	In plant repairs to the cables shall not be accepted. Pimples, fish eye, blow holes etc. are not acceptable.
3.00.00	**Cable selection & sizing**
3.01.00	LT Power cables shall be sized based on the following considerations: (a) Rated current of the equipment (b) The voltage drop in the cable, during motor starting condition, shall be limited to 10% and during full load running condition, shall be limited to 3% of the rated voltage (c) Short circuit withstand capability This will depend on the feeder type. For a fuse protected circuit, cable should be sized to withstand the let out energy of the fuse.For breaker controlled feeder, cable shall be capable of withstanding the system fault current level for total breaker tripping time inclusive of relay pickup time. (d) The minimum conductor size shall be 6 sqmm for aluminium conductor cables and 2.5 sqmm for copper conductor cables. The constructional details of copper conductor cables shall be same as indicated for copper control cable.
302.00	Derating Factors Derating factors for various conditions of installations including the following shall be considered while selecting the cable sizes: a) Variation in ambient temperature for cables laid in air b) Grouping of cables c) Variation in ground temperature and soil resistivity for buried cables.
3.03.00	Cable lengths shall be considered in such a way that straight through cable joints are avoided.
3.04.00	Cables shall be armoured type if laid in switchyard area or directly buried.

3.05.00 All LT power cables of sizes more than 120 sq.mm. shall be XLPE insulated and preferable sizes are 1Cx150, 1Cx300, 1Cx630, 3Cx150 & 3Cx240 sq.mm.

4.00.00 CONSTRUCTIONAL FEATURES

(a.) **1.1 KV grade XLPE power cables** shall have compacted aluminium conductor, XLPE insulated, PVC inner sheathed (as applicable), armoured/ unarmoured, FRLS PVC outer sheathed conforming to IS:7098. (Part-I).

(b.) **1.1KV grade PVC power cables** shall have aluminium conductor (compacted type for sizes above 10 sq.mm), PVC Insulated, PVC inner sheathed, armoured/ unarmoured, FRLS PVC outer sheathed conforming to IS:1554 (Part-I).

5.00.00 CABLE DRUMS

(a) Cables shall be supplied in non returnable wooden or steel drums of heavy construction. The surface of the drum and the outer most cable layer shall be covered with water proof cover. Both the ends of the cables shall be properly sealed with heat shrinkable PVC/ rubber caps secured by 'U' nails so as to eliminate ingress of water during transportation, storage and erection. Wood preservative anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with IS: 10418.

(b) Each drum shall carry manufacturer's name, purchaser's name, address and contract number, item number and type, size and length of cable and net gross weight stencilled on both sides of the drum. A tag containing same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

(c) The standard drum length for power cables shall not be less than 500 meters. The length per drum shall be subjected to a maximum tolerance of +/- 5% of the standard drum length. The Employer shall have the option of rejecting cable drum with shorter lengths. For each size, the variance of total quantity, adding all the supplied drum lengths, from the ordered quantity, shall not exceed +/- 2%.

5.00.00 TYPE TESTS

5.01.00 General

All equipments to be supplied shall be of type tested design. During detailed engineering, the contractor shall submit for Owner's approval the reports of all the type tests as listed in this specification and carried out within last ten years from the

date of bid opening. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client /owners representative and submit the reports for approval.

All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.

The type test reports once approved for any projects shall be treated as reference. For subsequent projects of NTPC, an endorsement sheet will be furnished by the manufacturer confirming similarity and "No design Change". Minor changes if any shall be highlighted on the endorsement sheet.

5.02.00 **Type Tests**

5.02.01 The reports for the following type tests shall be submitted for one size each of LT XLPE and LT PVC Power cables. Size shall be decided by the employer during detailed engineering :

S.No.	Type test	Remarks
	For Conductor	
1.	Resistance test	
2.	Tensile test	For circular non-compacted conductors only
3.	Wrapping test	For circular non-compacted only
	For Armour Wires/ Formed Wires	
4.	Measurement of Dimensions	
5.	Tensile Test	
6.	Elongation test	

7.	Torsion test	For round wires only
8.	Wrapping test	For aluminium wires / formed wires only.
9.	Resistance test	
10(a)	Mass of zinc coating test	For GS Formed wires/wires only
10(b)	Uniformity of zinc coating	For GS Formed wires /wires only
11.	Adhesion test	For GS Formed wires/wires only
	For PVC/XLPE insulation & PVC Sheath	
12.	Test for thickness	
13.	Tensile strength & elongation tests	before ageing and after ageing
14.	Ageing in air oven	
15.	Loss of mass test	For PVC insulation and sheath only
16.	Hot deformation test	For PVC insulation and sheath only
17.	Heat shock test	For PVC insulation and sheath only
18.	Shrinkage test	
19.	Thermal stability test	For PVC insulation and sheath only
20.	Hot set test	For XLPE insulation only
21.	Water absorption test	For XLPE insulation only
22.	Oxygen index test	For outer sheath only
23.	Smoke density test	For outer sheath only

	24.	Acid gas generation test	For outer sheath only
		For completed cables	
	25.	Insulation resistance test	
		(Volume resistivity method)	
	26.	High voltage test	
	27.	Flammability test as per IEC-332 Part-3 (Category-B)	
5.02.02	**Acceptance Tests** (as per QA table)		
5.02.03	**Routine Tests** (as per QA table)		

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B - 4

L.T. CONTROL CABLES

LARA SUPER THERMAL POWER PROJECT, STAGE-I (2X800 MW) DARLIPALI SUPER THERMAL POWER PROJECT, STAGE-I (2X800 MW) GAJMARA SUPER THERMAL POWER PROJECT, STAGE-I (2X800 MW) KUDGI SUPER THERMAL POWER PROJECT, STAGE-I (3X800 MW) STEAM TURBINE GENERATOR PACKAGE	TECHNICAL SPECIFICATION SECTION-VI PART-B

LT CONTROL CABLES

1.00.00 CODES & STANDARDS

1.01.00 All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions. In case of conflict between this specification and those (IS : codes, standards, etc.) referred to herein, the former shall prevail. All the cables shall conform to the requirements of the following standards and codes :

IS :1554 - I	PVC insulated (heavy duty) electric cables for working voltages upto and including 1100V.
IS : 3961	Recommended current ratings for cables
IS : 3975	Low carbon galvanised steel wires, formed wire and tapes for armouring of cables.
IS : 4905	Methods for random sampling.
IS : 5831	PVC insulation and sheath of electrical cables.
IS : 8130	Conductors for insulated electrical cables and flexible cords.
IS : 10418	Specification for drums for electric cables.
IS : 10810	Methods of tests for cables.
ASTM-D -2843	Standard test method for density of smoke from the burning or decomposition of plastics.
IEC-754 (Part-I)	Test on gases evolved during combustion of electric cables.
IEC -332	Tests on Electric cables under fire conditions Part-3 : Tests on bunched wires or cables (category - B)

2.00.00 TECHNICAL REQUIREMENTS

2.01.00 The cables shall be suitable for laying on racks, in ducts, trenches, conduits and under ground burried installation with chances of flooding by water.

2.02.00 Cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses develop under steady state and transient operating conditions as specified elsewhere in this specification.

2.03.00 Conductor of control cables shall be made of multi stranded, plain annealed copper.

2.04.00 PVC insulation shall be suitable for continuous conductor temperature of 70 deg C and short circuit conductor temperature of 160 deg. C.

2.05.00 The cable cores shall be laid up with fillers between the cores wherever necessary. It shall not stick to insulation and inner sheath. All the cables, other than single core unarmoured cables, shall have distinct extruded PVC inner sheath of black colour as per IS : 5831.

2.06.00 For multicore armoured cables, the armouring shall be of galvanised steel as follows :-

	Calculated nominal dia of cable under armour	**Size and Type of armour**
1)	Upto 13 mm	1.4mm dia GS wire
2)	Above 13 upto 25 mm	0.8 mm thick GS formed wire / 1.6 mm dia GS wire
3)	Above 25 upto 40 mm	0.8mm thick GS formed wire / 2.0mm dia GS wire
4)	Above 40 upto 55mm	1.4 mm thick GS formed wire/ 2.5mm dia GS wire
5)	Above 55 upto 70 mm	1.4mm thick GS formed wire / 3.15mm dia GS wire
6)	Above 70mm	1.4 mm thick GS formed wire / 4.0 mm dia GS wire

The gap between armour wire / formed wire shall not exceed one armour wire / formed wire space and there shall be no cross over / over-riding of armour wire / formed wire. The minimum area of coverage of armouring shall be 90%. The breaking load of armour joint shall not be less than 95% of that of armour wire / formed wire. Zinc rich paint shall be applied on armour joint surface.

2.07.00 Outer sheath shall be of PVC(grade as applicable) and grey in colour . In addition to meeting all the requirements of Indian standards referred to, outer sheath of all the cables shall have the following FRLS properties.

(a) Oxygen index of min. 29 (As per IS:10810 (part-58))

(b) Acid gas emission of max. 20% (As per IEC-754-I).

(c) Smoke density rating shall not be more than 60% during Smoke Density Test as per ASTMD-2843.

2.08.00 Cores of the cables of upto 5 cores shall be identified by colouring of insulation. Following colour scheme shall be adopted.

1 core - Red, Black, Yellow or Blue

2 core - Red & Black

3 core - Red, Yellow & Blue

4 core - Red, Yellow, Blue and Black

5 core - Red, Yellow, Blue, Black and Grey

2.09.00 For cables having more than 5 cores, core identification shall be done by numbering the insulation of cores sequentially, starting by number 1 in the inner layer (e.g. say for 10 core cable, core numbering shall be from 1 to 10). The number shall be printed in Hindu-Arabic numerals on the outer surfaces of the cores. All the numbers shall be of the same colour, which shall contrast with the colour of insulation. The colour of insulation for all the cores shall be grey only. The numerals shall be legible and indelible. The numbers shall be repeated at regular intervals along the core, consecutive numbers being inverted in relation to each other. When the number is a single numeral, a dash shall be placed under neath it. If the number consists of two numerals, these shall be disposed one below the other and a dash placed below the lower numeral. The spacing between consecuture numbers shall not exceed 50 mm.

2.10.00 In addition to manufacturer's identification on cables as per IS, following marking shall also be provided over outer sheath :

(a) Cable size and voltage grade - To be embossed

(b) Word 'FRLS' at every 5 metre - To be embossed

(c) Sequential marking of length of the cable in metres at every one metre. - To be embossed / printed.

The embossing / printing shall be progressive, automatic, in line and marking shall be legible and indelible.

2.11.00	All cables shall meet the fire resistance requirement as per Category-B of IEC 332 Part -3.
2.12.00	Allowable tolerances on the overall diameter of the cables shall be +\-2 mm maximum over the declared value in the technical data sheets.
2.13.00	In plant repairs to the cables shall not be accepted. Pimples, fish eye, blow holes etc. are not acceptable.
2.14.00	**Cable selection & sizing**
2.14.01	LT Control cables shall be sized based on the following considerations: (a) Rated current of the equipment (b) The voltage drop in the cable, during motor starting condition, shall be limited to 10% and during full load running condition, shall be limited to 3% of the rated voltage (c) Short circuit withstand capability This will depend on the feeder type. For a fuse protected circuit, cable should be sized to withstand the let out energy of the fuse.For breaker controlled feeder, cable shall be capable of withstanding the system fault current level for total breaker tripping time inclusive of relay pickup time. (d) The minimum size of conductor shall be 1.5 sqmm
2.14.02	Derating Factors Derating factors for various conditions of installations including the following shall be considered while selecting the cable sizes: a) Variation in ambient temperature for cables laid in air b) Grouping of cables c) Variation in ground temperature and soil resistivity for buried cables.
2.14.03	Cable lengths shall be considered in such a way that straight through cable joints are avoided.
2.14.04	Cables shall be armoured type if laid in switchyard area or directly buried.

3.00.00 **CONSTRUCTIONAL FEATURES**

3.01.00 **1.1 KV Grade Control Cables**

Control Cables shall have stranded copper conductor multicore PVC insulated, PVC inner-sheathed, armoured / unarmoured, PVC outer-sheathed conforming to IS:1554. (Part-I).

3.02.00 **Cable Drums**

(a) Cables shall be supplied in non returnable wooden or steel drums of heavy construction. The surface of the drum and the outer most cable layer shall be covered with water proof layer. Both the ends of the cables shall be properly sealed with heat shrinkable PVC/ rubber caps secured by 'U' nails so as to eliminate ingress of water during transportation, storage and erection. Wood preservative anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with IS : 10418.

