

**UTTAR PRADESH RAJYA VIDYUT UTPADAN NIGAM  
LIMITED**

**1X660 MW PANKI TPP EXTN.**

**TECHNICAL SPECIFICATION  
FOR  
COMPRESSED AIR SYSTEM**

**SPECIFICATION NO.: PE- TS- 426- 555- A001, Rev 02**



**BHARAT HEAVY ELECTRICALS LIMITED  
POWER SECTOR - PROJECT ENGINEERING MANAGEMENT  
NOIDA, INDIA**

**1x660 MW PANKI TPS - CAS****INDEX**

SPECIFICATION NO. PE-TS-426-555-A001

REV 02

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1x660 MW PANKI TPS

COMPRESSED AIR SYSTEM

SECTION – I

(INTENT OF SPECIFICATION)



BHARAT HEAVY ELECTRICALS LTD  
POWER SECTOR PROJECT ENGINEERING MANAGEMENT  
NOIDA-INDIA



**TECHNICAL SPECIFICATION FOR  
COMPRESSED AIR SYSTEM  
1X660 MW PANKI TPS**

SPECIFICATION NO. PE-TS-426-555-A001

INTENT OF SPECIFICATION

SECTION I

REV - 02

DATE: 30.01.2020

**1.0 INTENT OF SPECIFICATION**

- 1.1 The specification is intended to cover Supply part, Services part and Mandatory spares comprising of design (i.e. Preparation and submission of drawing /documents including "As Built" drawings and O&M manuals), engineering, manufacture, fabrication, assembly, inspection / testing at vendor's & sub-vendor's works, painting, maintenance tools & tackles (as applicable), fill of lubricants & consumables, mandatory spares along with spares for erection, start up and commissioning as required, forwarding, proper packing, shipment and delivery at site, unloading, handling, transportation & storage at site, in-site transportation, assembly, erection & commissioning, final painting at site, minor civil work, trial run at site, preparation of layout drawings and carrying out Performance guarantee / Functional / Demonstration tests at site (As applicable), training of customer/client O&M staff and handover in flawless condition of the package to the end customer complete with all accessories for the total scope defined as per BHEL NIT & tender technical specification as specified above, amendment & agreements till placement of order.
- 1.2 The contractor shall be responsible for providing all material, equipment & services, which are required to fulfil the intent of ensuring operability, maintainability, reliability and complete safety of the complete work covered under this specification, irrespective of whether it has been specifically listed herein or not. Omission of specific reference to any component / accessory necessary for proper performance of the equipment shall not relieve the contractor of the responsibility of providing such facilities to complete the supply, erection and commissioning of COMPRESSED AIR SYSTEM.
- 1.3 It is not the intent to specify herein all the details of design and manufacture. However, the equipment shall conform in all respects to high standards of design, engineering and workmanship and shall be capable of performing the required duties in a manner acceptable to purchaser 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.
- 1.4 The extent of supply under the contract includes all items shown in the drawings, notwithstanding the fact that such items may have been omitted from the specification or schedules. Similarly, the extent of supply also includes all items mentioned in the specification and /or schedules, notwithstanding the fact that such items may have been omitted in the drawing.
- 1.5 The general term and conditions, instructions to tenderer and other attachment referred to elsewhere are made part of the tender specification. The equipment materials and works covered by this specification is subject to compliance to all attachments referred to in the specification. The bidder shall be responsible for and governed by all requirements stipulated herein.
- 1.6 While all efforts have been made to make the specification requirement complete & unambiguous, it shall be bidders' responsibility to ask for missing information, ensure completeness of specification, to bring out any contradictory / conflicting requirement in different sections of the specification and within a section itself to the notice of BHEL and to seek any clarification on specification requirement in the format enclosed under **SECTION-III** of the specification within 10 days of receipt of tender documents. In absence of any such clarifications, in case of any contradictory requirement, the more stringent requirement as per interpretation of Purchaser/Customer shall prevail and shall be complied by the bidder without any implication on account of the same. Further in case of any missing information in the



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specification not brought out by the prospective bidders as part of bid clarification, the same shall be furnished by Purchaser/ Customer as and when brought to their notice either by the bidder or by purchaser/ customer themselves. However, such requirements shall be binding on the successful bidder without any commercial & delivery implication.

- 1.7 The bidder's offer shall not carry any sections like clarification, interpretations and /or assumptions.
- 1.8 Deviations / clarifications, if any, should be very clearly brought out clause by clause in the format enclosed in the specification; otherwise, it will be presumed that the vendor's offer is strictly in line with NIT specification. Each deviation shall be furnished with its cost of withdrawal in both priced and un-priced bid. In case of No-deviation, bidder to furnish the No-deviation / compliance certificate in the format enclosed in SEC-III of this specification.
- 1.9 In case all above requirements are not complied with, the offer may be considered as incomplete and would become liable for rejection.
- 1.10 Unless specified otherwise, all through the specification, the word contractor shall have same meaning as successful bidder /vendor and Customer/ Purchaser/Employer will mean BHEL and /or UPRVUNL and /or DCPL and / or NTPC.

1X660 MW PANKI TPS

COMPRESSED AIR SYSTEM

SECTION – I

(PROJECT INFORMATION)



BHARAT HEAVY ELECTRICALS LTD  
POWER SECTOR PROJECT ENGINEERING MANAGEMENT  
NOIDA-INDIA

## 1.0 PROJECT INFORMATION

|        |                                                          |   |                                                                                                                                                                                 |               |
|--------|----------------------------------------------------------|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| 1.1    | Owner                                                    | : | <b>UTTAR PRADESH RAJYA VIDYUT UTPADAN NIGAM LIMITED, LUCKNOW</b>                                                                                                                |               |
| 1.2    | Project Title                                            | : | Panki Thermal Power Station (1x660MW)                                                                                                                                           |               |
| 1.3    | Owner's Engineer                                         | : | <b>DEVELOPMENT CONSULTANTS PVT. LTD</b> and NTPC                                                                                                                                |               |
| 1.4    | Project Site Location                                    | : | Place                                                                                                                                                                           | Panki         |
|        |                                                          | : | District                                                                                                                                                                        | Kanpur        |
|        |                                                          | : | State                                                                                                                                                                           | Uttar Pradesh |
|        |                                                          | : | Country                                                                                                                                                                         | India         |
| 1.5    | Latitude & Longitude of project site                     | : | North                                                                                                                                                                           | N26°28'20"    |
|        |                                                          | : | East                                                                                                                                                                            | E 80°14'32"   |
| 1.6    | Nearest Railway Station                                  | : | Panki                                                                                                                                                                           | 5 km          |
| 1.7    | Nearest Town                                             | : | Kanpur                                                                                                                                                                          | 16km          |
| 1.8    | Nearest Highway                                          | : | National Highway - 25                                                                                                                                                           |               |
| 1.9    | Nearest Airport                                          | : | Kanpur                                                                                                                                                                          | 25 km         |
|        |                                                          | : | Lucknow                                                                                                                                                                         | 80 Km         |
| 1.10   | Nearest Commercial Airport                               | : | Delhi                                                                                                                                                                           | 140 km        |
| 1.11   | Nearest Water Body                                       | : | Lower Ganga Canal, adjacent to site                                                                                                                                             |               |
| 1.12   | Land                                                     | : | Land is in possession of UPRVUNL.                                                                                                                                               |               |
| 1.13   | Station Graded Level Elevation from Mean sea level (MSL) | : | Plant FGL → RL(+) 126.0M → El(-) 0.500M<br>Plant FFL → RL(+) 126.5M → El(+/-) 0.000M                                                                                            |               |
| 1.14   | Water                                                    | : |                                                                                                                                                                                 |               |
| 1.14.1 | Nearest Water Source                                     | : | Lower Ganga Canal system running adjacent for project site                                                                                                                      |               |
| 1.14.2 | Water Requirement for station                            | : | ~ 1927 m <sup>3</sup> /hr considering closed cooling cycle with NDCT.<br>Additional 700m <sup>3</sup> /hr for ash slurry preparation during emergency ash disposal to ash dyke. |               |
| 1.14.3 | Raw Water Analysis from Upper Ganga Canal                | : | Refer Appendix - I                                                                                                                                                              |               |
| 1.15   | Site Ambient Condition                                   | : |                                                                                                                                                                                 |               |
| 1.15.1 | Monthly mean (DBT)                                       | : | Maximum                                                                                                                                                                         | 44.4 °C       |
|        |                                                          | : | Minimum                                                                                                                                                                         | 3.8 °C        |
| 1.15.2 | Extreme Recorded (DBT)                                   | : | Maximum                                                                                                                                                                         | 47.3 °C       |
|        |                                                          | : | Minimum                                                                                                                                                                         | -0.9 °C       |
| 1.15.3 | Monthly mean (WBT)                                       | : | Maximum                                                                                                                                                                         | 27.3 °C       |
|        |                                                          | : | Minimum                                                                                                                                                                         | 9.2 °C        |
| 1.15.4 | Relative Humidity                                        | : | Maximum                                                                                                                                                                         | 84 %          |
|        |                                                          | : | Minimum                                                                                                                                                                         | 28 %          |
| 1.15.5 | Average relative humidity                                | : | Annual Average                                                                                                                                                                  | 65 %          |
| 1.15.6 | Rainfall                                                 | : | Annual average                                                                                                                                                                  | 832.6 mm      |