(b) Each drum shall carry manufacturer's name, purchaser's name, address and contract number, item number and type, size and length of cable and net gross weight stencilled on both the sides of the drum. A tag containing same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

(c.) The standard drum length for control cables shall not be less than 1000 metres. The length per drum shall be subjected to a maximum tolerance of +/- 5% of the standard drum length. The Employer shall have the option of rejecting cable drums with shorter lengths. For each size, the variance of total quantity, adding all the supplied drum lengths, from the ordered quantity, shall not exceed +/- 2%.

4.00.00 **TESTS**

4.01.00 **GENERAL**

All equipments to be supplied shall be of type tested design. During detailed engineering, the contractor shall submit for Owner's approval the reports of all the type tests as listed in this specification and carried out within last ten years from the date of bid opening. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client /owners representative and submit the reports for approval.

All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.

The type test reports once approved for any projects shall be treated as reference. For subsequent projects of NTPC, an endorsement sheet will be furnished by the manufacturer confirming similarity and "No design Change". Minor changes if any shall be highlighted on the endorsement sheet.

4.02.00 **TYPE TESTS:**

4.02.01 The Type tests reports for the following shall be submitted for one size of LT control cable :

S. No.	Type Test	Remarks
a)	**For Conductor**	
1.	Resistance test	
b)	**For Armour Wires / Formed wires**	
2.	Measurement of Dimensions	
3.	Tensile Test	
4.	Elongation test	
5.	Torsion test	For round wire only
6.	Winding test	For Formed wires
7.	Resistance test	
8.	Zinc Coating test	For G.S. conductors only.
c)	**For PVC insulation & PVC Sheath**	
9.	Test for thickness	

	10. Tensile strength and elongation test before ageing and after ageing	
	11. Ageing in air oven	
	12. Loss of mass test	For PVC insulation and sheath only
	13. Hot deformation test	For PVC insulation and sheath only
	14. Heat shock test	For PVC insulation and sheath only
	15. Shrinkage test	
	16. Thermal stability test	For PVC insulation and sheath only
	17. Oxygen index test	For outer sheath only
	18. Smoke density test	For outer sheath only
	19. Acid gas generation test	For outer sheath only
	d) **For completed cables**	
	20. Insulation resistance test (Volume resistivity method)	
	21. High voltage test	
	23. Flammability test as per IEC - 332 Part-3 (Category-B)	
4.02.02	**Acceptance Tests** (as per QA table)	
4.03.00	**Routine Tests** (as per QA table)	

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GENERAL TECHNICAL REQUIREMENTS

FOR

LV MOTORS

SPECIFICATION NO.: PE-SS-999-506-E101 Rev 00

1.0 INTENT OF SPECIFIATION

The specification covers the design, materials, constructional features, manufacture, inspection and testing at manufacturer's work, and packing of Low voltage (LV) squirrel cage induction motors along with all accessories for driving auxiliaries in thermal power station.

Motors having a voltage rating of below 1000V are referred to as low voltage (LV) motors.

2.0 CODES AND STANDARDS

Motors shall fully comply with latest edition, including all amendments and revision, of following codes and standards:

IS:325	Three phase Induction motors
IS : 900	Code of practice for installation and maintenance of induction motors
IS: 996	Single phase small AC and universal motors
IS: 4722	Rotating Electrical machines
IS: 4691	Degree of Protection provided by enclosures for rotating electrical machines
IS: 4728	Terminal marking and direction of rotation rotating electrical machines
IS: 1231	Dimensions of three phase foot mounted induction motors
IS: 8789	Values of performance characteristics for three phase induction motors
IS: 13555	Guide for selection and application of 3-phase A.C. induction motors for different types of driven equipment
IS: 2148	Flame proof enclosures for electrical appliance
IS: 5571	Guide for selection of electrical equipment for hazardous areas
IS: 12824	Type of duty and classes of rating assigned
IS: 12802	Temperature rise measurement ofr rotating electrical machnines
IS: 12065	Permissible limits of noise level for rotating electrical machines
IS: 12075	Mechnical vibration of rotatinf electrical machines

In case of imported motors, motors as per IEC-34 shall also be acceptable.

3.0 DESIGN REQUIREMENTS

3.1 Motors and accessories shall be designed to operate satisfactorily under conditions specified in data sheet-A and Project Information, including voltage & frequency variation of supply system as defined in Data sheet-A

3.2 Motors shall be continuously rated at the design ambient temperature specified in Data Sheet-A and other site conditions specified under Project Information
Motor ratings shall have at least a 15% margin over the continuous maximum demand of the driven equipment, under entire operating range including voltage & frequency variation specified above.

3.3 Starting Requirements

3.3.1 Motor characteristics such as speed, starting torque, break away torque and starting time shall be properly co-ordinated with the requirements of driven equipment. The accelerating torque at any speed with the minimum starting voltage shall be at least 10% higher than that of the driven equipment.

3.3.2 Motors shall be capable of starting and accelerating the load with direct on line starting without exceeding acceptable winding temperature.

The limiting value of voltage at rated frequency under which a motor will successfully start and accelerate to rated speed with load shall be taken to be a constant value as per Data Sheet - A during the starting period of motors.

3.3.3 The following frequency of starts shall apply

i) Two starts in succession with the motor being initially at a temperature not exceeding the rated load temperature.

ii) Three equally spread starts in an hour the motor being initially at a temperature not exceeding the rated load operating temperature. (not to be repeated in the second successive hour)

iii) Motors for coal conveyor and coal crusher application shall be suitable fro three consecutive hot starts followed by one hour interval with maximum twenty starts per day and shall be sutable fro mimimum 20,000 starts during the life time of the motor

3.4 **Running Requirements**

3.4.1 Motors shall run satisfactorily at a supply voltage of 75% of rated voltage for 5 minutes with full load without injurious heating to the motor.

3.4.2 Motor shall not stall due to voltage dip in the system causing momentary drop in voltage upto 70% of the rated voltage for duration of 2 secs.

3.5 **Stress During bus Transfer**

3.5.1 Motors shall withstand the voltage, heavy inrush transient current, mechnical and torque stress developed due to the application of 150% of the rated voltage for at least 1 sec. caused due to vector difference between the motor residual voltage and the incoming supply voltage during occasional auto bus transfer.

3.5.2 Motor and driven equipment shafts shall be adequately sized to satisfactorily withstand transient torque under above condition.

3.6 Maximum noise level measured at distance of 1.0 metres from the outline of motor shall not exceed the values specified in IS 12065.

3.7 The max. vibration velocity or double amplitude of motors vibration as measured at motor bearings shall be within the limits specified in IS: 12075.

4.0 **CONSTRUCTIONAL FEATURES**

4.1 Indoor motors shall conform to degree of protection IP: 54 as per IS: 4691. Outdoor or semi-indoor motors shall conform to degree of protection IP: 55 as per IS: 4691and shall be of weather-proof construction. Outdoor motors shall be installed under a suitable canopy

4.2 Motors upto 160KW shall have Totally Enclosed Fan Cooled (TEFC) enclosures, the method of cooling conforming to IC-0141 or IC-0151 of IS: 6362.

Motors rated above 160 KW shall be Closed Air Circuit Air (CACA) cooled

4.3 Motors shall be designed with cooling fans suitable for both directions of rotation.

4.4. Motors shall not be provided with any electric or pneumatic operated external fan for cooling the motors.

4.5 Frames shall be designed to avoid collection of moisture and all enclosures shall be provided with facility for drainage at the lowest point.

4.6 In case Class 'F' insulation is provided for LV motors, temperature rise shall be limited to the limits applicable to Class 'B' insulation.
In case of continuous operation at extreme voltage limits the temperature limits specified in table-1 of IS:325 shall not exceed by more than 10°C.

4.7 **Terminals and Terminal Boxes**

4.7.1 Terminals, terminal leads, terminal boxes, windings tails and associated equipment shall be suitable for connection to a supply system having a short circuit level, specified in the Data Sheet-A.

Unless otherwise statedin Data Sheet-A, motors of rating 110 kW and above will be controlled by circuit breaker and below 110 kW by switch fuse-contactor. The terminal box of motors shall be designed for the fault current mentioned in data sheet "A".

4.7.2 Unless otherwise specified or approved, phase terminal boxes of horizontal motors shall be positioned on the left hand side of the motor when viewed from the non-driving end.

4.7.3 Connections shall be such that when the supply leads R, Y & B are connected to motor terminals A B & C or U, V & W respectively, motor shall rotate in an anticlockwise direction when viewed from the non-driving end. Where such motors require clockwise rotation, the supply leads R, Y, B will be connected to motor terminals A, C, B or V W & V respectively.

4.7.4 Permanently attached diagram and instruction plate made preferably of stainless steel shall be mounted inside terminal box cover giving the connection diagram for the desired direction of rotation and reverse rotation.

4.7.5 Motor terminals and terminal leads shall be fully insulated with no bar live parts. Adequate space shall be available inside the terminal box so that no difficulty is encountered for terminating the cable specified in Data Sheet-A.

4.7.6 Degree of protection for terminal boxes shall be IP 55 as per IS 4691.

4.7.7 Separate terminal boxes shall be provided for space heaters.. If this is not possible in case of LV motors, the space heater terminals shall be adequately segregated from the main terminals in the main terminal box. Detachable gland plates with double compression brass glands shall be provided in terminal boxes.

4.7.8. Phase terminal boxes shall be suitable for 360 degree of rotation in steps of 90 degree for LV motors.

4.7.9 Cable glands and cable lugs as per cable sizes specified in Data Sheet-A shall be included. Cable lugs shall be of tinned Copper, crimping type.

4.8 Two separate earthing terminals suitable for connecting G.I. or MS strip grounding conductor of size given in Data Sheet-A shall be provided on opposite sides of motor frame. Each terminal box shall have a grounding terminal.

4.9 **General**

4.9.1 Motors provided for similar drives shall be interchangeable.

4.9.2 Suitable foundation bolts are to be supplied alongwith the motors.

4.9.3 Motors shall be provided with eye bolts, or other means to facilitate safe lifting if the weight is 20Kgs. and above.

4.9.4 Necessary fitments and accessories shall be provided on motors in accordance with the latest Indian Electricity rules 1956.

4.9.5 All motors rated above 30 kW shall be provided with space heaters to maintain the motor internal air temperature above the dew point. Unless otherwise specified, space heaters shall be suitable for a supply of 240V AC, single phase, 50 Hz.

4.9.6 Name plate with all particulars as per IS: 325 shall be provided

4.9.7 Unless otherwise specified, the colour of finish shall be grey to Shade No. 631 and 632 as per IS:5 for motors installed indoor and outdoor respectively. The paint shall be epoxy based and shall be suitable for withstanding specified site conditions.

5.0 **INSPECTION AND TESTING**

5.1 All materials, components and equipments covered under this specification shall be procured, manufactured, as per the BHEL standard quality plan No. PED-506-00-Q-006/0 and PED-506-00-Q-007/2 enclosed with this specification and which shall be complied.

5.2 LV motors of type-tested design shall be provided. Valid type test reports not more than 5 year shall be furnished. In the absence of these, type tests shall have to be conducted by manufacturer without any commercial implication to purchaser.

5.3 All motors shall be subjected to routine tests as per IS: 325 and as per BHEL standard quality plan.

5.4 Motors shall also be subjected to additional tests, if any, as mentioned in Data Sheet A.

6.0 **DRAWINGS TO BE SUBMITTED AFTER AWARD OF CONTRACT**

a) OGA drawing showing the position of terminal boxes, earthing connections etc.
b) Arrangement drawing of terminal boxes.
c) Characteristic curves:
(*To be given for motor above 55 kW unless otherwise specified in Data Sheet*).

i) Current vs. time at rated voltage and minimum starting voltage.
ii) Speed vs. time at rated voltage and minimum starting voltage.
iii) Torque vs. speed at rated voltage and minimum voltage.
For the motors with solid coupling the above curves i), ii), iii) to be furnished for the motors coupled with driven equipment. In case motor is coupled with mechanical equipment by fluid coupling, the above curves shall be furnished with and without coupling.
iv) Thermal withstand curve under hot and cold conditions at rated voltage and max. permissible voltage.