|        |                                         |   |                                                                                                                                                                                                                                                    |                           |
|--------|-----------------------------------------|---|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
|        |                                         |   | Heaviest fall recorded in 24 hrs                                                                                                                                                                                                                   | 247.4 mm                  |
| 1.15.7 | Basic Wind Speed                        | : | 47.00 m/s                                                                                                                                                                                                                                          | As per IS: 875 part – III |
|        |                                         |   | For wind resistance design of structure & equipment refer relevant civil section                                                                                                                                                                   |                           |
| 1.15.8 | Climatic condition                      | : | For detailed information refer attached Climatological data as published by IMD for Kanpur station.                                                                                                                                                |                           |
| 1.16   | Seismic data                            | : | Zone – III                                                                                                                                                                                                                                         | As per IS: 1893           |
|        |                                         |   | For earthquake resistance design of structure & equipment refer relevant civil section                                                                                                                                                             |                           |
| 1.17   | Fuel Data                               |   |                                                                                                                                                                                                                                                    |                           |
| 1.17.1 | Coal Source                             | : | Coal requirement for this stage of the project is estimated as 2.99 million tones/annum considering 660 MW capacity, GCV of blended coal 4030 kcal/kg, Heat Rate as 2317 kcal/kwh and 90% PLF as per CERC operative norms effective from 1/4/2009. |                           |
| 1.17.2 | Coal Transportation                     | : | Thru BOXN wagons of Indian Railways System                                                                                                                                                                                                         |                           |
| 1.17.3 | Coal Analysis                           | : | Refer Appendix – II                                                                                                                                                                                                                                |                           |
| 1.17.4 | Support Fuel (HFO / LDO) transportation | : | Support fuel will be transported by road tankers or by Railway system. Start-up / support fuel for the proposed project will be LDO/HFO.                                                                                                           |                           |
| 1.17.5 | Support Fuel (HFO / LDO) analysis       | : | Refer Appendix - II                                                                                                                                                                                                                                |                           |

**Appendix – I: Raw Water Analysis (Source - Lower Ganga Canal)**

| S. No. | Description              | Unit                     | Parameter |
|--------|--------------------------|--------------------------|-----------|
| 1      | Physical characteristics |                          |           |
|        | pH at 25 <sup>0</sup> C  | -                        | 8.00      |
|        | Turbidity                | Silica Scale             | 500       |
|        | Total Suspended solids   | ppm                      | 250       |
|        | Total Dissolved solids   | ppm                      | 241       |
|        | Colour                   | Hazen                    | < 5       |
| 2      | Cations                  |                          |           |
|        | Calcium Hardness         | ppm as CaCO <sub>3</sub> | 80        |
|        | Magnesium Hardness       | ppm as CaCO <sub>3</sub> | 40        |
|        | Sodium + Potassium       | ppm as CaCO <sub>3</sub> | 36        |
|        | Iron                     | ppm as CaCO <sub>3</sub> | 1.5       |
|        | Total Cations            | ppm as CaCO <sub>3</sub> | 157.5     |
| 3      | Anions                   |                          |           |
|        | Bicarbonate              | ppm as CaCO <sub>3</sub> | 100       |
|        | Carbonate                | ppm as CaCO <sub>3</sub> | 0.95      |



| S. No. | Description                        | Unit                     | Parameter |
|--------|------------------------------------|--------------------------|-----------|
|        | Hydroxyl                           | ppm as CaCO <sub>3</sub> | 0.05      |
|        | Chlorides                          | ppm as CaCO <sub>3</sub> | 20        |
|        | Sulphate                           | ppm as CaCO <sub>3</sub> | 36        |
|        | Nitrate                            | ppm as CaCO <sub>3</sub> | 0.5       |
|        | Total Anions                       | ppm as CaCO <sub>3</sub> | 157.5     |
| 4      | Carbon Di-oxide as CO <sub>2</sub> | ppm                      | 1.97      |
| 5      | Dissolved Silica                   | ppm as SiO <sub>2</sub>  | 10.0      |
| 6      | Colloidal Silica                   | ppm as SiO <sub>2</sub>  | 0.5       |
| 7      | Organic Matter                     | ppm as O <sub>2</sub>    | 4.0       |

**Appendix – II : Coal Quality Parameter**

| Sl. No.     | Particulars                                   | Unit             | Performance / Design Fuel | Worst Fuel  | Best Fuel   |
|-------------|-----------------------------------------------|------------------|---------------------------|-------------|-------------|
| <b>1.0.</b> | <b>Proximate Analysis (As Received Basis)</b> | <b>By Weight</b> |                           |             |             |
| 1.1.        | Moisture                                      | %                | 10.5                      | 12          | 12          |
| 1.2.        | Ash                                           | %                | 35                        | 43          | 32          |
| 1.3.        | Volatile Matter                               | %                | 26                        | 19          | 27          |
| 1.4.        | Fixed Carbon                                  | %                | 28.5                      | 26          | 29          |
| 1.5.        | <b>Total</b>                                  | %                | <b>100</b>                | <b>100</b>  | <b>100</b>  |
| <b>1.6.</b> | <b>Gross Calorific Value</b>                  | <b>kcal/kg</b>   | <b>3700</b>               | <b>3200</b> | <b>4200</b> |
| <b>2.0.</b> | <b>Ultimate Analysis (As Received Basis)</b>  |                  |                           |             |             |
| 2.1.        | Moisture                                      | %                | 10.5                      | 12          | 12          |
| 2.2.        | Ash                                           | %                | 35                        | 43          | 32          |
| 2.3.        | Carbon                                        | %                | 42                        | 33.5        | 44          |
| 2.4.        | Hydrogen                                      | %                | 2.0                       | 2.4         | 2.77        |
| 2.5.        | Nitrogen                                      | %                | 1.6                       | 1.3         | 1.5         |
| 2.6.        | Sulfur                                        | %                | 0.46                      | 0.45        | 0.5         |
| 2.7.        | Oxygen                                        | %                | 8.44                      | 7.35        | 7.23        |
| 2.8.        | <b>Total</b>                                  | %                | <b>100</b>                | <b>100</b>  | <b>100</b>  |
| <b>3.0.</b> | <b>Hard Groove Index</b>                      |                  | <b>53</b>                 | <b>50</b>   | <b>55</b>   |
| <b>4.0.</b> | <b>Ash Fusion Range</b>                       |                  |                           |             |             |
| a)          | Initial Deformation Temperature               | <sup>o</sup> C   | 1200                      | 1154        | 1165        |
| b)          | Hemispherical Temperature                     | <sup>o</sup> C   | 1350                      | 1300        | >1350       |

| Sl.No. | Particulars        | Unit | Performance / Design Fuel | Worst Fuel | Best Fuel |
|--------|--------------------|------|---------------------------|------------|-----------|
| c)     | Fusion Temperature | °C   | >1400                     | >1400      | >1400     |

**Source:** Saharpur Jamarpani Coal Mine, Jharkhand  
**Imported Coal**

| Sl. No. | Item                | Unit    | Design Coal |
|---------|---------------------|---------|-------------|
| 1.      | Gross heating Value | Kcal/kg | 5500        |

**Source:** Indonesia / South African coal

**Appendix – III : Light Diesel Oil (LDO)**  
**As per IS: 1460-2000**

| S.No. | Property                            | Unit              | Value       |
|-------|-------------------------------------|-------------------|-------------|
| 1.0   | Ash content (max)                   | % by mass         | 0.02        |
| 2.0   | Carbon residue (Rams Bottom) max    | % by mass         | 0.2         |
| 3.0   | Cetane number (Min)                 | -                 | -           |
| 4.0   | Pour Point (max)                    |                   |             |
|       | a) Winter                           | °C                | 12          |
|       | b) Summer                           |                   | 21          |
| 5.0   | Flash Point (min)                   |                   |             |
|       | a) Abel                             | °C                | --          |
|       | b) Pensky0Martens                   |                   | 68          |
| 6.0   | Kinematic Viscosity at 38 deg       | Cst               | 2.5 to 15.7 |
| 7.0   | Sediments (max)                     | % by mass         | 0.1         |
| 8.0   | Sulphur Content (max)               | % by mass         | 1.8         |
| 9.0   | Water Content (max)                 | % by volume       | --          |
| 10.0  | Gross Calorific Value (GCV), approx | kCal/kg           | 10,000      |
| 11.0  | Density at 15°C                     | Kg/m <sup>3</sup> | 850 to 870  |

**Appendix – IV : Heavy Fuel Oil (HFO)**  
**As per IS: 1593-1982**

| S.No. | Property                            | Unit              | Value      |
|-------|-------------------------------------|-------------------|------------|
| 1.0   | Viscosity at 50 °C                  | Cst               | 370        |
| 2.0   | Density at 15°C (approx)            | Kg/m <sup>3</sup> | 890 to 950 |
| 3.0   | Flash Point (min)                   | °C                | 66         |
| 4.0   | Pour Point (max)                    | °C                | 20         |
| 5.0   | Water Content (max)                 | % by volume       | 1          |
| 6.0   | Sediments (max)                     | % by weight       | 0.25       |
| 7.0   | Sulphur Content (max)               | % by weight       | 4.5        |
| 8.0   | Ash content (max)                   | % by weight       | 0.1        |
| 9.0   | Gross Calorific Value (GCV), approx | kCal/kg           | 10,000     |

## 2.0 Access to Site

The nearest town Kanpur is about 16 km from site. It is easily accessible by Railway/Road.

Dedicated railway link is available for the transportation of coal and fuel oil for the power plant. No problem is envisaged in accessibility and transportation of heavy equipment to site by road or rail.

### **3.0 Plant Rating, Capacity, Availability, PLF**

Plant continuous rating will be 660 MW at generator terminals based on the following site conditions.

- Ambient air temperature
- Condenser cooling water inlet temperature of 33°C and 10°C temperature rise across the condenser.
- Generator power factor of 0.85 (zero point eight-five).
- Fuel specification as given elsewhere.
- Design temperature for electrical equipment is 50°C.

The VWO capacity of the steam turbine 660 MW will be 105% or 693 MW and the Boiler maximum Continuous Rating (MCR) will be established to match the steam requirement at VWO conditions. The capacity of the unit is selected so as to deliver the rated output even after ageing that will occur between overhauls, as a result of deposition of salts in turbine blades, wear and tear etc.

### **4.0 Power Evacuation**

The power generated from the proposed project will be evacuated over the 400 KV through a 400 KV open switchyard. Further to Switchyard distribution will be by UPTRANSCO. Interconnection of proposed 400 KV Switchyard with existing 220 kV switchyard shall be done as specified elsewhere in specification.

# जलवायवी सारणी CLIMATOLOGICAL TABLE

1951 से 1976 तक के अवधि पर आधारित  
BASED ON OBSERVATIONS FROM 1951 TO 1976

स्थान : कानपुर (A) STATION : Kanpur (A) देश : भारत INDIA राज्य : उत्तर प्रदेश U.P. जिला : कानपुर Kanpur

उचाई : 226 फीट 68.8 मीटर HEIGHT ABOVE M.S.L. : 120 METRES

वर्षा : वर्षा

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स्टेशन :कानपुर (ए)  
STATION: Kanpur (A)

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1X660 MW PANKI TPS

COMPRESSED AIR SYSTEM

SECTION I-A

SPECIFIC TECHNICAL REQUIREMENT -MECHANICAL



BHARAT HEAVY ELECTRICALS LTD  
POWER SECTOR PROJECT ENGINEERING MANAGEMENT  
NOIDA-INDIA



## COMPRESSED AIR SYSTEM

### 1X 660MW PANKI TPS EXTN

DOCUMENT NO.: PE-TS-426-555-A001

SCOPE OF SUPPLY, EXCLUSION &amp; TP.

SECTION-IA

REV - 02

DATE: 30.01.2020

#### 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 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 equipment:
  - 1.1.1 Three (3) Nos. Instrument Air Compressors (Oil Free Screw) each of minimum 40 NM<sup>3</sup>/Min capacity at 8.5 Kg/sqcm (g) discharge pressure with 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. heat of compression desiccant type (rotary drum type or conventional twin tower type) Air Drying Plants of minimum 44.0 Nm<sup>3</sup>/min capacity (1.1 times the IA compressor capacity) with all instruments, control panels and other accessories as specified.
  - 1.1.3 Three (3) Nos. Service Air Compressors (Oil Free Screw) each of minimum 40 NM<sup>3</sup>/Min capacity at 8.5 Kg/sqcm (g) discharge pressure with suction filter with silencer, inter cooler and after cooler with moisture separators, automatic drain traps, instruments, control system and other accessories.
  - 1.1.4 Six (6) Nos. Air Receivers of 15 cum capacity each adjacent to compressor house, two (2) nos of 10 cum capacity each in TG hall, one (1) no of 2 cum capacity and one (1) no of 5 cum capacity in DM plant area, one (1) nos of 5 cum capacity in FGD area and one (1) nos of 5 cum capacity in CHP area. Each air receiver shall be complete with instruments, relief valve, drain connection with electronic timer controlled solenoid operated automatic trap stations and other accessories as specified.
  - 1.1.5 Three (3) Nos. Electronic Dew point meters.
  - 1.1.6 Pipes and fittings for compressed air line & interconnecting airline, cooling water line 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 and water line valves – Lot.
  - 1.1.8 Field instruments as specified in technical specification, all instruments necessary for performance testing of compressors as well as air drying plants – Lot.
  - 1.1.9 Microprocessor/PLC based integrated control system for each compressor and dryer. – Lot.
  - 1.1.10 Cables as specified – Lot.
  - 1.1.11 Maintenance and erection 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 All commissioning spares & consumables for trouble free operation shall be in scope of bidder.



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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 Erection and commissioning of compressed air system.

#### 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.

2.2 250 Nb Cooling water supply pipeline connection will be provided by the purchaser outside the compressor house (at 10.0 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. Refer enclosed tender drawing.

#### 3.0 EXCLUSIONS:

3.1 HT motors for Air compressors. HT motors are not in bidder's scope of supply, bare motors only shall be supplied as free issue by BHEL to successful bidder based on motor inputs furnished by bidder, like motor rating and TS (Torque - Speed) curve. The responsibility for satisfactory operation for combined performance of compressors & motors shall rest with the bidder only as if, the drive motors also have been supplied by the bidder. Couplings, base plate, foundation bolts, any other fittings, etc. as required shall be supplied by the bidder only. BHEL shall supply motors to successful bidder works for shop testing of compressors with job motors. All other motors (mandatory spare) shall be dispatched by BHEL directly to project sites.

3.2 MCC/Switchgear for power supply to Air Compressors and other drives and panels.

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

3.4 Lighting and ventilation of compressor house.

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

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

#### 4. SUB-VENDOR ITEMS

The tentative make of Sub-vendor items shall be generally as per Annexure-I, Section IA enclosed which is subject to customer approval during detail engineering.

#### 5. DRAWINGS AND DOCUMENTS TO BE SUBMITTED WITH THE BID

The drawings and documents to be submitted with the bid shall strictly be as mentioned under Section IIIA. Any documents other than those indicated in Section IIIA will not be reviewed and will not form part of contract.

#### 6. DRAWINGS/ DOCUMENTS REQUIRED DURING DETAIL ENGINEERING

List of drawing / document required to be submitted during detail engineering is attached in Annexure-III, Section IA. Any other drawings and documents as required by BHEL / Customer / Consultant shall be





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furnished by the successful bidder during detail engineering stage for which no implication shall be entertained by BHEL.

#### 7. DRAWINGS DISTRIBUTION SCHEDULE

Drawing/document needs to be submitted by successful bidder during detail engineering shall be as per Annexure-II, Section IA.

#### 8. DRAWINGS ENCLOSED WITH THE SPECIFICATION

Drawings as per Annexure-IV, Section IA enclosed will form part of the specification.