	TITLE	SPECIFICATION NO.
	LV MOTORS	VOLUME II B
		SECTION D
	DATA SHEET-A	REV NO. DATE
		SHEET 1 OF 1

1.0	Design ambient temperature	:	50 ^{o}C
2.0	Maximum acceptable kW rating of LV motor	:	200 KW
3.0	Installation (Indoors/ Outdoors)	:	As required
4.0	Details of supply system		
	a) Rated voltage (with variation)	:	415V ± 10%, 11/3.3kV ± 6%,
	b) Rated frequency (with variation)	:	50 Hz +3% & -5%
	c) Combined voltage & freq. variation	:	10% (sum of absolute values)
	d) System fault level at rated voltage	:	40 kA for 1 sec for 11kV & 3.3kV 45 kA for 1 sec for 415V system
	e) LV System grounding	:	Solidly
5.0	Class of insulation	:	Class 'F', with temp rise limited to Class B.
6.0	Minimum voltage for starting (As percentage of rated voltage)	:	80% of rated voltage
7.0	Space heater supply	:	240 V, 1¢ , 50 Hz
8.0	Rating up to which Single phase motor	:	Acceptable below 0.2 kW
9.0	Locked rotor current		
	a) Limit as percentage of FLC	:	Details as per spec attached
	b) Permissible tolerance, if any	:	±20%
10.0	Energy Efficient Motors	:	Details as per spec attached
11.0	Additional tests	:	As per QP
12.0	Flame-proof motor		
	a) Enclosure suitable (As per IS:2148)	:	As per requirement
	b) Classification of Hazardous area (As per IS: 5572 part-I)	:	As per requirement
13			
.0	Makes	:	ABB/ Bharat Bijlee/ CGL / KEC/ NGEF/Siemens/ALSTOM (SUBJECT TO CUSTOMER APPROVAL DURING DETAILED ENGG)

Note: **Motor name plate rating at 50°C shall have at least 10% margin over input power requirement at rated duty point unless otherwise stated in driven equipment specification**

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B - 2

MOTORS

LARA SUPER THERMAL POWER PROJECT, STAGE-I (2X800 MW) DARLIPALI SUPER THERMAL POWER PROJECT, STAGE-I (2X800 MW) GAJMARA SUPER THERMAL POWER PROJECT, STAGE-I (2X800 MW) KUDGI SUPER THERMAL POWER PROJECT, STAGE-I (3X800 MW) STEAM TURBINE GENERATOR PACKAGE	TECHNICAL SPECIFICATION SECTION-VI PART-B

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MOTORS

1.00.00 GENERAL REQUIREMENTS

1.01.00 For the purpose of design of equipment/systems, an ambient temperature of 50 deg. Centigrade and relative humidity of 95% (at 40 deg C) shall be considered. The equipment shall operate in a highly polluted environment.

1.02.00 All equipments shall be suitable for rated frequency of 50 Hz with a variation of +3% & -5%, and 10% combined variation of voltage and frequency unless specifically brought out in the specification.

1.03.00 Contractor shall provide fully compatible electrical system, equipments, accessories and services.

1.04.00 All the equipment, material and systems shall, in general, conform to the latest edition of relevant National and international Codes & Standards, especially the Indian Statutory Regulations.

1.05.00 The auxiliary AC voltage supply arrangement shall have 11kV, 3.3 kV and 415V systems and DC voltage shall be 220 V. It shall be designed to limit voltage variations as given below under worst operating condition :

(a) 11kV, 3.3 kV +/- 6%

(b) 415/240V +/- 10%

(c) 220 V DC -15% to +10%. However the nominal continuous DC power supply shall be 242V.

1.06.00 The voltage level for motors shall be as follows :-

a) Upto 0.2KW : Single phase 240V AC / 3 phase 415V AC

b) Above 0.2KW and upto 200KW : 3 phase 415V AC — S no 116 Amdt: 7/14 d-4 : 9/2..

c) Above 200KW and upto 1500 KW: 3.3 kV

d) Above 1500 KW : 11 kV

1.07.00 Fault level shall be limited to 40kA RMS for 1 second for 11kV & 3.3 kV system and 45 kA RMS 1 second for 415V system. 415V system shall be solidly grounded and 220 VDC system shall be isolated type.

1.08.00 Paint shade shall be as per RAL 5012 (Blue) for indoor and outdoor equipment.

1.09.00 The responsibility of coordination with electrical agencies and obtaining all necessary clearances shall be of the contractor. — S.no - 117/Amdt-4

1.10.00 Degree of Protection

Degree of protection for various enclosures as per IS:4691, IEC60034-05 shall be as follows :-

i)	Indoor motors	-	IP 54
ii)	Outdoor motors	-	IP 55
iii)	Cable box-indoor area	-	IP 54
iv)	Cable box-Outdoor area	-	IP 55

2.00.00 CODES AND STANDARDS

1)	Three phase induction motors	:	IS:325, IEC:60034
2)	Single phase AC motors	:	IS:996, IEC:60034
3)	Crane duty motors	:	IS:3177, IEC:60034
4)	DC motors/generators	:	IS:4722
5)	Energy Efficient motors	:	IS 12615, IEC:60034-30

3.00.00 TYPE

3.01.00 **AC Motors:**

a) Squirrel cage induction motor suitable for direct-on-line starting.

b) Continuous duty LT motors upto 160 KW Output rating (at 50 deg.C ambient temperature), shall be Energy Efficient motors, Efficiency class-Eff 1, conforming to IS 12615, or High efficiency (IE2) as per IEC:60034-30.

c) Crane duty motors shall be slip ring/ squirrel cage Induction motor as per the requirement.

3.02.00 DC Motors Shunt wound.

4.00.00 RATING

(a) Continuously rated (S1). However, crane motors shall be rated for S4 duty, 40% cyclic duration factor.

(b) Whenever the basis for motor ratings are not specified in the corresponding mechanical specification sub-sections, maximum continuous motor ratings shall be at least 10% above the maximum load demand of the driven

equipment under entire operating range including voltage and frequency variations.

(c) For BFP motors starting MVA shall be restricted to 80 MVA. S.vw-118 Amdt-4 dtd. 25/8

5.00.00 **TEMPERATURE RISE**

Air cooled motors

70 deg. C by resistance method for both thermal class 130(B) & 155(F) insulation.

Water cooled

80 deg. C over inlet cooling water temperature mentioned elsewhere, by resistance method for both thermal class 130(B) & 155(F) insulation.

6.00.00 **OPERATIONAL REQUIREMENTS**

6.01.00 **Starting Time**

6.01.01 For motors with starting time upto 20 secs. at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be at least 2.5 secs. more than starting time.

6.01.02 For motors with starting time more than 20 secs. and upto 45 secs. at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be at least 5 secs. more than starting time.

6.01.03 For motors with starting time more than 45 secs. at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be more than starting time by at least 10% of the starting time.

6.01.04 Speed switches mounted on the motor shaft shall be provided in cases where above requirements are not met.

6.02.00 **Torque Requirements**

6.02.01 Accelerating torque at any speed with the lowest permissible starting voltage shall be at least 10% motor full load torque.

6.02.02 Pull out torque at rated voltage shall not be less than 205% of full load torque. It shall be 275% for crane duty motors.

6.03.00 **Starting voltage requirement**

(a) 85% below 110 KW

(b) 80% from 110 KW to 200 KW

(c) 85% above 200 KW to 1000 KW

(d) 80% from 1001 KW to 4000 KW

(e) 75% above 4000KW

Except AOP & JOP motors running on D.G emergency supply, starting voltage shall be 80%.

7.00.00 DESIGN AND CONSTRUCTIONAL FEATURES

7.01.00 Suitable single phase space heaters shall be provided on motors rated 30KW and above to maintain windings in dry condition when motor is standstill. Separate terminal box for space heaters & RTDs shall be provided. However for flame proof motors , space heater terminals inside the main terminal box may be acceptable.

7.02.00 All motors shall be either Totally enclosed fan cooled (TEFC) or totally enclosed tube ventilated (TETV) or Closed air circuit air cooled (CACA) type. However, motors rated 3000KW or above can be Closed air circuit water cooled (CACW). CW motors can be screen protected drip proof (SPDP) type. Motors and EPB located in hazardous areas shall have flame proof enclosures conforming to IS:2148 as detailed below

(a)	Fuel oil area	:	Group – IIB
(b)	Hydrogen generation		:Group - IIC (or Group-I, Div-II as per plant area NEC) or (Class-1, Group-B, Div-II as per NEMA /IEC60034)

7.03.00 Winding and Insulation

(a)	Type	:	Non-hygroscopic, oil resistant, flame resistant
(b)	Starting duty	:	Two hot starts in succession, with motor initially at normal running temperature.
(c)	11kV & 3.3 kV AC motors	:	Thermal class 155 (F) insulation. The winding insulation process shall be total Vacuum Presure Impregnated i.e resin poor method. The lightning Impulse & interturn insulation surge withstand level shall be as per IEC-60034 part-15
(d)	240VAC, 415V AC & 220V DC motors	:	Thermal Class(B) or better

7.04.00 Motors rated above 1000KW shall have insulated bearings to prevent flow of shaft currents.

CLAUSE NO.	TECHNICAL REQUIREMENTS
7.05.00	Motors with heat exchangers shall have dial type thermometer with adjustable alarm contacts to indicate inlet and outlet primary air temperature.
7.06.00	Noise level for all the motors shall be limited to 85dB(A) except for BFP motor for which the maximum limit shall be 90dB(A). Vibration shall be limited within the limits prescribed in IS:12075 / IEC 60034-14 . Motors shall withstand vibrations produced by driven equipment. HT motor bearing housings shall have flat surfaces, in both X and Y directions, suitable for mounting 80mmX80mm vibration pads.
7.07.00	In HT motors, at least four numbers simplex / two numbers duplex platinum resistance type temperature detectors shall be provided in each phase stator winding. Each bearing of HT motor shall be provided with dial type thermometer with adjustable alarm contact and preferably 2 numbers duplex platinum resistance type temperature detectors.
7.08.00	Motor body shall have two earthing points on opposite sides.
7.09.00	HT motors can be offered with either elastimould termination or dust tight phase separated double walled (metallic as well as insulated barrier) cable boxes. In case elastimould terminations are offered, then protective cover and trifurcating sleeves shall also be provided. In case cable box is offered, then Employer shall provide termination kit. Removable gland plates of thickness 3 mm (hot/cold rolled sheet steel) or 4 mm (non magnetic material for single core cables) shall be provided in case of cable boxes.
7.10.00	The spacing between gland plate & centre of terminal stud shall be as per Table-I.
7.11.00	All motors shall be so designed that maximum inrush currents and locked rotor and pullout torque developed by them at extreme voltage and frequency variations do not endanger the motor and driven equipment.
7.12.00	The motors shall be suitable for bus transfer schemes provided on the 11kV, 3.3 kV /415V systems without any injurious effect on its life.
7.13.00	For motors rated 2000 KW & above, neutral current transformers of PS class shall be provided on each phase in a separate neutral terminal box.
7.14.00	11kV and 3.3 kV motor Terminal Box shall be suitable for fault level of 750MVA for 0.12 sec and 250 MVA for 0.12 sec respectively. Elastimould termination kit shall be suitable for fault level of 25 KA for 0.17 seconds.
7.15.00	The size and number of cables (for HT and LT motors) to be intimated to the successful bidder during detailed engineering and the contractor shall provide terminal box suitable for the same.
8.00.00	The ratio of locked rotor KVA at rated voltage to rated KW shall not exceed the following (without any further tolerance) except for BFP motor.

	(a) Below 110KW : 10.0 (b) From 110 KW & upto 200 KW : 9.0 (c) Above 200 KW & upto 1000KW : 10.0 (d) From 1001KW & upto 4000KW : 9.0 (e) Above 4000KW : 6 to 6.5
10.00.00	**TYPE TEST**
10.01.00	**HT MOTORS**
10.01.01	The contractor shall carry out the type tests as listed in this specification on the equipment to be supplied under this contract. The bidder shall indicate the charges for each of these type tests separately in the relevant schedule of Section - VII-(BPS) and the same shall be considered for the evaluation of the bids. The type tests charges shall be paid only for the test(s) actually conducted successfully under this contract and upon certification by the employer's engineer.
10.01.02	The type tests shall be carried out in presence of the employer's representative, for which minimum 15 days notice shall be given by the contractor. The contractor shall obtain the employer's approval for the type test procedure before conducting the type test. The type test procedure shall clearly specify the test set–up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.
10.01.03	In case the contractor has conducted such specified type test(s) within last ten years as on the date of bid opening, he may submit during detailed engineering the type test reports to the owner for waival of conductance of such test(s). These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client. The owner reserves the right to waive conducting of any or all the specified type test(s) under this contract. In case type tests are waived, the type test charges shall not be payable to the contractor.
10.01.04	Further the Contractor shall only submit the reports of the type tests as listed in "LIST OF TESTS FOR WHICH REPORTS HAVE TO BE SUBMITTED"and carried out within last ten years from the date of bid opening. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client. However if the

contractor is not able to submit report of the type test(s) conducted within last ten years from the date of bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client/owners representative and submit the reports for approval.

10.01.05 **LIST OF TYPE TESTS TO BE CONDUCTED**

The following type tests shall be conducted on each type and rating of HT motor

(a) No load saturation and loss curves upto approximately 115% of rated voltage

(b) Measurement of noise at no load.

(c) Momentary excess torque test (subject to test bed constraint).