The P&I diagrams are indicative and show the minimum requirement to be followed including minimum requirement of instruments. Any other item and instruments required (within the terminal points) to make the system complete in all respect and for satisfactory operation of the system shall also deemed to have been included by the bidder in their scope. The detailed P&I diagrams for compressed air system in line with specification requirement shall be developed by the vendor during detail engineering for customer's approval and without any commercial implication to customer. Bidder to note that the while preparing PIDs after placement of order, successful bidder shall incorporate line numbers, Instrument tag nos., KKS Numbering, equipment no, Line Spec, Line MOCs, legend / symbol chart, equipment capacity, relief valve capacity and set pressure, control valve capacity, range, fail position etc. in these drawing and same are subject to the customer approval.

#### 9. MANDATORY SPARES

General requirement of mandatory spares will be as per the list enclosed under Annexure-V, Section IA. The successful bidder immediately after approval of PID, Layout & equipment/ instrument data sheets /GA will prepare detailed list of mandatory spares with regard to their exact quantities, applicability/ non applicability; supply of alternate items against non-applicable items etc. This list will be submitted to customer for getting their approval. The successful bidder will proceed for ordering only after approval of the list. BHEL reserves the right to buy any or all the mandatory spares parts as mentioned in the list.

#### 10. GUARANTEED POWER CONSUMPTION

Bidder to furnish the Guaranteed power consumption (GPC) as per the format attached at Section IIIF of this specification. Bidder to furnish GPC along with its technical bid and not in sealed priced bid.

#### 11. OTHER REQUIREMENTS

- Detailed erection manual for each of the equipment as well as complete system supplied under this contract at least 2 months before the scheduled erection of the concerned equipment / component or along with supply of concerned equipment / component whichever is earlier.
- The O&M Manual to be submitted by the successful bidder will necessarily address the following:
  - a. Complete System Description along with PIDs, write up on electrical philosophy and safety/process interlocks etc.
  - b. Instructions for plant operation
  - c. Commissioning procedure of the system
  - d. Chapter on precautions to be taken during:
    - Operation
    - Idle time



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- Long shutdown
- e. Chapter on trouble shooting during plant operation covering:
  - Safely aspects
  - Do's and do not's
  - Maintenance schedule
  - Schedule of lubricants & consumables
- f. O & M instruction for all individual equipment which shall invariably contain but not necessarily limited to the following:
  - Equipment description/interdiction
  - Data sheet, Equipment GA & Cross Section Drawing
  - Catalogue of each equipment
  - DO's & DON'T's
  - Duty Conditions
  - Installation & Safety Recommendation
  - Start-up & shut down procedure
  - Instructions for testing and adjustment of system parameters
  - Disassembly & Assembly Instructions giving sequence no. of each component
  - List of Replacement/ Spare parts along with their drawing and catalogues and procedure for ordering spares.
  - Reason & Remedy Chart for any problem
  - Maintenance Schedules- Daily, Weekly, Monthly, Half Yearly and Annual indicating clearly the spares part and man-hour requirement for each stage.
  - Detailed specification/ Schedule of all the consumables including lubricant oils, greases, chemicals etc. required for the complete system
  - Commission procedure for equipment.
- Document approval by customer under Approval category or information category shall not absolve the vendor of their contractual obligations of completing the work as per specification requirement. Any deviation from specified requirement shall be reported by the vendor in writing and require written approval. Unless any change in specified requirement has been brought out by the vendor during detail engineering in writing while submitting the document to customer for approval, approved document (with implicit deviation) will not be cited as a reason for not following the specification requirement.
- In case vendor submits revised drawing/doc after approval of the corresponding drawing/doc, any delay in approval of revised drawing shall be to vendor's account and shall not be used as a reason for extension in contract completion. However, in case changes are necessitated due to any constraints at customer end, delay in review/ approval of such revised drawing beyond one month will be to customer's account.
- Bidder to note that during detail engineering, successful bidder to submit the drg/doc through web based Document Management System in addition to hard copies to be submitted as per dwg/ document distribution schedule. Bidder would be provided access to the DMS for drg/doc approval and adequate training for the same. Detailed methodology would be finalized during the kick-off meeting. Bidder to ensure following at their end.



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- Internet explorer version – Minimum Internet Explorer 7
- Internet speed – 2 mbps (Minimum preferred)
- Pop ups from our external DMS IP (124.124.36.198) should not be blocked
- Vendor's Internal proxy setting should not block DMS application's link (<http://124.124.36.198/wrenchwebaccess/login.aspx>)

DMS user manuals to be used by BHEL PEM vendors for uploading, viewing, revising, commenting and tracking documents on PEM's DMS have been uploaded on PEM internet website ([www.bhelpem.com](http://www.bhelpem.com)) under the Vendor session.

For quick access bidder may refer the link <http://bhelpem.com/DMSManuals/DMSManuals.html>

- Final Electrical Load list will be submitted by the successful bidder as per agreed drawing/ doc submission schedule. Thereafter any change in the electrical load list shall be entertained only subject to its feasibility, and BHEL reserves the right to debit the vendor cost of any changes necessitated in the switch gear /MCC on account of changed loads.
- Wherever CIVIL works is excluded from the bidder's scope, successful bidder shall furnish civil assignment drawings. The corresponding CIVIL drawing prepared by BHEL / CIVIL agency, based on civil assignment drawing of bidder will be furnished to the successful bidder for concurrence. In case any modification is required in the civil work already carried out based on final civil inputs given by vendor, BHEL reserves the right to debit cost of such rework to vendor".
- If any deviation is there then same to be indicated separately under the heading "Schedule of Technical Deviation" enclosed as per Volume III of the Technical Specification along with Cost of Withdrawal. In case 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.

## 12 BIDDER TO NOTE THE FOLLOWING INFORMATION:

- 12.1 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.
- 12.2.1 Compressor and air dryer shall be designed for cooling water (from passivated DM water) with inlet temp of thermal 38 deg C and terminal pressure 10 kg/sqcm(g). Bidder to restrict the temperature rise to 10 deg C and pressure drop across Compressed Air System within terminal points to 10 MWC. Qty of cooling water shall be 320 cum/hr (Maximum) considering working equipment only.
- 12.3 Design Inlet conditions for Compressor
  - a) Temp : 45.0 Deg C
  - b) Relative humidity : 75%
  - c) Altitude : 126.0 m above MSL
- 12.4 Design, all calculations, equipment selection criterion, layout drawings/schemes/G.A. drg and documents like data sheet/Technical particulars etc. shall be prepared by successful bidder and shall be subjected to Customer & BHEL approval during detail engineering stage.



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- 12.5 The maximum velocity to be considered in compressed air shall be 10.0 m/s (under Average pr. & Temp. Conditions).
- 12.6 All drawings and documents shall be computer based.
- 12.7 All commissioning spares & consumables for trouble free operation shall be provided, with minimum to what specified elsewhere in the specification.
- 12.8 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 terms of safety, trouble free operation of equipment's & system as a whole and isolation of individual equipment for maintenance, then same shall be supplied by the bidder without any commercial implication to BHEL.
- 12.9 Grouting of equipment's, like Air receiver, Air dryer & foundation bolts etc. are in the scope of the bidder.
- 12.10 Performance test for compressors shall be carried out at shops with job motor only.
- 12.11 All the instruments as required for performance testing shall be arrange by bidder. Instrument for testing shall be calibrated from government certified labs & this is in the bidder scope. Bidder to ensure validity of such reports before the performance tests.
- 12.12 The height of two number, 10 cum, unit air receivers, to be located inside TG Hall, shall be limited to 4M.
- 12.13 Access platform required for the maintenance of instruments/valves on the towers of HOC type air drier shall be in bidder's scope of work.
- 12.14 Only KKS tagging shall be used in all document/drawings and in the field for all items/equipment/signals etc. No other tagging method is acceptable. The successful bidder shall provide detailed drawing with KKS only. Operational write up of the system should strictly contain KKS code for identification and description.