(d) Full load test(subject to test bed constraint)

(e) Temperature rise test at rated conditions. During heat run test, bearing temp., winding temp.,coolant flow and its temp. shall also be measured. In case the temperature rise test is carried at load other than rated load,

specific approval for the test method and procedure is required to be obtained. Wherever ETD's are provided, the temperature shall be measured by ETD's also for the record purpose.

(f) Lightning Impulse withstand test on the sample coil shall be as per clause no. 4.3 IEC-60034, part-15

(g) Surge-withstand test on interturn insulation shall be as per clause no. 4.2 of IEC 60034, part-15

10.01.06 **LIST OF TESTS FOR WHICH REPORTS HAVE TO BE SUBMITTED**

The following type test reports shall be submitted for each type and rating of HT motor

(a) Degree of protection test for the enclosure followed by IR, HV and no load run test.

(b) Terminal box-fault level withstand test for each type of terminal box of HT motors only.

10.02.00 **LT Motors**

10.02.01 LT Motors supplied shall be of type tested design. During detailed engineering, the contractor shall submit for Owner's approval the reports of all the type tests as listed in this specification and carried out within last *ten* years from the date of bid opening.

These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

10.02.02 However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client/owners representative and submit the reports for approval.

10.02.03 **LIST OF TESTS FOR WHICH REPORTS HAVE TO BE SUBMITTED**

The following type test reports shall be submitted for each type and rating of LT motor of above 50 KW only

1. Measurement of resistance of windings of stator and wound rotor.
2. No load test at rated voltage to determine input current power and speed
3. Open circuit voltage ratio of wound rotor motors (in case of Slip ring motors)
4. Full load test to determine efficiency power factor and slip .
5. Temperature rise test .
6. Momentary excess torque test.
7. High voltage test .
8. Test for vibration severity of motor.
9. Test for noise levels of motor(Shall be limited as per clause no 7.06.00 of this section)
10. Test for degree of protection and
11. Overspeed test.
12. Type test reports for motors located in fuel oil area having flame proof enclosures as per IS 2148 / IEC 60079-1

10.03.00 All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.

CLAUSE NO.	TECHNICAL REQUIREMENTS
10.04.00	The type test reports once approved for any projects shall be treated as reference. For subsequent projects of NTPC, an endorsement sheet will be furnished by the manufacturer confirming similarity and "No design Change". Minor changes if any shall be highlighted on the endorsement sheet.

TABLE - I

DIMENSIONS OF TERMINAL BOXES FOR LV MOTORS

Motor MCR in KW	Minimum distance between centre of stud and gland plate in mm
UP to 3 KW	As per manufacturer's practice.
Above 3 KW - upto 7 KW	85
Above 7 KW - upto 13 KW	115
Above 13 KW - upto 24 KW	167
Above 24 KW - upto 37 KW	196
Above 37 KW - upto 55 KW	249
Above 55 KW - upto 90 KW	277
Above 90 KW - upto 125 KW	331
Above 125 KW-upto 200 KW	203

For HT motors the distance between gland plate and the terminal studs shall not be less than 500 mm.

PHASE TO PHASE/ PHASE TO EARTH AIR CLEARANCE:

NOTE: Minimum inter-phase and phase-earth air clearances for LT motors with lugs installed shall be as follows:

Motor MCR in KW	Clearance
UP to 110 KW	10mm
Above 110 KW and upto 150 KW	12.5mm
Above 150 KW	19mm

	TITLE	SPECIFICATION NO.
	MOTOR	VOLUME II B
		SECTION D
	DATA SHEET - C	REV NO. 00 DATE 28.01.10
		SHEET 1 OF 2

S. No.	Description		Data to be filled by successful bidder
A.	**General**		
1	Manufacturer & country of origin		
2	Motor type		
3	Type of starting		
4	Name of the equipment driven by motor & Quantity		
5	Maximum Power requirement of driven equipment		
6	Rated speed of Driven Equipment		
7	Design ambient temperature		
B.	**Design and Performance Data**		
1	Frame size & type designation		
2	Type of duty		
3	Rated Voltage		
4	Permissible variation for		
5	a	Voltage	
6	b	Frequency	
7	c)	Combined voltage & frequency	
8	Rated output at design ambient temp (by resistance method)		
9	Synchronous speed & Rated slip		
10	Minimum permissible starting voltage		
11	Starting time in sec with mechanism coupled		
12	a) At rated voltage		
13	b) At min starting voltage		
14	Locked rotor current as percentage of FLC (including IS tolerance)		
15	Torque		
	a) Starting		
	b) Maximum		
16	Permissible temp rise at rated output over ambient temp & method		
17	Noise level at 1.0 m (dB		
18	Amplitude of vibration		
19	Efficiency & P.F. at rated voltage & frequency		
	a) At 100% load		
	c) At 75% load		

NAME OF VENDOR					
			SEAL	REV.	
NAME	SIGNATURE	DATE			

S. No.	Description	Data to be filled by successful bidder
	c) At starting	
C.	**Constructional Features**	
1	Method of connection of motor driven equipment	
2	Applicable Standard	
3	DOP of Enclosure	
4	Method of cooling	
5	Class of insulation	
6	Main terminal box	
	a) Type	
	b) Power Cable details (Conductor, size, armour/unarmour)	
	c) Cable Gland & lugs details (Size, type & material)	
	d) Permissible Fault level (kArms & duration in sec)	
7	Space heater details (Voltage & watts)	
8	Flame proof motor details (if applicable)	
	a) Enclosure	
	b) suitability for hazardous area	
	i Zone	O / I / II
	ii Group	IIA / IIB / IIC
9	No. of Stator winding	
10	Winding connection	
11	Kind of rotor winding	
12	Kind of bearings	
13	Direction of rotation when viewed from NDE	
14	Paint Shade & type	
15	Net weight of motor	
16	Outline mounting drawing No (To be enclosed as annexure)	
D.	**Characteristic curves/ drawings** (To be enclosed for motors of rating ≥ 55KW)	
	a) Torque speed characteristic	
	b) Thermal withstand characteristic	
	c) Current vs time	
	d) Speed vs time	

NAME OF VENDOR			SEAL	REV.	
NAME	SIGNATURE	DATE			

			CUSTOMER :			PROJECT TITLE			SPECIFICATION : NUMBER :			
		QUALITY PLAN	BIDDER/ VENDOR :			QUALITY PLAN NUMBER PED-506-00-Q-007/2			SPECIFICATION : TITLE			
		SHEET 1 OF 9	SYSTEM			ITEM: AC ELECT. MOTORS 75KW & ABOVE (LV & MV)			SECTION			VOLUME III
SL. NO.	COMPONENT/OPERATION	CHARACTERISTIC CHECK	CAT.	TYPE/ METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY			REMARKS
									P	**W**	**V**	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**			**11**
1.0	RAW MATERIAL & BROUGHT CONTROL											
1.1	SHEET STEEL, PLATES, SECTION, EYEBOLTS	1.SURFACE CONDITION	MA	VISUAL	100%	-	FREE FROM BLINKS, CRACKS, WAVINESS ETC	LOG BOOK	3	-	-	
		2.DIMENSIONS	MA	MEASUREMENT	SAMPLE	MANFR'S DRG./SPEC	MANFR'S DRG./SPEC	-DO-	3	-	-	
		3.PROOF LOAD TEST (EYE BOLT)	MA	MECH. TEST	-DO-	-DO-	-DO-	INSPEC. REPORT	3	-	-	
1.2	HARDWARES	1.SURFACE CONDITION	MA	VISUAL	100%		FREE FROM CRACKS, UN-EVENNESS ETC.	-DO-	3	-	-	
		2.PROPERTY CLASS	MA	VISUAL	SAMPLES	MANFR'S DRG./SPEC BOOK	RELEVENT IS/SPEC.	SUPPLIERS TC & LOG	3	-	2	PROPERTY CLASS MARKING SHALL BE CHECKED BY THE VENDOR
1.3	CASTING	1.SURFACE CONDITION	MA	VISUAL	100%		FREE FROM CRACKS, BLOW HOLES ETC.	LOG BOOK	3	-	-	
		2.CHEM. & PHY. PROP.	MA	CHEM & MECH TEST	1/HEAT NO.	MANFR'S DRG./SPEC	RELEVENT IS/	SUPPLIER'S TC	3	-	2	HEAT NO. SHALL BE VERIFIED
		3.DIMENSIONS	MA	MEASUREMENT	100%	MANUFR'S DRG.	MANUFR'S DRG.	LOG BOOK	3	-	-	
1.4	PAINT & VARNISH	1.MAKE, SHADE, SHELF LIFE & TYPE	MA	VISUAL	100% CONTINUOUS	MANFR'S DRG./SPEC	MANFR'S DRG./SPEC	LOG BOOK	3	-	-	
BHEL			**PARTICULARS**		**BIDDER/VENDOR**							

			CUSTOMER :			PROJECT TITLE			SPECIFICATION : NUMBER :			
		QUALITY PLAN	BIDDER/ VENDOR :			QUALITY PLAN NUMBER PED-506-00-Q-007/2			SPECIFICATION : TITLE			
		SHEET 2 OF 9	SYSTEM			ITEM: AC ELECT. MOTORS 75KW & ABOVE (LV & MV)			SECTION			VOLUME III
SL. NO.	COMPONENT/OPERATION	CHARACTERISTIC CHECK	CAT.	TYPE/ METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY			REMARKS
									P	**W**	**V**	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**			**11**
1.5	SHAFT (FORGED OR ROLLED)	1. SURFACE COND.	MA	VISUAL	100%	-	FREE FROM VISUAL DEFECTS	-DO-	3	-	-	VENDOR'S APPROVAL IDENTIFICATION SHALL BE MAINTAINED
		2. CHEM. & PHYSICAL PROPERTIES	MA	CHEM. & PHYSICAL TESTS	1/HEAT NO. OR HEAT TREATMENT BATCH NO	MFG. DRG. SPEC.	RELEVANT IS	SUPPLIER'S TC	3	-	2	
		3. DIMENSIONS	MA	MEASUREMENT	100%	-DO-	MANUFR'S DRG.	LOG BOOK	3	-	-	
		4.INTERNAL FLOWS	CR	UT	-DO-	ASTM-A388	MANUFR'S SPEC. BHEL SPEC.	-DO-	3	2	1	FOR DIA OF 55 MM & ABOVE
1.6	SPACE HEATERS, CONNEC-TORS, TERMINAL BLOCKS, CABLES, CABLE LUGS, CARBON BRUSH TEMP. DETECTORS, RTD, BTD'S	1. MAKE & RATING	MA	VISUAL	-DO-	MANUFR'S DRG. SPEC.	MANUFR'S DRG. SPEC.	-DO-	3	-	-	
		2. PHYSICAL COND.	MA	-DO-	-DO-	-	NO BREAKAGE ON OTHER PHY. DESIGN	-DO-	3	-	-	
		3.DIMENSIONS (WHEREVER APPLICABLE)	MA	MEASUREMENT	SAMPLE	MANUFR'S DRG./ SPEC.	MANUFR'S DRG. / SPEC.	-DO-	3	-	-	
		4.PERFORMANCE/ CALIBRATION	MA	TEST	100%	-DO-	-DO-	INSP. REPORT	3	-	-	

BHEL	**PARTICULARS**	**BIDDER/VENDOR**	
	NAME		
	SIGNATURE		
	DATE		BIDDER'S/VENDORS COMPANY SEAL

			CUSTOMER :			PROJECT TITLE			SPECIFICATION : NUMBER :			
		QUALITY PLAN	BIDDER/ VENDOR :			QUALITY PLAN NUMBER PED-506-00-Q-007/2			SPECIFICATION : TITLE			
		SHEET 3 OF 9	SYSTEM			ITEM: AC ELECT. MOTORS 75KW & ABOVE (LV & MV)			SECTION			VOLUME III
SL. NO.	COMPONENT/OPERATION	CHARACTERISTIC CHECK	CAT.	TYPE/ METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY			REMARKS
									P	**W**	**V**	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**			**11**
1.7	OTHER INSULATING MATERIALS LIKE SLEEVES, BINDINGS CORDS, PAPERS, PRESS BOARDS ETC.	1. SURFACE COND.	MA	VISUAL	100%	-	NO VISUAL DEFECTS	INSPT. REPORT	3	-	-	
		2. OTHER CHARACTERISTICS	MA	TEST	SAMPLE	MANUF'S SPEC.	MANUF'S SPEC.	LOG BOOK AND OR SUPPLIER'S TC	3	-	2	
1.8	SHEET STAMPING (PUNCHED)	1. SURFACE COND.	MA	VISUAL	100%	-	NO VISUAL DEFECTS (FREE FROM BURS)	LOG BOOK	3	-	-	
		2.DIMENSIONS INCLUDING BURS HEIGHT	MA	MEASUREMENT	SAMPLE	MANUFR'S DRG. .	MANUFR'S DRG.	-DO-	3	-	2	FOR MV MOTOR INSULA-TION/VARNISH THICKNESS SHALL BE MORE THAN THE BURS HEIGHT
		3. ACCEPTANCE TESTS	MA	ELECT. & MECH TESTS	-DO-	MANUF'S SPEC./ RELEVANT IS	RELEVANT IS	SUPPLIER'S TC	3	-	2	
1.9	CONDUCTORS	1. SURFACE FINISH	MA	VISUAL	100%	-	FREE FROM VISUAL DEFECTS	LOG BOOK	3	-	-	
		2.ELECT. PROP, & MECH. PROP	MA	ELECT. & MECH.TEST	SAMPLES	RELEVANT IS/ BS OR OTHER STANDARDS	RELEVANT IS/ BS OR OTHER STANDARDS	SUPPLIERS TC & VENDOR'S INSPN. REPORTS	3/2	-	2	

BHEL	**PARTICULARS**	**BIDDER/VENDOR**	
	NAME		
	SIGNATURE		
	DATE		BIDDER'S/VENDORS COMPANY SEAL

			CUSTOMER :			PROJECT TITLE			SPECIFICATION : NUMBER :			
		QUALITY PLAN	BIDDER/ VENDOR :			QUALITY PLAN NUMBER PED-506-00-Q-007/2			SPECIFICATION : TITLE			
		SHEET 4 OF 9	SYSTEM			ITEM: AC ELECT. MOTORS 75KW & ABOVE (LV & MV)			SECTION			VOLUME III
SL. NO.	COMPONENT/OPERATION	CHARACTERISTIC CHECK	CAT.	TYPE/ METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY			REMARKS
									P	**W**	**V**	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**			**11**
		3.DIMENSIONS	MA	MEASUREMENT	-DO-	-DO-	-DO-	Log Book	3	-	-	
1.10	BEARINGS	1.MAKE & TYPE	MA	VISUAL	100%	MANFR'S DRG.	MANFR'S DRG.	-DO-	3	-	-	
		2.DIMENSIONS	MA	MEASUREMENT	SAMPLE	BHEL DATA SHEET	BHEL DATA SHEET BEARING MANUF'S CATALOGUES	-DO-	3	-	-	
		3.SURFACE FINISH	MA	VISUAL	100%	-	FREE FROM VISUAL DEFECTS	-DO-	3	-	-	
1.11	SLIP RING	1.SURFACE COND.	MA	VISUAL	100%	-	-DO-	-DO-	3	-	-	
		2.DIMENSIONS	MA	MEASUREMENT	SAMPLE	MANUF'S DRG	MANUF'S DRG	-DO-	3	-	-	
		3.TEMP.WITH-STAND CAPACITY	MA	ELECT.TEST	-DO-	MANUF'S SPEC.	MANUF'S SPEC.	-DO-	3	-	-	
		4.HV/IR	MA	-DO-	100%	-DO-	-DO-	-DO-	3	-	-	
1.12	OIL SEALS & GASKETS	1.MATERIAL OF GASKET	MA	VISUAL	100%	MANUF'S DRG/SPECS	MANUF'S DRG./ SPECS.	-DO-	3	-	-	
		2.SURFACE COND.	MA	VISUAL	100%	-	FREE FROM VISUAL DEFECTS	-DO-	3	-	-	
		3.DIMENSIONS	MA	MEASUREMENT	SAMPLE	MANUF'S DRG	MANUF'S DRG	-DO-	3	-	-	
BHEL			**PARTICULARS**		**BIDDER/VENDOR**							
			NAME									
			SIGNATURE									

			CUSTOMER :			PROJECT TITLE			SPECIFICATION : NUMBER :			
		QUALITY PLAN	BIDDER/ VENDOR :			QUALITY PLAN NUMBER PED-506-00-Q-007/2			SPECIFICATION : TITLE			
		SHEET 5 OF 9	SYSTEM			ITEM: AC ELECT. MOTORS 75KW & ABOVE (LV & MV)			SECTION			VOLUME III
SL. NO.	COMPONENT/OPERATION	CHARACTERISTIC CHECK	CAT.	TYPE/ METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY			REMARKS
									P	**W**	**V**	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**			**11**
2.0	IN PROCESS											
2.1	STATOR FRAME WELDING (IN CASE OF FABRICATED STATOR)	1.WORKMANSHIP & CLEANNESS	MA	VISUAL	100%	-DO-	GOOD FINISH	LOG BOOK	3	-	-	
		2.DIMENSIONS	MA	MEASUREMENT	-DO-	MANUF'S DRG	MANUF'S DRG	-DO-	3	-	-	
2.2	MACHINING	1.FINISH	MA	VISUAL	100%	-DO-	GOOD FINISH	LOG BOOK	3	-	-	
		2.DIMENSIONS	MA	MEASUREMENT	-DO-	MANUF'S DRG	MANUF'S DRG	-DO-	3	-	-	
		3.SHAFT SURFACE FLOWS	MA	PT	-DO-	RELEVENT SPEC./ ASTM-E165	MANUFR'S SPEC./ BHEL SPEC./	-DO-	3	-	1	
2.3	PAINTING	1.SURFACE PREPARATION	MA	VISUAL	100%	MANFR'S SPEC/BHEL SPEC./ RELEVANT STAND	BHEL SPEC. SAME AS COL.7	LOG BOOK	3	-	-	
		2.PAINT THICKNESS (BOTH PRIMER & FINISH COAT)	MA	MEASUREMENT BY ELCOMETER	SAMPLE	-DO-	-DO-	-DO-	3	-	2	
		3.SHADE	MA	VISUAL	-DO-	-DO-	-DO-	Log Book	3	-	-	
		4.ADHESION	MA	CROSS CUTTING & TAPE TEST	-DO-	-DO-	-DO-	Log Book	3	-	-	

BHEL	**PARTICULARS**	**BIDDER/VENDOR**	
	NAME		
	SIGNATURE		
	DATE		BIDDER'S/VENDORS COMPANY SEAL

			CUSTOMER :			PROJECT TITLE			SPECIFICATION : NUMBER :			
		QUALITY PLAN	BIDDER/ VENDOR :			QUALITY PLAN NUMBER PED-506-00-Q-007/2			SPECIFICATION : TITLE			
		SHEET 6 OF 9	SYSTEM			ITEM: AC ELECT. MOTORS 75KW & ABOVE (LV & MV)			SECTION			VOLUME III
SL. NO.	COMPONENT/OPERATION	CHARACTERISTIC CHECK	CAT.	TYPE/ METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY			REMARKS
									P	**W**	**V**	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**			**11**
2.4	SHEET STACKING	1.COMPLETENESS	MA	MEASUREMENT	SAMPLE	MANUFR'S SPEC.	MANUFR'S SPEC.	Log Book	3	-	-	
		2.COMPRESSION & TIGHTENING	MA	MEASUREMENT	100%	-DO-	-DO-	Log Book	3	-	-	
		3.CORE LOSS & HOTOPOT	MA	ELECT.TEST	-DO-	-DO-	-DO-	Log Book	3	-	2	(FOR MOTORS OF 2MW AND ABOVE)
2.5	WINDING	1.COMPLETENESS	CR	VISUAL	100%	MANUFR'S SPEC./BHEL SPEC.	MANUFR'S SPEC./BHEL SPEC.	Log Book	3	-	-	
		2.CLEANLINESS	CR	-DO-	-DO-	-DO-	-DO-	Log Book	3	-	-	
		3.IR-HV-IR	CR	ELECT. TEST	-DO-	-DO-	-DO-	Log Book	3	-	-	
		4.RESISTANCE	CR	-DO-	-DO-	-DO-	-DO-	Log Book	3	-	2	
		5.INTERTURN INSULATION	CR	-DO-	-DO-	-DO-	-DO-	Log Book	3	2	-	
		6.SURGE WITH STAND AND TAN. DELTA TEST	CR	-DO-	-DO-	-DO-	-DO-	Log Book	3	2	1	FOR MV MOTOR
2.6	IMPREGNATION	1.VISCOSCITY	MA	PHY. TEST	AT STARTING	-DO-	-DO-	Log Book	3	-	-	
		2.TEMP. PRESSURE VACCUM	MA	PROCESS CHECK	CONTINUOUS	-DO-	-DO-	Log Book	3	-	-	
		3.NO. OF DIPS	MA	-DO-	-DO-	-DO-	-DO-	Log Book	3	-	2	THREE DIPS TO BE GIVEN
BHEL			**PARTICULARS**		**BIDDER/VENDOR**							
			NAME									
			SIGNATURE									

			CUSTOMER :			PROJECT TITLE			SPECIFICATION : NUMBER :			
		QUALITY PLAN	BIDDER/ VENDOR :			QUALITY PLAN NUMBER PED-506-00-Q-007/2			SPECIFICATION : TITLE			
		SHEET 7 OF 9	SYSTEM			ITEM: AC ELECT. MOTORS 75KW & ABOVE (LV & MV)			SECTION			VOLUME III
SL. NO.	COMPONENT/OPERATION	CHARACTERISTIC CHECK	CAT.	TYPE/ METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY P	W	V	REMARKS
1	2	3	4	5	6	7	8	9	10			11
		4.DURATION	MA	-DO-	-DO-	-DO-	-DO-	Log Book	3	-	2	
2.7	COMPLETE STATOR ASSEMBLY	1.COMPACTNESS & CLEANLINESS	MA	VISUAL	100%	-DO-	-DO-	Log Book	3	-	-	
2.8	BRAZING/COMPRESSION JOINT	1.COMPLETENESS	CR	-DO-	-DO-	-DO-	-DO-	Log Book	3	-	-	
		2.SOUNDNESS	CR	MALLET TEST & MV TEST	-DO-	-DO-	-DO-	Log Book	3	-	-	
		3.HV	MA	ELECT. TEST	-DO-	-DO-	-DO-	Log Book	3	-	-	
2.9	COMPLETE ROTOR ASSEMBLY	1.RESIDUAL UNBALANCE	CR	DYN. BALANCE	-DO-	MFG SPEC./ ISO 1940	MFG. DWG.	Log Book	3	2	1	VERIFICATION FOR MV MOTOR ONLY
		2.SOUNDNESS OF DIE CASTING	CR	ELECT. (GROWLER TEST)	-DO-	MFG. SPEC.	MFG. SPEC.	Log Book	3	2	-	
2.10	ASSEMBLY	1.ALIGNMENT	MA	MEAS.	-DO-	-DO-	-DO-	Log Book	3	-	-	
		2.WORKMANSHIP	MA	VISUAL	-DO-	-DO-	-DO-	Log Book	3	-	-	
		3.AXIAL PLAY	MA	MEAS.	-DO-	-DO-	-DO-	Log Book	3	-	2	
		4.DIMENSIONS	MA	-DO-	-DO-	MFG.DRG./ MFG SPEC.	MFG. DRG/ RELEVANT IS	Log Book	3	-	-	
		5.CORRECTNESS, COMPLETENESS TERMINATIONS/ MARKING/ COLOUR CODE	MA	VISUAL	100%	MFG SPEC. RELEVANT IS	MFG SPEC. RELEVANT IS	Log Book	3	-	-	
BHEL			PARTICULARS		BIDDER/VENDOR							
			NAME									
			SIGNATURE									
			DATE						BIDDER'S/VENDORS COMPANY SEAL			

			CUSTOMER :			PROJECT TITLE			SPECIFICATION : NUMBER :			
		QUALITY PLAN	BIDDER/ VENDOR :			QUALITY PLAN NUMBER PED-506-00-Q-007/2			SPECIFICATION : TITLE			
		SHEET 8 OF 9	SYSTEM			ITEM: AC ELECT. MOTORS 75KW & ABOVE (LV & MV)			SECTION			VOLUME III
SL. NO.	COMPONENT/OPERATION	CHARACTERISTIC CHECK	CAT.	TYPE/ METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY			REMARKS
									P	**W**	**V**	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**			**11**
3.0	TESTS	1.TYPE TESTS INCLUDING SPECIAL TESTS AS PER BHEL SPEC.	MA	ELECT.TEST	1/TYPE/SIZE	IS-325/ BHEL SPEC./ DATA SHEET	IS-325/ BHEL SPEC./ DATA SHEET	TEST REPORT	3	1	1,2	NOTE - 1
		2.ROUTINE TESTS INCLUDING SPECIAL TEST AS PER BHEL SPEC.	MA	-DO-	100%	-DO-	-DO-	-DO-	3	1,2	1,2	NOTE - 2
		3.VIBRATION	MA	-DO-	100%	IS-12075	IS-12075	-DO-	3	1,2	-	
		4.OVERALL DIMENSIONS AND ORIENTATION	MA	MEASUREMENT & VISUAL	100%	APPROVED DRG/DATA SHEET	APPROVED DRG/DATA SHEET & RELEVANT IS	INSPC. REPORT	3	2,1	-	
		5.DEGREE OF PROTECTION	MA	ELECT. & MECH. TEST	1/TYPE/ SIZE	RELEVANT IS	BHEL SPEC. AND DATA SHEET	TC	3	-	2,1	TC FROM AN INDEPENDENT LABORATORY NOTE-3
		6.NAMEPLATE DETAILS	MA	VISUAL	100%	IS-325 & DATA SHEET	IS-325 & DATA SHEET	INSPC. REPORT	3	2,1	-	
		7.EXPLOSION FLAME PROOF NESS (IF SPECIFIED)	MA	EXPLOSION FLAME PROOF TEST	1/TYPE	IS-3682 IS-8239 IS-8240	IS-3682 IS-8239 IS-8240	TC	3	-	2,1	NOTE-3
		8.PAINT SHADE, THICKNESS & FINISH	MA	VISUAL & MEASUREMENT BY ELKOMETER	SAMPLE	BHEL SPEC. & DATA SHEET	BHEL SPEC. & DATA SHEET	TC	3	2,1	-	SAMPLING PLAN TO BE DECIDED BY INSPECTION AGENCY
BHEL			**PARTICULARS**		**BIDDER/VENDOR**							
			NAME									
			SIGNATURE									