1X660 MW PANKI TPS

COMPRESSED AIR SYSTEM

SECTION IA

(TECHNICAL REQUIREMENT - MECHANICAL)



BHARAT HEAVY ELECTRICALS LTD  
POWER SECTOR PROJECT ENGINEERING MANAGEMENT  
NOIDA-INDIA



## 1X660 MW PANKI TPS EXTN.

### COMPRESSED AIR SYSTEM

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Section IA

#### 1. SYSTEM DESCRIPTION

- 1.1.1** Compressed air system is provided in the power plant to supply compressed air through the distribution network to various user points.
- 1.1.2** The compressed air system shall comprise of the instrument air system and the plant/service air system. Instrument air is required for the various pneumatically operated valves and instruments in the power plant, while plant air is required for general plant services.
- 1.2** Compressed Air System includes the following
- 1.2.1** Three (3) nos. (2 working + 1 standby) Instrument air compressors and three (3) nos. Plant air compressor (2 working + 1 standby), including drives, intercoolers, after coolers, step up gearbox, silencer and other accessories.
- 1.2.2** Three (3) nos. (2 working + 1 standby) air-drying plants (ADP) each suitable for connecting to individual instrument air compressor.
- 1.2.3** Intake air filters.
- 1.2.4** Six (06) nos. air receivers, (3 nos. for instrument air service and 3 nos. for plant air service) near compressor house, two (2) nos as Unit air receiver in TG Hall (for instrument air service), Two (2) nos for DM Plant (1 no. for instrument air service and 1 no. for plant air service), one (1) no for FGD (instrument air service) and one (1) no for CHP (service air service).
- 1.2.5** Interconnecting piping, valves, fittings, supports/hangers, control air tubing (complete with valves and fittings between air receivers, compressor and local panel for each compressor), cooling water piping & valves for safe and satisfactory operation of air compressors.
- 1.2.6** Instruments including the electronic on line dew point meter with suitable sampling connection and isolation valve at the outlet of each Air Drying Plant shall be provided.

#### 2. DESIGN INPUTS/ CRITERIA

##### 3.1 AIR COMPRESSORS

- 2.1.1** The capacity of each instrument air compressor shall be 40.0 NM<sup>3</sup>/min. Delivery pressure will be 8.5 Kg/cm<sup>2</sup> (g) at compressor outlet while 8.0 Kg/cm<sup>2</sup> (g) at ADP outlet. Each compressor will be designed to deliver the nominal capacity at the required delivery pressure. (Refer compressor sizing calculation).
- 2.1.2** The capacity of each plant air compressor shall be 40.0 NM<sup>3</sup>/Min. Delivery pressure will be 8.5 Kg/cm<sup>2</sup> (g) at outlet of SA compressor. (Refer compressor sizing calculation).
- 2.1.3** Air compressors will be multi stage oil free, screw type.
- 2.1.4** The compressors' capacity will be designed for 45° C DBT and 75% RH at atmospheric pressure at site & at 193.0m above mean sea level (MSL).
- 2.1.5** Testing of compressor shall be as per ISO 1217.
- 2.1.6** Air compressors will be designed for continuous operation with high efficiency to satisfy the performance requirement.
- 2.1.7** The maximum continuous motor ratings shall be arrived at considering 15% margin over the duty point input.
- 2.1.8** Satisfactory operation in parallel will be ensured without any uneven load sharing, undue vibration, noise etc.

|                                                                                   |                                                                     |                                         |            |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------|-----------------------------------------|------------|
|  | <b>1X660 MW PANKI TPS EXTN.</b><br><br><b>COMPRESSED AIR SYSTEM</b> | BHEL Doc. No: <b>PE-TS-426-555-A001</b> |            |
|                                                                                   |                                                                     | <b>REV</b>                              | REV - 02   |
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|               |                                                                                                                                                                                                                                                                                                                                                                               |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>2.1.9</b>  | Noise level shall not exceed 85 dBA plus tolerances as per ISO standard when measured at a distance of 1.5 meter above the floor and 1.0 meter from the compressor under free field conditions. Acoustic enclosure, if required, shall be provided to meet the above condition.                                                                                               |
| <b>2.1.10</b> | The compressed air velocity shall be limited to 10 m/s for pipe sizing.                                                                                                                                                                                                                                                                                                       |
| <b>2.1.11</b> | The material of construction for the Air Compressor shall be as mentioned in attached customer specification.                                                                                                                                                                                                                                                                 |
| <b>2.2</b>    | <b>ROTOR.</b>                                                                                                                                                                                                                                                                                                                                                                 |
| <b>2.2.1</b>  | Rotors will be one-piece construction with a suitable forged carbon steel or stainless steel coated with corrosion resistant material to minimise leakage and wear.                                                                                                                                                                                                           |
| <b>2.2.2</b>  | The rotors will have an asymmetric profile, so as to keep leakage losses to a minimum and ensure high efficiency.                                                                                                                                                                                                                                                             |
| <b>2.2.3</b>  | Highly precise timing gears will be mounted on the rotor shafts to maintain the rotors in correct relative position.                                                                                                                                                                                                                                                          |
| <b>2.2.4</b>  | These gears will be designed to counteract the axial forces incurred in compression.                                                                                                                                                                                                                                                                                          |
| <b>2.2.5</b>  | Rotors shall be dynamically balanced.                                                                                                                                                                                                                                                                                                                                         |
| <b>2.3</b>    | <b>AIR DRYING PLANT.</b>                                                                                                                                                                                                                                                                                                                                                      |
| <b>2.3.1</b>  | Air-drying plant shall be of heat of compression desiccant type (rotary drum type or conventional twin tower type), drying by adsorption method. Capacity of each ADP shall be 44.0 Nm³/min (i.e. 1.1 times the compressor capacity).                                                                                                                                         |
| <b>2.3.2</b>  | Quality of outlet air from ADP shall be in accordance to Instrument Society of American Standard S7.3 "Quality Standard for Instrument Air" as follows.<br><br>a) Dew point at outlet of the air drying plant will be minus (-) 40° C at atmospheric pressure.<br><br>b) Dust particle size in instrument air will be less than two (2) micron.                               |
| <b>2.3.3</b>  | Desiccant shall be activated alumina for conventional twin tower type ADP. For rotary drum type ADP silica gel impregnated inorganic fibre rotor as per manufacturer standard shall be used.                                                                                                                                                                                  |
| <b>2.4</b>    | <b>AIR RECEIVER.</b>                                                                                                                                                                                                                                                                                                                                                          |
| <b>2.4.1</b>  | The capacity of 06 nos. air receivers provided near to compressor house shall be 15 m³ (nominal) and for 02 nos. air receivers provided in TG hall as unit air receiver shall be 10 m³ (nominal). Capacity of 02 nos are receivers provided in DM plant shall be 2 m³ and 5m³ (nominal). Air receivers provided in for CHP and FGD areas shall be of 5 m³ (nominal) capacity. |
| <b>2.4.2</b>  | The air receivers shall be vertical self-supporting cylindrical vessels with supporting legs for resting on their foundation.                                                                                                                                                                                                                                                 |
| <b>2.4.3</b>  | Design Pressure & Temperature for the air receiver shall be 1.5 times compressor discharge pressure & 80° C respectively. Air receivers shall be designed as per ASME Section VIII or IS: 2825.                                                                                                                                                                               |
| <b>2.4.4</b>  | The material of construction of shell, dished ends, flanges etc. of the air receivers shall be of carbon steel as per IS: 2062 / equivalent.                                                                                                                                                                                                                                  |
| <b>2.4.5</b>  | Air receiver shall be provided with nozzles, air release vents, safety valve, pressure gauge, temperature gauge, minimum 500 mm dia. manhole for inspection.                                                                                                                                                                                                                  |
| <b>2.5</b>    | <b>INTAKE FILTER</b>                                                                                                                                                                                                                                                                                                                                                          |
| <b>2.5.1</b>  | Dry type suction air filters will be provided at the compressor inlet to prevent dust and dirt from entering the compression chambers of compressors. The filtering efficiency                                                                                                                                                                                                |



**1X660 MW PANKI TPS EXTN.**  
**COMPRESSED AIR SYSTEM**

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shall be 99.0 %, down to 2 microns. Sound suppressing characteristics will be considered in the filter design.

**2.6 PIPING AND VALVES (WITHIN COMPRESSOR HOUSE)**

**2.6.1** All interconnecting compressed air piping shall conform to ASTM A-53 type E grade B / IS 1239 heavy galvanised / IS 3589 Gr 410 galvanised. All cooling water piping will be IS-3589 Gr.410/ IS-1239 Heavy grade. Oil Piping shall be API 5L. The fittings shall be conforming to relevant BIS standard and Grade equivalent that of parent pipe Grade. Compressed air piping handling hot air will be suitably insulated so as to restrict surface temperature to 60 deg. C. The compressed air pipe joints will be screwed type. Cooling water lines of 65 Nb and above shall be joined by butt welding and 50 Nb and below by socket welding.