		QUALITY PLAN	CUSTOMER :			PROJECT TITLE			SPECIFICATION : NUMBER :		
			BIDDER/ VENDOR :			QUALITY PLAN NUMBER PED-506-00-Q-007/2			SPECIFICATION : TITLE		
		SHEET 9 OF 9	SYSTEM			ITEM: AC ELECT. MOTORS 75KW & ABOVE (LV & MV)			SECTION		VOLUME III
SL. NO.	COMPONENT/OPERATION	CHARACTERISTIC CHECK	CAT.	TYPE/ METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY P	W	V	REMARKS
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**			**11**

NOTES:

1 DEPENDING UPON THE SIZE AND CRITICALLY, WITNESSING BY BHEL SHALL BE DECIDED.

2 ROUTINE TESTS ON 100% MOTORS SHALL BE DONE BY THE VENDOR. HOWEVER, BHEL SHALL WITNESS ROUTINE TESTS ON RANDOM SAMPLES. THE SAMPLING PLAN SHALL BE MUTUALLY AGREED UPON.

3 IN CASE TEST CERTIFICATES FOR THESE TESTS ON SIMILAR TYPE, SIZE AND DESIGN OF MOTOR FROM INDEPENDENT LABORATORY ARE AVAILABLE, THESE TEST MAY NOT BE REPEATED.

4 WHEREVER CUSTOMER IS INVOLVED IN INSPECTION WITH THE CUSTOMERS, AGENCY (1) SHALL MEAN BHEL AND CUSTOMERS BOTH TOGETHER.

BHEL	**PARTICULARS**	**BIDDER/VENDOR**	
	NAME		
	SIGNATURE		
	DATE		BIDDER'S/VENDORS COMPANY SEAL

			CUSTOMER :			PROJECT TITLE			SPECIFICATION : NUMBER :			
		QUALITY PLAN	BIDDER/ VENDOR :			QUALITY PLAN NUMBER PED-506-00-Q-006/0			SPECIFICATION TITLE			
		SHEET 1 OF 2	SYSTEM			ITEM AC ELECT. MOTORS BELOW 75KW (LV)			SECTION			VOLUME III
SL. NO.	COMPONENT/OPERATION	CHARACTERISTICS CHECK	CAT.	TYPE/ METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY			REMARKS
									P	**W**	**V**	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**			**11**
1.O	PAINTING	1.SHADE	MA	VISUAL	SAMPLE	MANUFR'S SPEC/BHEL SPEC./RELEVANT STANDARD	BHEL SPEC. SAME AS COL.7	LOG BOOK	3	-	-	
2.0	ASSEMBLY	1.WORKMANSHIP	MA	VISUAL	100%	MANUF'S SPEC	MANUF'S SPEC	-DO-	3	-	-	
		2.DIMENSIONS	MA	-DO-	-DO-	MFG. DRG./ MFG. SPEC.	MFG. DRG./ MFG. SPEC.	-DO-	3	-	-	
		3.CORRECTNESS COMPLETENESS TERMINATIONS/ MARKING/COLOUR CODE	MA	VISUAL	100%	MFG.SPEC./ RELEVANT IS	MFG.SPEC. RELEVANT IS	-DO-	3	-	-	
3.0	TESTS	1.ROUTINE TEST INCLUDING SPECIAL TEST AS PER BHEL SPEC.	MA	-DO-	100%	IS-325/ BHEL SPEC./ DATA SHEET	SAME AS COL.7	TEST REPORT	3	2,1	2,1	NOTE -1
		2.OVERALL DIMENSIONS & ORIENTATION	MA	MEASUREMENT & VISUAL	100%	APPROVED DRG/DATA SHEET	APPROVED DRG/DATA SHEET & RELEVANT IS	INSPN. REPORT	2	1	-	

BHEL	**PARTICULARS**	**BIDDER/VENDOR**
	NAME	
	SIGNATURE	
	DATE	BIDDER'S/VENDORS COMPANY SEAL

		QUALITY PLAN	CUSTOMER :			PROJECT TITLE			SPECIFICATION : NUMBER :			
			BIDDER/ VENDOR :			QUALITY PLAN NUMBER PED-506-00-Q-006/0			SPECIFICATION : TITLE :			
		SHEET 2 OF 2	SYSTEM			ITEM AC ELECT. MOTORS BELOW 75KW (LV)			SECTION			VOLUME III
SL. NO.	COMPONENT/OPERATION	CHARACTERISTICS CHECK	CAT.	TYPE/ METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY P	W	V	REMARKS
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**			**11**
		3.NAMEPLATE DETAILS	MA	VISUAL	100%	IS-325 & DATA SHEET	IS-325 & DATA SHEET	INSPN. REPORT	3	1	-	

NOTES:

1 ROUTINE TESTS ON 100% MOTORS SHALL BE DONE BY THE VENDOR. HOWEVER, BHEL SHALL WITNESS ROUTINE TESTS ON RANDOM SAMPLES. THE SAMPLING PLAN SHALL BE MUTUALLY AGREED UPON

2 WHERE EVER CUSTOMER IS INVOLVED IN INSPECTION, (1) SHALL MEAN BHEL AND CUSTOMERS BOTH TOGETHER.

3 FOR EXHAUST/VENTILATION FAN MOTORS OF RATING UPTO 1.5KW , ONLY ROUTINE TEST CERTIFICATES SHALL BE FURNISHED FOR SCRUTINY.

BHEL	**PARTICULARS**	**BIDDER/VENDOR**	
	NAME		
	SIGNATURE		
	DATE		BIDDER'S/VENDORS COMPANY SEAL

LOAD TITLE	RATING (KW / A)		UNIT (U)/STN (S)	Nos.		VOLTAGE CODE*	FEEDER CODE**	EMER. LOAD (Y)	CONT.(C)/ INTT.(I)	STARTING TIME >5 SEC (Y)	LOCATION	BOARD NO.	CABLE		BLOCK CABLE DRG. No.	CONTROL CODE	REMARKS	LOAD No.
	NAME PLATE	MAX. CONT. DEMAND (MCR)		RUNNING	STANDBY								SIZE CODE	NOs				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

ANNEXURE-II

NOTES:

1. COLUMN 1 TO 12 & 18 SHALL BE FILLED BY THE REQUISITIONER (ORIGINATING AGENCY); REMAINING COLUMNS ARE TO BE FILLED UP BY PEM (ELECTRICAL)
2. ABBREVIATIONS : * VOLTAGE CODE (7):- (ac) A=11 KV, B=6.6 KV, C=3.3 KV, D=415 V, E=240 V (1 PH), F=110 V (cc): G=220 V, H=110 V, J=48 V, K=+24V, L=-24 V
   : ** FEEDER CODE (8):- U=UNIDIRECTIONAL STARTER, B=BI-DIRECTIONAL STARTER, S=SUPPLY FEEDER, D=SUPPLY FEEDER (CONTACTER CONTROLLED)

LOAD DATA (ELECTRICAL)	JOB NO.	310	ORIGINATING AGENCY		PEM (ELECTRICAL)	
	PROJECT TITLE	2 X 800 MW GADARWARA TPP	NAME		DATA FILLED UP ON	
	SYSTEM	COMPRESSED AIR SYSTEM	SIGN.		DATA ENTERED ON	
	DEPTT. / SECTION	ELECTRICAL	SHEET 1 OF 1	REV. 00	DE'S SIGN. & DATE	

SECTION C.4

SPECIFIC TECHNICAL REQUIREMENTS(C&I) COMPRESSED AIR SYSTEM

Specific Technical Requirements (C&I):

1.0 Integrated microprocessor based control system along with suitable operator interface shall be provided for each Instrument Air Compressor & Service Air Compressor. All PT, DPT, TE, and other instruments outside the compressor skid shall also be hooked-up to this system. Dual two way Ethernet connectivity to DCS shall be provided through optical fiber link for information and overall control of air compressors. Protocol (MODBUS or OPC) for connectivity to DCS shall be finalized during detail engineering. In addition to the soft link, provision for hardwired START, STOP, LOAD & UNLOAD commands from DCS to all the compressors & their status feedbacks to DCS shall also be provided. Bidder to furnish the configuration diagram of control system of compressor showing communication with DCS along with the bid.

2.0 Ethernet to F.O. converter, L.I.U.(Light Interface Unit), patch cords, etc. required at the compressor end for soft link to DCS shall be in bidder's scope.

3.0 Group control is envisaged to clock more or less or equal number of running hours for each air compressor, hence the necessary logic/control scheme, write-up and HMI graphics for overall operation of the compressor from DCS is to be submitted by the bidder during detailed engineering.

4.0 Bidder to include all the instruments (PG, PS, LS, TS, Dew Point meter, etc.) required for the package along with fittings, accessories and valve manifold.

5.0 The solenoid operated valves shall have limit switches for open/ close feedback

6.0 All motor operated valves/electric actuators shall be envisaged with integral starter.

7.0 All pneumatic operated regulating control valves shall be envisaged with smart positioner.

8.0 The junction boxes for termination of instruments /actuator limit switches/ solenoid valve limit switches etc. are in bidder's scope.

9.0 Power supply required for instruments and compressor's control system shall be derived from 415 V, 3 phase, AC supply provided for the compressor. No other power supply shall be provided.

10.0 The Bidder to provide Vibration monitoring system for all compressors and their motors. The bidder to provide 4-20mA signal for each vibration monitoring instrument which will be hooked-up to DCS for necessary interlock and protection.

11.0 The winding and bearing temperature sensors of all compressor motors shall be hooked-up to the DCS for necessary interlocks and protection.

12.0 The temperature transmitters to be provided by the bidder for all temperature measurement points including winding and bearing temperature, to be hooked up to the DCS. Necessary JB's(Junction Boxes) shall be in bidder's scope.

13.0 The make/model of various instruments/items/systems shall be subject to approval of owner/purchaser during detailed engineering stage. No commercial implication in this regard shall be acceptable. In case of any conflict and repetition of clauses in the specification, the more stringent requirements among them are to be complied with. In case of any contradiction most stringent clause/condition shall prevail.

14.0 Drawings/Documents and data to be furnished along with the bid :

- Control philosophy for microprocessor based control system
- Power requirement for instrument and control system.
- Configuration diagram of control system

15.0 Drawings/Documents and data to be furnished after award of the contract:

- Control & operational write-up for the system
- Recommended control scheme/ logic diagram
- Process manuscript for implementation in DCS
- Drive List and I/O list
- Power requirement and grounding scheme.
- Field instruments quality plan.
- Instruments data sheet.
- JB/LIE/LIR Grouping document
- Cable schedule and cable interconnection drawing.
- Instrument schedule
- Any other document decided during detailed engineering.

16.0 All the instrument cables, control cables, fiber optic cables and any other cable between control system of compressor and DCS shall be under bidder's scope.

17.0 The specifications outline the minimum requirements of the system. The Bidder is to supply any additional instruments and/or accessories required for ensuring safe and reliable operation of the system even if it may not be mentioned in the specifications.

18.0 Mandatory spares (as applicable) to be provided as follows:

SI. NO.	PARTICULARS	QUANTITY
	2. Meters	
	2.1 Ammeters	1 no. of each type & range
	2.2 Voltmeters	1 no. of each type & range
	3. Relays (Protection, aux. relays, Interposing relays, overload relays & timer etc.)	1 no. of each type
	4. Contactors and auxiliary power controller.	3 no. of each type & rating
	5. Air breaker switches	2 nos. of each rating
	6. Control switch and selector switches	1 nos. of each type & rating
	7.	
	7.1 Indicating lamps	5% of installed capacity
	7.2 Indicating lamp covers of different colours, lamp resistors & holders.	5% of installed capacity
	8. Primary disconnect (Power) for MCC Module complete set	1 no. of each rating
	9. Push buttons of various colours	5% each type & colour.
	10. Maintenance tools and accessories for maintenance	2 nos.
	11. Control supply transformers	1 no. of each rating
2.01.00	**Electrical Actuators**	
	1. Power unit for modulating actuator	One of each type & size
	2. DC-DC unit/power pack units	One of each type & size
	3. Electronic cards	1 set
	4. Position feed back transmitters	One of each type & size
	5. Control unit	1 no. of each type
	6. Torque and limit switch assembly of each unit	1 no. of each type
	7. Actuators	One of each type make & rating
3.00.00	**Control and Instrumentation (Applicable For Steam Generator and Auxiliaries Including Mill Reject System, Fuel Oil Pressurisation and Heating System, Auxiliary Boiler, Dozing System, Air Compressors Etc.)**	
3.01.00	**Distributed Digital Control Monitoring and Information System (DDCMIS) (See General Clause also)**	
	1. Keyboards/mouse	
	1.1 Keyboard	2 nos. of each type.

SI. NO.	PARTICULARS	QUANTITY
	1.2 Mouse	2 nos. of each type.
	2. Printers and their parts	
	2.1 Color laser printer (A4)	1 no
	3. HMIPIS Devices	
	3.1 Work stations with licensed software loaded along with monitor	2 nos. of each type and model.
	3.2 Server for unit LAN or Information Work Stations (As applicable)	1 nos.
	3.3 Net work components like Switch /repeaters/hubs etc. (as applicable)	2 nos. of each type and model.
	3.4 Other drives/peripheral devices of each type and model no. in MMIPIS like terminal Servers, DAT tape drive etc. (as applicable), which are not covered in above items but are required to make the system complete.	2 nos. of each type and model
	3.5 Control units for LVS	1 no.
	3.6 Graphical Interface Unit	1 no. of each type & model
	4. Cables and Connectors.	
	4.1 Prefab interconnecting cables with connectors	2 nos. of each type and length.
	4.2 System bus cable with connectors	-do-
	4.3 I/O bus cable with connectors for remote I/O units	-do-
	5.	
	5.1 Power Supply Modules & Power Packs for control system	20 % or 4 nos. of each type, model and rating, whichever is more.
	5.2 Intelligent UPS for workstation, server, PCs	1 no. of each size and rating
	6. Electronic modules of each type and model for control system (This shall include all type of cards like I/O cards, controller cards, CPU module or Card, logic cards etc.)	10% or 2 nos. of each type and model whichever is more
	7. Bus coupler/Interface hardware and other communication devices (If applicable)	10% of each type and model
	8. Relays	10% of each type and rating
	9. PCs	1 no. of each type & model.
	10. Batteries used for battery backup of RAMs (If applicable)	10% of each type and model

SI. NO.	PARTICULARS	QUANTITY
	11. Fuses	200 %
	12. Expendable items including but not limited to the followings Cooling fans for Power supply and cabinets	**10 % or 2 nos. of each type and model, whichever is more.**
3.02.00	**OTHER RELATED CONTROL AND INSTRUMENTATION SYSTEMS / EQUIPMENTS**	
	Other SG related sub-systems	
	1. Flame Monitoring System	
	1.1 Complete Flame Scanner Assembly including scanner head assembly, scanner housing, and fibre optic cables.	20% or 4 nos., whichever is more
	1.2 Flame Scanner Lens	100%
	1.3 Electronic cards for scanners	10% or 2 nos. of each type whichever is more.
	1.4 Power Supply Modules	20% or 2 nos. of each type whichever is more.
	2. Coal Feeders	
	2.1 Motion monitor	10% or 2 nos. whichever is more.
	2.2 Speed pick-up	10% or 2 nos. whichever is more.
	2.3 Torque switch	10% or 2 nos. whichever is more.
	2.4 Load Cell	10% or 2 nos. whichever is more.
	2.5 Electronic cards & Power Supply cards	10% or 2 nos. whichever is more.
	2.6 Clutch (if applicable)	10% or 2 nos. whichever is more.
	2.7 Local indication lamps	200 %
	2.8 Panel meters	10% or 2 nos. whichever is more.
	2.9 Limit switch assembly for coal-on-belt, no coal flow, shear pin failure, etc.	10% or 2 nos., whichever is more.
	2.10 Coupling (eddy current type etc., VFD as applicable)	10% or 2 nos. whichever is more.
	3. Electromatic Safety Valves Pressure switches, local PB stations and solenoid Valves.	10% or 2 nos. of each type whichever is more.
	4. Furnace Temperature Probes Thermocouple	2 Nos.
	5. Acoustic Pyrometers	
	5.1 Signal Processor and interface modules	20% or 2 nos. of each type and model whichever is more

SI. NO.	PARTICULARS	QUANTITY
	5.2 Sensors and Transceivers	20% or 2 nos. of each type and model which is more.
	5.3 All Electronic Cards including Power Packs	20% or 2 nos. of each type and model which is more.
	5.4 Seal kit for Sound Generator	20% or 2 nos. of each type and model which is more.
	6. Furnace and Flame viewing system	
	6.1 Flame Cameras	10% or 2 nos., whichever is more
	6.2 Electronic Modules	10% or 2 nos. of each type whichever is more
	7. Conductivity type level monitoring system (for driplegs)	
	7.1 Electrodes	50% of population
	7.2 Electronic Cards	20% or 2 nos. of each type and model whichever is more.
	7.3 Lamps/LEDs of display units	100%
	8. Mill and Air heater Fire detection system.	
	8.1 Thermocouple	10%
	8.2 Process actuator switches	10%
	9.. Acoustic steam Leak Detection system (ASLD) (if applicable)	
	(i) Processor and Interface modules	10% or 1 no. of each type and model, whichever is more
	(ii) Sensors and Transceivers	10% or 1 no. of each type and model, whichever is more
3.03.00	**MEASURING INSTRUMENTS**(for all systems including Air Compressor, Auxiliary Boiler, FOPH, Dosing System, ECW System etc.)	
	1. Electronic Transmitters	
	1.1 Transmitters of all types, ranges and model no. (for the measurement of Pressure, differential pressure flow, level, etc.)	10% or 1 No. of each type and model, whichever is more.
	1.2 Level Transmitters (Ultrasonic/ radar type)	50% of each type and length, including sensors
	2. Temperature elements	
	2.1 RTD's of each type and length(with head assembly, terminal block & nipple)	10% or 2 nos. of each type and length, whichever is more

SI. NO.	PARTICULARS	QUANTITY
	2.2 Thermocouples of each type like K-type, R-type, metal etc. (with head assembly, terminal block & nipple)	10% or 2 nos. of each type and length which ever is more
	2.3 Thermowell for application like mill outlet temperature and SH/RH/Eco/ flue gas temp. in furnace	10% or 2 nos. of each type and length whichever is more
	2.4 Temperature transmitters	10% of each type and model
	3. Local Indicators like temperature gauges, pressure gauges, differential pressure gauges, flow gauges, flow meters etc.,	5% or 1 no. of each make, model and type whichever is more (to be divided to various ranges in proportion to main of all make, model, type population)
	4. Process Actuated Switch Devices Includes all types of Pressure, differential pressure, flow, temperature, differential temperature, level switch Devices	5% or 1 no. of each type and model whichever is more
	5. PD Type Flow Transmitters	1 no. of each type and model
	6. Flue Gas Analyzer Instruments for Oxygen (i) Electronic Card Assemblies of each type (ii) Sets of Gaskets/ "O" rings (iii) Temperature Sensor & heater Assembly (iv) Complete Probe with shield assembly. (v) Consumables like filter elements.	1 no. each complete instrument. 10% 2 sets 20% 2 nos. 100%
3.04.00	**POWER SUPPLY SYSTEM** **(24 V DC power supply system)** (To be provided for each system)	
	1. Silicon controlled thyristors, diodes, power transistors	100%(1 Lot)
	2. Capacitors	1 set
	3. Fuse free Circuit breakers	5% or 1 no. of each type and rating, whichever is more
	4. Electronic modules of all types.	20% or 2 nos. of each type and model, whichever is more
	5. Cooling Fans	10% or 2 nos. of each type, whichever is more.
	6. Indication Lamps	200%
	7. Lamp holders with series resistor, if any	20%
	8. Digital / analog panel meters / indicators	10%
	9. Relays of all types including overload relays	20%

SI. NO.	PARTICULARS	QUANTITY
3.05.00	**PROCESS CONNECTION PIPING (FOR IMPULSE PIPING/TUBING, SAMPLING PIPING / TUBING AND AIR SUPPLY PIPING AS APPLICABLE)**	
	1. Valves of all types and models	10% or 1 no. of each type, class, size and model whichever is more.
	2. 2 way, 3way, 5way valve manifolds	10% or 1 no. of each type, class, size and model whichever is more.
	3. Fittings	10% or 1 packet of each type, class, size and model whichever is more.
	4. Purge meters	5% of each model or 1 no. whichever is more.
	5. Filter regulators	20% of each model or 2 nos. whichever is more.
3.06.00	**INSTRUMENTATION CABLE, INTERNAL WIRING & ELECTRICAL FIELD**	
	1. Pre fabricated cable of each type.	10% of installed quantity
	2. Pre fabricated cable connector of each type	10% or 1 no. of each type and model, whichever is more.
	3. Other cables	5% of each type, pair and size of actual installed quantity
3.07.00	**CONTROL VALVES, ACTUATORS & ACCESSORIES**	
	1. Pneumatic and electro-hydraulic actuator assembly	10% or 1 no. of each type, model and rating, whichever is more
	2. Valve trim (including cage, plug, stem, seat rings, guide bushings etc.)	1 set for each type of control valve.
	3. Diaphragms, O' rings, seals etc. of all types, make etc.	200%
	4. Pressure Gauges of all types, make, rating etc.	10% or 2 nos. of each type whichever is more.
	5. Solenoid valves (if applicable)	10% or 2 nos. of each type whichever is more.
	6. Positioner units (complete unit)	10% or 1 no. of each type whichever is more.
	7. Pneumatic air-filter/Regulator of each type, make, rating etc.	10% or 2 nos., whichever is more
	8. Air lock relays	10% or 2 nos. of each type, whichever is more

SI. NO.	PARTICULARS	QUANTITY
3.08.00	**PADO**	
	1. Work station with all accessories and licensed software, along with Monitor	1 no.
	2. Interface cards	10% or 2 nos. of each type whichever is more
3.09.00	**MICROPROCESSOR BASED/PLC BASED CONTROL SYSTEM FOR AIR COMPRESSOR & DRYER UNIT**	
	1. Complete set including integral microprocessor based control system alongwith system & application software and special cables	10% or 1 set whichever is more

SPECIFICATIONS

FOR

MEASURING INSTRUMENTS,

CONTROL VALVES,

AND

FLOW ELEMENTS

MEASURING INSTRUMENTS

1.00.00 MEASURING INSTRUMENTS

1.01.00 Measuring instruments/equipment and subsystems offered by the Bidder shall be from reputed experienced manufacturers of specified type and range of equipment, whose guaranteed and trouble free operation has been proven. Refer Sub-section-IV:I1(Basic Design Criteria). Further, all instruments shall be of proven reliability, accuracy, and repeatability requiring a minimum of maintenance. They shall comply with the acceptable international standards and shall be subject to Employer's approval. All instrumentation equipment and accessories under this specification shall be furnished as per technical specifications, ranges, makes/numbers as approved by the Employer during detailed engineering.

1.02.00 Every panel-mounted instrument requiring power supply shall be provided with a pair of easily replaceable glass cartridge fuses of suitable rating. Every instrument shall be provided with a grounding terminal and shall be suitably connected to the panel grounding bus.

1.03.00 All local gauges as well as transmitters, sensors, and switches for parameters like pressure, temperature, level, flow etc. as required for the safe and efficient operation and maintenance as well as for operator and management information (including all computation) of equipment under the scope of specification shall be provided on as required basis within the quoted lump sum price. For bidding purpose, tentative minimum instruments have been indicated on the P&IDs. However, contractor shall supply any additional local gauges/ switches/ transmitters/sensors for reasons mentioned above without any additional cost to the Employer.

1.04.00 The necessary root valves, impulse piping, drain cocks, gauge-zeroing cocks, valve manifolds and all the other accessories required for mounting/erection of these local instruments shall be furnished, even if not specifically asked for, on as required basis. The contacts of equipment mounted instruments, sensors; switches etc. for external connection including spare contacts shall be wired out in flexible/rigid conduits, independently to suitably located common junction boxes. The proposal shall include the necessary cables, flexible conduits, junction boxes and accessories for the above purpose. Double root valves shall be provided for all pressure tapping where the pressure exceeds 40 Kg./sq.cm.