**2.6.2** Necessary auto drain shall also be provided at strategic points in compressed air line.

**2.6.3 VALVES**

**3.6.3.1 Compressed Air service.**

**a)** All airline valves shall be ball valve type. For compressed air application, valve body material shall be stainless steel.

**3.6.3.2 Water service**

**a)** Cooling water / drain water application valve shall be gate / globe / ball valve type. Valve material shall be Cast iron for size 65 Nb and above; gun metal / forged carbon steel for sizes 50 Nb and below.

**3.6.3.3** End connections shall be screwed or flanged as required.

**2.7 LAYOUT CONSIDERATION**

**2.7.1** Air compressors will be located indoor in a separate compressor room; compressor room layout is attached with this specification. Bidder to accommodate compressor and dryers in the space allocated in compressor room.

**2.7.2** The air receivers will be located outdoors and adjacent to the compressor room.

**2.7.3** Complete ADP equipment shall be preferably mounted on a skid and located indoor.

**3. OPERATION & CONTROL PHILOSOPHY**

**3.1** The necessary instrumentation and control shall be provided for safe and trouble free operation of compressed air system.

**3.2** Individual compressor control shall be through microprocessor based control system in line with requirements mentioned in attached customer specification and C&I specification.

**3.3** Overall controls of the Compressors like, load, unload, field instruments shall be through main plant DDCMIS.



1X660 MW PANKI TPS

COMPRESSED AIR SYSTEM

SECTION IA

(CUSTOMER SPECIFICATION)



BHARAT HEAVY ELECTRICALS LTD  
POWER SECTOR PROJECT ENGINEERING MANAGEMENT  
NOIDA-INDIA

## **23.0 COMPRESSED AIR SYSTEM**

### **23.1 INTENT OF SPECIFICATION**

23.1.1 This specification is intended to cover the Design, Engineering, Manufacture, Fabrication, Assembly, Inspection, Testing at Manufacturer's works, Packing, Transportation, Delivery, Receipt, Unloading, Storage and handling at site, supervision of Erection, Testing, Commissioning and Field Acceptance / Performance Guarantee test of Compressed Air System consisting of air compressors and their motor drives, receivers and air drier units with all associated accessories and auxiliaries as specified herein after and as required for safe trouble free operation and maintenance for 1x660 MW Panki Thermal Power Station, Kanpur, Uttar Pradesh.

23.1.2 Since the project is being implemented on turnkey concept of engineering, procurement and construction (EPC) with single point responsibility with the successful bidder, it not intended to specify completely herein, all details of design and construction of equipments. However, the equipment shall conform in all respects to high standards of engineering, design and workmanship and be capable of performing in continuous commercial operation up to the vendor's guarantee in a manner acceptable to the owner. The owner will interpret the meaning of drawings and specifications and shall be entitled to reject any work of material which in his judgment is not in full accordance therewith.

23.1.3 Compressed Air is mainly required in the following areas :

- a. Pulveriser coal sampling.
- b. APH soot blowing.
- c. Turbine Generator (TG) and Auxiliaries.
- d. CPU Area
- e. DM Plant & Water system area.
- f. TG & SG area cleaning and maintenance.
- g. Fuel oil pump house area
- h. LDO atomization
- i. Station C & I area
- j. CHP area
- k. AHP Area
- l. ETP area
- m. Any other area (if required) which is not covered above.

Besides, dedicated Compressed Air Systems (as described in respective Chapters) shall be provided for each of the following areas:

- (a) CHP area
- (b) AHP area
- (c) Mill Reject handling system

## **23.2 System Description**

- 23.2.1 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 compressors, instrumentation and control, control panels, interconnection compressed air piping in the compressor house, instrument air piping network, service air piping network and unit instrument air receiver.
- 23.2.2 The air compressors & drives, instruments, control panels and ADP's 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 traveling, Cross travel and lifting) operated, overhead traveling type (EOT) crane as specified elsewhere in tender specification.
- 23.2.3 In addition to the air receivers mentioned above Unit air receivers for instrument air system shall be provided to cater to the requirements of 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.
- 23.2.4 Further a dedicated air receiver shall be provided near DM plant to meet the instrument air requirement of water treatment plant.
- 23.2.5 The compressed air system comprises of Instrument Air (IA) air system and Service Air (SA) system.
- 23.2.6 The IA system shall supply required quality air to various pneumatically operated valves and instruments of SG, TG and all BOP systems and SA system shall meet the service air requirement of the proposed Unit.
- 23.2.7 The compressors shall be arranged such that all the service air compressors shall be able to supply air upstream of each ADP through an isolation valve and a non-return valve and control valve so that in event of failure of instrument air compressor, instrument air is ensured continuously from service air compressor. The valves and piping arrangement for such interconnection shall also be provided as preliminary indicated in the flow diagram enclosed with the specification.
- 23.2.8 All the piping works for IA & SA system including all accessories shall be provided.
- 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
- 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
-

### **23.3 Codes & Standards**

The equipment to be provided under this section shall specifically conform to the following codes, standards, specifications and regulations as applicable, including all its latest amendments subsequent to the year of publication as mentioned below:

- BS-726 : Measurement of Air Flow for Compressor
- IS-2825 : Code for unfired pressure vessels.
- IS-4503 : Shell and Tube Type Heat Exchanger
- IS-5456 : Code of Practice for testing of positive displacement type air Compressors and exhausters.
- IS-5727 : Glossary of terms relating to compressors and exhausters.
- IS-1239 Part-1 : Mild Steel tubes, tubulars and other wrought steel pipes.
- IS-1239 Part-2 : Mild steel tubes, tubulars and other wrought steel fittings.
- IS-6206 : Guide for selection, installation and maintenance of air compressors / plants with operating pressure up to 10 bars.
- ANSI-B16.5 : Steel Pipes Flanges and Fittings.
- IS-7938 : Air Receivers for Compressed Air Installations.
- IS-10431 Part-I : Measurement of Air Flow of Compressor and Exhausters by nozzles.
- ASME PTC-9 : Performance Test Codes for Displacement Compressors, Vacuum Pumps and Blowers.
- BS-5169/1975 : Fusion Welded Steel Air Receiver.
- ISO-7183 : Compressed Air Dryers - Specification and Testing.
- ISO-7183 (Part-II) : Compressed Air Dryers - Performance rating.
- IS-12258 : Technical supply condition for Screw Air Compressor.
- BS-1571 : Simplified Acceptance Test for Air Compressor and Exhausters.
- IS-2062 : Steel for General Structural Purpose- Specification.
- IS-11989 : Compressed air dryer.
- 
- ISO 8753.1 : Filter quality classes.

### **23.4 Design Requirements & Performance Guarantee:**

23.4.1 Air Compressors shall be identical and all equipments shall be designed for continuous operation with high efficiency to satisfy the performance requirements as specified in Data Sheet enclosed with this section. Frequent start/ stop of the system shall not result deterioration in performance nor damage to the equipment.

23.4.2 The compressors and Air Drying Plants shall operate under the following ambient conditions.

- a) Minimum Temperature 2 Deg C
- b) Maximum Temperature 50 Deg C
- c) Design Condition (Temp & RH) 45 Deg C & 75%

- 23.4.3 The capacity of each IA compressor and SA compressor shall be 40 NM<sup>3</sup>/min (minimum) or as computed by procedure for capacity determination of IA and SA in clause no. 23.4.10 below, whichever is higher. The discharge pressure at the outlet of after cooler shall not be less than 8.5 Kg/cm<sup>2</sup> (g).
- 23.4.4 The Compressed Air System shall ensure a reliable supply of adequate quantity and quality of oil free dry air on continuous and intermittent basis. It consists of two sub systems namely,
- i) Instrument Air (IA) for Instrumentation and Control purposes.
  - ii) Service Air (SA) for some boiler equipment, general house cleaning and other miscellaneous usage.
- 23.4.5 The normal pressure of Instrument Air supply at the outlet of Air Dryer shall be 8.0 kg/cm<sup>2</sup> (g) (minimum). Corresponding to the normal pressure at the outlet of dryer, the rated discharge pressure of IA compressor shall be worked out, allowing for pressure drops in system piping, equipment and all other accessories. The rated discharge pressure of IA compressor shall be computed as per guidelines specified above or 8.5 kg/cm<sup>2</sup> (g) (minimum) at the outlet of after cooler, whichever is higher. Each Service Air compressor shall be designed to deliver service air at a rated discharge pressure equal to the rated discharge pressure of each Instrument Air Compressor. The maximum expected pressure in the system shall be computed by considering 20% overpressure over and above the rated discharge pressure of each air compressor as computed above.
- 23.4.6 Noise level shall not exceed 85 dBA when measured at a distance of 1.0 meter from the compressor. Acoustic enclosures as required shall 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.
- 23.4.7 Service air compressors and instrument air compressors shall be interconnected for flexibility in operation, designed for continuous operation with high efficiency to satisfy the system requirements. The compressors shall be of indoor duty complete with air coolers necessary valves with vent pipe work ducted to a safe discharge outlet. The air pipe work shall be of ERW pipes to IS: 3589/1239 heavy quality construction.
- 23.4.8 Compressors shall be identical oil free, rotary, dry screw type, water cooled, horizontal and multistage. Each compressor shall have an inlet filter and silencer unit having inlet area large enough to ensure that frequent filter changes are not required. The silencer unit shall comply with the statutory noise requirements specified for which necessary acoustic enclosure shall be provided for housing the compressors. Drive motor shall comply with standard specification for induction motors enclosed with the specification and shall be connected directly to the gear box of the compressor.

- 23.4.9 Each air compressor shall have its own control panel with indication lights for power on; service hour-run meter; load hour-run meter; inlet air filter differential pressure high; outlet air pressure & temperature (analogue gauge); oil filter differential pressure high; separator element differential high; motor overload; low oil level; compressor temperature high; oil temperature before and after oil cooler (analog gauge). The compressor should trip on motor overload; low oil level; and compressor temperature high.
- 23.4.10 The total Instrument Air requirements shall be assessed by the following guideline :  

$$Z = \{(A+B)+C+D\} \times [1 + (mw+ml)/100]$$
where,  
A = Instrument Air requirement for SG & auxiliaries (continuous).  
B = Instrument Air requirement (continuous) for TG & auxiliaries  
C = Instrument Air requirement (continuous) for Water treatment plant and other facilities  
D = Station C&I requirement (continuous).  
mw = Wear & tear margin (10%)  
ml = Leakage margin (10%)  
Z = Total Instrument Air requirement
- The total Service Air requirement shall be assessed by considering the following guideline:  

$$Y = \{(E+F)+G+H\} \times [1 + (mw+ml)/100]$$
where  
Y = Total service air requirement (continuous)  
E = Service Air requirement (continuous) for SG, TG & auxiliaries.  
F = Service Air requirement (continuous) for Water treatment plant and other facilities. **F = 2.5 NM3/min (minimum)**  
G = Service Air Requirement for AHP  
H = Service Air Requirement for CHP  
mw = Wear & tear margin (10%)  
ml = Leakage margin (10%)  
Each Service Air Compressor shall have capacity identical to that of each IA compressor but in no case less than the value Y as computed above.
- While calculating the air requirement of bidder's equipment/ plant/ systems for continuous requirement of service air, no diversity factor shall be considered and they are 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 0.6.
- 23.4.11 Compressed air system shall comprise one (1) IA group and one (1) SA group of compressors.
- 23.4.12 Equipment operating on Instrument Air and Service Air System shall be designed for a pressure of 120% of rated discharge pressure of each air compressor.

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- 23.4.13 The delivered compressed air shall not contain any trace of oil, grease or any other impurities. Size of particles in the delivered air shall not exceed 1 Microns.
- 23.4.14 Compressed air system equipment requiring DMCW cooling water shall be capable of operation at design capacity with DMCW cooling water inlet temperature subject to a maximum of 38°C (Indicative). The above equipment shall also be capable to withstand a pressure not less than the shut off head of each DMCW pump.
- 23.4.15 The temperature of air at outlet of after cooler shall not exceed 8°C above the cooling water inlet temperature.
- 23.4.16 As more than one (1) compressor with drive is specified, satisfactory operation in parallel shall be ensured without any uneven load sharing, undue vibration, and keeping noise level within permissible limits for the number of compressors working simultaneously.
- 23.4.17 Each Air Receiver shall be so sized that even in the event of total stoppage of air inflow to the same, the pressure in the Air Receiver shall not fall below 5.5 kg/cm<sup>2</sup> (g) within two (2) minutes of such stoppage, while maintaining an out flow of air at a rate equal to the rated capacity of a single compressor, during the aforesaid period. In no case, the size of each Air Receiver shall be less than that arrived from IS 7938.
- 23.4.18 Air receivers shall be provided for service air and instrument air separately as shown in the flow diagram.
- 23.4.19 Air receivers shall be designed in accordance with ASME Section-VIII or IS: 2825. Corrosion allowance of minimum 3 mm shall be considered for the design. The air receiver shall be of vertical cylindrical design with dished ends.
- 23.4.20 Air receivers shall be designed for minimum 1.5 times compressor discharge pressure.
- 23.4.21 The air receiver shall have inlet / outlet connections, safety relief valves, fusible plugs, pressure gauges, pressure switches, temperature gauges, flanged pipe connections, inspection manholes with automatic drain traps. The air receiver shall have access platforms for maintenance of safety relief valves and instruments.
- 23.4.22 Three (3) HOC type air drying plants shall be provided (2W +1S) and shall be designed to deliver continuous instrument air. The capacity of each air drying plant shall be provided to match the corresponding 1.10 times capacity of each Instrument air compressor. Discharge pressure available at the outlet of Air Drying Plant shall be minimum 8.00Kg/cm<sup>2</sup> (g) or more as per requirement of contractor.
- 23.4.23 The air drying plants receiving compressed air saturated with moisture shall be capable of operating continuously to provide reliable moisture free compressed air. Dew point of the outlet air measured at the stated operating pressure shall be as mentioned in Data Sheet or lower
-

- throughout the operation. For calculating moisture load, relative humidity and dry bulb temperature at ADP inlet shall be taken as 100% & 50°C respectively.
- 23.4.24 The drying process shall employ heat of compression type air drying plant using adsorption process through a desiccant medium drying to remove moisture from air. The air drying plant shall be considered to remove the moisture and dry air shall have following quality:
- (a) Dew point at atmospheric pressure (-) 40° C.
  - (b) Oil content 0.01 ppm (maximum tolerable) or oil free.
  - (c) Dust – Practically dust free but maximum particle size 1 micron. Air quality after air drying plant shall be in accordance with ISA – 57.3 (Instrument Society of America) quality standards for instrument air.
  - (d) Contaminants - No corrosive hazardous, toxic or flammable materials.
- 23.4.25 Air Driers shall be suitable for part load operation while maintaining the outlet air dew point as specified above. Necessary instruments and controls shall be provided to ensure that the specified dew point is maintained irrespective of input variations.
- 23.4.26 Air Dryers shall include at least the following:
- a) Pre-filters with condensate discharge trap stations.
  - b) After-filters with condensate discharge trap station.
  - c) Inter connecting piping, fittings, specialties, drain trap station etc. complete with isolation valves, solenoid valves, check valves, pressure relief valves etc. Including all drain piping as required.
  - d) Complete control and instrumentation including control cabling from instrument to junction boxes including junction boxes, tubing, wiring inside plant.
  - e) Terminal counter flanges with nuts, bolts, gaskets, etc.
- 23.4.27 The contractor shall assume full responsibility in the operation of the air drying plant as a whole.
- 23.4.28 For the air drying capacity and all other relevant details pertaining to Air Drying Plant, Data Sheet shall be referred to.
- 23.4.29 Compressed air piping shall be sized for minimum pressure drops and considering velocity range as specified in Chapter 34, Volume III as per IS: 6206. All pipelines shall have butt welded connections with minimum flange joints for connection to vessels and equipment. All pipelines shall be suitably supported and routed such that there shall be minimum hindrance for the operating personnel.



## 23.5 Scope of Supply & Works

23.5.1 The Instrument Air System shall include but not limited to the following:

- a. Three (3) (2W+1S), oil free, dry screw type, water cooled, horizontal multistage rotary screw compressors. Each IA compressor capacity shall be  $40 \text{ Nm}^3/\text{min}$  (minimum) or as computed by procedure for capacity determination of IA and SA in clause no. 23.4.10 above, which ever is higher, at pressure  $8.5 \text{ kg/cm}^2 \text{ (g)}$  (minimum) at the outlet of after cooler.
- b. Shell and tube type water cooled Inter cooler and After cooler with moisture separators and drain traps
- c. Suction filter along with blow off valve and silencer
- d. Three (3) (2W+1S) HOC type Air Drying Plants along with Pre-filter & After-filter in the air inlet & outlet of Air Dryer respectively to ensure dry moisture free Instrument quality air. Capacity of each drier shall be 1.10 times to capacity of each IA compressor.
- e. All instruments as required including pressure switches, temperature switches, pressure gauges, temperature gauges, mass flow meters, control panels etc.
- f. Three (3) vertical Air Receivers [of capacity  $15 \text{ M}^3 \text{ (min)}$ ] complete with supporting structure, pressure gauges and switches, safety valves, drain traps etc.
- g. Microprocessor based control panel for individual compressor, DCS (BHEL scope) based control system for control and monitoring of the overall CAS.
- h. Minimum three (3) Unit Air Receivers, two in main plant area and one in DM plant area. Capacity of each unit air receiver in main plant area shall be minimum  $10 \text{ NM}^3$  and for DM plant area it shall be minimum  $2 \text{ NM}^3$ .
- i. Instrument air distribution piping as required with all valves and instrumentation.