1.05.00 For all instruments envisaged for sea water applications, they shall be provided with wetted parts made of monel/Hastelloy C or any other material (if provenness experience of the proposed material for such applications is established by Contractor).

1.06.00 All instruments shall be provided with durable epoxy coating for housings and all exposed surfaces of the instruments.

2.00.01 SPECIFICATION FOR ELECTRONIC TRANSMITTER FOR PRESSURE, D.P., FLOW AND LEVEL

ELECTRONIC TRANSMITTERS

Sl.No.	Features	Essential/Minimum Requirements
1.	Type of Transmitter	Microprocessor based 2 wire type, Hart protocol compatible.
2.	Accuracy	± 0.1% of calibrated span (minimum)

3.	Output signal range	4-20 mA DC (Analog) along with superimposed digital signal (based on HART protocol)
4.	Turn down ratio	10:1 for vacuum/very low pressure applications.
		30:1 for other applications.
5.	Stability	± 0.1% of calibrated span for six months for Ranges up to and including70 Kg/cm².
		± 0.25% of calibrated span for six months for Ranges more than 70 Kg/cm² (g).
6.	Zero and span drift	+/- 0.015% per deg. C at maximum span.
		+/-0.11% per deg. C at minimum span.
7.	Load impedance	500 ohm (min.)
8.	Housing	Weather proof as per IP-55 with durable corrosion resistant epoxy coating.
9.	Over Pressure	150% of maximum operating pressure
10.	Connection (Electrical)	Plug and socket type
11.	Process connection	1/2 inch NPT (F)
12.	Span and Zero	Continuous, tamper proof, Remote as well as adjustability manual from instrument with zero suppression and elevation facility.
13.	Accessories	-Diaphragm seal, pulsation dampeners, syphon etc. as required by service and operating condition.
		-2 valve manifold for absolute pressure transmitters (3-valve manifold for gauge/ vacuum pressure transmitters) and 5 valve manifold for DP/level/flow transmitters.
		-For hazardous area, explosions proof enclosure as described in NEC article 500.
14.	Diagnostics	Self Indicating feature
15.	Power supply	24V DC ± 10%.
16.	Adjustment/calibration/maintenance	Centralised PC based system (In Employer's Scope). In addition total two (2) no. of hand- held type universal calibrators per unit, compatible with HART protocol, shall be provided.

Notes
In case it becomes necessary to use a DP transmitter for pressure measurement, then a 3-valve manifold should be used in place of 2-valve manifold.
LVDT type is not acceptable.
Where the process fluids are corrosive, viscous, solid bearing or slurry type, diaphragm seals shall be provided. Parts below the diaphragm shall be removable for cleaning. The entire volume above the diaphragm shall be completely filled with an inert liquid suitable for the application.

2.01.00 **Ultrasonic Type level Transmitter**

Sl. No	Features	Essential/Minimum requirements
1.	Type of Transmitter	Non contact Microprocessor based 2 wire type, HART protocol compatible Ultrasonic transmitter.
2.	Output signal	Galvanically isolated 4-20mA DC (Analog) along with superimposed digital signal (based on HART protocol).
3.	Sensor Accuracy	+/- 0.5% of calibrated span.
4.	Sensor Repeatability	3 mm or better.
5.	Power supply	24 V DC +/- 10%
6.	Temperature compensation	To be provided within transducer.
7.	Configuration	Sensor unit and Electronic units are to be separate. It shall be possible to mount the Electronic unit at a remote accessible location from the transducer. All cables and weather proof fittings to interconnect transducer to electronic unit shall be provided by Bidder.
8.	Housing	Weather proof as per IP-55 with durable corrosion resistant epoxy coating.
9.	Calibration	Through HART Communicator.
10.	Zero and Span adjustment	Continuous, tamper proof, remote as well as manual adjustability from instrument. It shall be possible to calibrate the instrument without any level in the tank/sump etc
11.	Sensor Material	Corrosion resistant material to suit individual application requirement.

12.	False signal tolerance	Transmitter shall be capable of ignoring false echoes from internal tank/sumps obstructions such as pipes, heating coils or agitator blades. Also transmitter shall have adjustable damping circuitry
13.	Range	Range of transmitter shall be capable of covering the complete level span of tank taking care of blocking distance, frequency attenuation due to surface, obstructions, vapors etc
14.	Display	Minimum 4 character display with integral keypad, access protected by user code.
15.	Diagnostics	Loss of echo alarm etc
16.	Load Impedance	500 ohms minimum
17.	Electrical Connection	Plug and socket
18.	Accessories	• All weather canopy for protection from direct sunlight and direct rain. • All mounting hardware and accessories required for erection and commissioning mounting fittings material shall be SS 316. • For hazardous areas, explosion proof enclosure as described in NEC article 500.

3.00.00 TEMPERATURE ELEMENTS

3.01.00 **Thermocouple**

Sr. No.	Features		Essential/Minimum Requirements
1	Type of Thermocouple.	:	16 AWG wire of Chromel-Alumel (Type K) or 24 AWG wire Pt-Rhodium Pt (Type R) depending on operating temperature Range (ungrounded type).
2	No. of element	:	Duplex
3	Housing/Head	:	IP-55/Diecast Aluminium. Plug in connectors are to be provided for external signal cable connection.
4	Sheathing of Thermocouple	:	Swaged type magnesium oxide insulation.
5	Calibration and accuracy	:	As per IEC-751/ANSI-C-96.1(special class) for T/C.
6	Characteristic	:	Linear with respect to temp, within ±1/2 percent of top range value.

	7	Accessories	: Thermo well (as specified below) and shall be spring loaded for positive contacts with the well.
	8	Standard	: ANSI C 96.1 for Thermocouple and ASME PTC-19.3 for Thermo-well.

3.02.00 **Resistance Temperature Detector (RTD)**

Sr. No.	Features		Essential/Minimum Requirements
1	Type of RTD.	:	Four wire, Pt-100 (100 Ohms resistance at zero degree Centigrade).
2	No. of element	:	Duplex
3	Housing/Head	:	IP-55/Diecast Aluminium. Plug in connectors are to be provided for external signal cable connection.
4	Sheathing of RTD	:	Metal sheathed, ceramic packed
5	Calibration and accuracy	:	As per DIN-43760 Class-A for RTD
6	Characteristic	:	Linear with respect to temp, within ±1/2 percent of top range value.
7	Accessories	:	Thermo well (as specified below) and shall be spring loaded for positive contacts with the well.
8	Standard	:	DIN-43760 for RTD and ASME PTC-19.3 for Thermo-well.

3.03.00 **Metal Temperature Thermocouples**

Measuring Medium	Metal Temperature
Material of Thermocouple.	Chromel Alumel Type K
Type of Thermocouple	Duplex with separate hot junctions, ungrounded
Insulation	Mineral Insulation Magnesium Oxide.
Thermocouple wire gauge	16 AWG
Protective sheath	SS 321
Protective sheath dia	8 mm O.D
Characteristics of Thermocouple	Special limits of error as in ANSI thermocouple MC 96.01.1975
Mounting accessories	1/2" BSP SS sliding end connector, weld pad, clamps of heat resistant steel SS310.

	Cold end sealing	SS pot weal with colour coded PTFE headed sleeve Insulated flexible tails. Sealing compound- Epoxy resin.
	Minimum bending radius	30 mm
	Length of T/C	30 Mtr. (minimum)

3.04.00 **Thermo well (for all process temp. elements)**

(a) Shall be one piece solid bored type of 315 SS of step-less tapered design. (As per ASME PTC 19.3 1974)

(b) For Mill classifier outlet long life solid sintered tungsten carbide material of high abrasion resistance shall be provided.

(c) For Air & Flue gas 316 SS protecting tube with welded cap. (However contractor shall provide better material for Flue gas service if require based on the specify boiler design parameters).

(d) For furnace zone, impervious ceramic protecting tube of suitable material along with Incoloy supporting tubes and adjustable flanges.

4.00.00 TEMPERATURE TRANSMITTER

Following types of 2-wire temperature transmitter (directly powered from 4-20mA input cards of DDCMIS) shall be provided. The temperature transmitter shall be fully compatible with thermocouples and RTDs being provided by the contractor. Temperature compensation of the thermocouples shall be performed in the temperature transmitter itself.

a. Single Input Head mounted Temperature Transmitter

These shall be suitable for mounting in the head of temperature element itself. The protection class of head of thermo well along with its plug-in connector shall be min. IP65.

b. Single Input DIN-rail mounted Temperature Transmitter

These shall be especially designed for DIN-rail mounting in JBs. The specifications of the JBs shall be same as indicated in Subsection-IV:I7(INST CABLE) with additional DIN-rails and IP 65 Protection class. This temperature transmitter shall be the ones which are specially designed for DIN-rail mounting with IP 20 protection class. These shall have terminals for input/output provided on front side when mounted on DIN-rail. Head mounted temperature transmitter with clamps to make it suitable for DIN-rail mounting shall not be acceptable under this category.

c. Dual-input Temperature Transmitter With Indicator:

The dual-input TTs shall be suitable for mounting in enclosures/racks and shall be provided with clamps. Indicator shall be provided with these transmitters. These transmitters shall have bump less change over facility to second sensor in case first sensor fails .This change-over is to be alarmed. Protection class shall be IP65 minimum.

d. Common requirements for each of the above type of temperature transmitters

Output	:	2-wire (power supply from input card of Control System) with 4-20mA output with superimposed HART protocol signal.
Input	:	Same transmitter shall be capable to handle Pt-100 RTD , Thermocouples -K&R types (input type to be selectable at site through HART terminal)
Isolation	:	min. 500 V AC
EMC compatibility	:	as per EN 61326
Operating ambient temperature	:	0 to 85 deg C (without indicator) 0 to 70 deg C (with indicator)
Power supply		compatible with input module of Control System
Accessories		Mounting arrangements including clamps etc.
Composite Accuracy (Refer note 2)	(a)	For head mounted and DIN-rail mounted types: RTD =<0.4% of 0-250 deg C span T/C-K type =<0.4% of 0-600 deg C span T/C-R type =<0.4% of 0-1000 deg C span CJC accuracy (for thermocouples) shall be =< 1 deg C
	(b)	For dual-input type: RTD =<0.25% of 0-250 deg C span T/C-K type =<0.2% of 0-600 deg C span CJC accuracy (for thermocouples) shall be =< 1 deg C

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e. Field bus compatible temperature Transmitters (For Boiler Metal Temperature measurement applications)

Temperature transmitters *of this category shall be field mounting type* & *shall be capable of withstanding operating ambient temperature upto 85 deg C*. These modules shall be connected to DDCMIS through field bus such as Profibus, Foundation Field bus etc directly from the transmitter. *Maximum Number of inputs per such temperature transmitter shall be eight. These shall be mounted in cabinets in non-AC areas.*

As an alternate, these signals from temperature transmitters can be connected to DDCMIS through standard remote I/O modules of the DCS, in which case, the temperature transmitter signals will be acquired through 4-20mA input modules in the remote I/O cabinet for connecting to DDCMIS through remote I/O bus.

Notes:-*(Common for a to e above):-*

1. In case of failure (open or burn-out) of RTD/thermocouple, temp. Transmitter shall provide low temperature output.

2. Composite Accuracy is to be calculated as summation of all applicable accuracies of temp transmitter, for converting sensor input to output in 4-20 mA (e.g., basic accuracy, digital accuracy, D/A accuracy, etc.) and temperature effect on these accuracies at ambient temperature of 50 deg C, based on the figure/ formula given in the standard product catalogue for span as specified above for various types of Temperature Elements specified. All such accuracy/ temp effect figures in catalogue shall be first converted to deg C, and then percentage of this converted accuracy in specified span shall be calculated to compare with the specified composite accuracy figures.

5.00.00 SPECIFICATION FOR FLOW ELEMENTS

5.01.00 **Orifice Plate**

Features	Essential/Minimum Requirements
Type	Concentric as per ASME PTC-19.5 (Part-II), ISA RP-3.2, 1960 or BS-1042
Material	316 SS
Thickness	3 mm for main pipe diameter up to 300 mm and 6 mm for main pipe dia above300 mm.
Material of branch pipe	Same as main pipe
Root valve type	Globe
Root valve material	316 SS
Root valve size	1 inch
Impulse pipe of same material up to root valve	Required
Tappings	Flanged weld neck. 3 pairs. of tapping.
Beta Ratio	0.34 to 0.7
Beta Ratio calculation to be submitted	Yes
Assembly drg. and flow Vs DP Curves	Yes
Accessories	Root valves, flanges, Vent/drain hole (As required)