23.5.2 The Service Air System shall include but not limited to the following:

- a. Three (3) (2W+1S), oil free, dry screw type, water cooled, horizontal multistage rotary screw compressors. Each SA compressor capacity shall be  $40 \text{ Nm}^3/\text{min}$  (minimum) or as computed by procedure for capacity determination of IA and SA in clause no. 23.4.10 above, which ever is higher., at pressure  $8.5 \text{ kg/cm}^2 \text{ (g)}$  (minimum) at the outlet of after cooler.
- b. Shell and tube type water cooled Inter cooler and After cooler with moisture separators and drain traps
- c. Suction filter along with blow off valves and silencer
- d. All instruments as required including pressure switches, temperature switches, pressure gauges, temperature gauges, control panels
- e. Three (3) nos. vertical Air Receivers [of capacity  $15 \text{ M}^3 \text{ (min)}$ ] complete with welded supporting stand and foundation bolt, pressure gauge and switch, safety valves, drain cock as minimum.
- f. Microprocessor based control panel for individual compressor, DCS (BHEL scope) based control system for control and monitoring of the overall CAS.
- g. Service air distribution piping as required with all valves and instrumentation.

23.5.3 Handling arrangement of air compressors shall be as detailed in Chapter-28 (Cranes & Hoists) of this volume.

## **23.6 Design & Construction:**

The minimum requirements of design and construction features of various components of compressed air system are described below.

The motor drives shall be as per electrical specification.

### **23.6.1 Air Compressors**

Compressors shall be multi stage oil free screw type.

Multiple compression chambers shall be designed to ensure minimum unbalance and arranged in compact manner suitable for easy accessibility and maintenance of the compressors.

The compression chamber, housing two precision made screw type rotors, for each stage shall be designed with large port for fast filling and low velocities.

The stator (casing) shall be of Cast- Iron (IS- 210 grade) construction with integral jacket cooling. Suitable arrangement for cleaning of the cooling jackets during maintenance of compressor shall be provided.

The Rotors and shaft shall be of single piece of construction made of forged steel (AISIC 1141 or equivalent) Rotors shall be dynamically balanced, design with asymmetric profile, to keep leakage losses to a minimum and ensure high efficiency.

Highly precise timing gears to maintain rotors in correct relative position shall be shaft mounted, oil lubricated and designed to counteract the axial forces incurred in compression.

Bearing 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 and minimum operating life of 40000 running hours.

Shaft seals of floating restrictive ring type design to prevent air and oil leakage along the shaft into the elements. The shaft seals rings and retainers shall be of stainless steel construction and be free for radial self-adjustment on the rotor shafts.

The safety valves shall be provided on low pressure and high pressure stages to safeguard low pressure & high pressure circuit. Inlet throttle valve shall be provided to throttle the incoming air during idling period.

A direct shaft driven positive displacement type oil pump or a separate motor driven oil pump shall be provided. The lubrication system shall consist of lube oil reservoir, lube oil pumps, suction strainers for pumps, supply & return system, oil cooler and twin two full-flow (2 x 100%) of

filters, required instruments etc. the filters with replacement and re-pressurizing during operations.

The motor rating (at the design ambient temperature specified for the electric drive in the electrical specification) shall be sized as specified in the electrical volume.

Couplings shall be of non-lubricated flexible element spacer type and coupling guards shall be provided.

The inlet air filter & silencer shall be located at the downstream of discharge blow off valve.

The instrumentation controls and panels shall conform to the requirements specified in the control & instrumentation volume.

The intercoolers, after coolers, oil coolers shall conform to the requirements specified in subsequent clauses of this chapter.

Each compressor shall be provided with name plate, base plate, anchor bolts and shim packs, anti-vibration pads, eye bolts, operation & maintenance tools.

The material of construction of compressors shall be as per the enclosed datasheet.

### **23.6.2 Lubrication System**

The compressor package shall include a lubricant management system which shall lubricate the bearings and seal and the compressor chamber (screw rotor housing) shall be totally separated from bearing/ gear chamber.

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 rotary positive displacement type, having stainless steel rotors and steel casing. The pump discharge system shall be protected by a relief valve.

The heat exchanger of the lube oil cooler shall be water cooled. The heat exchanger shall be located within the compressor skid.

The fouling factors shall be considered as per recommendation of TEMA.

The lube oil cooler shall be designed for a heat duty corresponding to the peak power demand of the compressors.

The cooler shall be designed in accordance with the requirement of IS 2825.

Due consideration for the differential expansion of shell and tube shall be given in the design of the coolers.

### **23.6.3 Gear Box**

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

### **23.6.4 Intercoolers, Aftercoolers & oil Coolers**

Intercoolers, aftercoolers and oil coolers shall be of water cooled & shell and tube type with water on the tube side. Intercoolers & aftercoolers shall be designed in accordance with Section VIII of ASME code or equivalent.

Outlet temperature of air from intercooler shall be suitable to suit the equipment and outlet temperature of air from 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.

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.

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

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.

Design pressure shall be 8 kg/cm<sup>2</sup>(g) based on shut off head of DMCW pumps.

The coolers shall be designed for maximum heat load and at least 10% design margin shall be provided in the number of tubes.

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

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 with isolating cock.

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.

Cooler shells, channels and covers shall be of steel (SA 285 Gr 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.

### **23.6.5 Air Receivers**

There shall be one air receiver for each compressor near compressor house, one instrument air receiver for DM Plant (min. 2 cum) and two unit instrument air receiver near main plant (min 10 cum capacity, each).

Capacity of each of the air receivers in the compressor house shall be of minimum 15 cum (nominal). The capacity of the unit instrument air receiver near main plant shall be min 10NM<sup>3</sup> or to suit emergency storage requirement, whichever is higher.

Receivers other than unit air receivers shall be outdoor located and vertical cylindrical vessels with dished ends.

The design pressure and temperature shall be minimum 10 kg/cm<sup>2</sup>(g) and 50 Deg C respectively. Receivers shall be designed in accordance with Section VIII, Division 1 of ASME code or equivalent.

Air receivers are to be provided with gasketed 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.

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 and structure as that of the material welded. Welding electrodes shall be approved by owner. Electrodes to be dried before use.

Relief valves shall be provided to suit compressor capacity and set pressure of the same shall be at least 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.

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

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.

### **23.6.6 Intake Air Filter & Silencer**

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

The filters shall be complete with integral silencers. Separate silencers, if specified shall be provided and all other accessories. The filtering elements shall be easily removable for cleaning or for replacement.

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

The silencer shall be of very high efficiency type to adequately dampen the operating noise as per the requirement.

Pulsation dampener of approved design shall be provided on the compressor suction and discharge manifold.

### **23.6.7 Air Drying Plants**

One number air drying plant shall be provided for each instrument air compressor. Three (3) HOC type air drying plants shall be provided (two working and one standby) for instrument air. The capacity of each air drying plant shall be 1.10 times of the Instrument air compressors.

#### **23.6.7.1 Codes And Standards**

The design, manufacture, testing and performance of the various components of Air Drying Plant shall comply with at least the requirements of one or more of the following codes, as applicable:

- |      |            |   |                                    |
|------|------------|---|------------------------------------|
| i)   | IS-11989   | : | Specification for Air Dryers.      |
| ii)  | IS-2825    | : | Code for Unfired Pressure Vessels. |
| iii) | IS-11327   | : | HOC type units.                    |
| iv)  | ISO 8753.1 | : | Filter quality classes.            |

#### **23.6.7.2 Technical requirements**

The capacity of air drying plant shall be equal to the 1.10 times 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".

Discharge pressure available at the outlet of Air drying Plant shall be minimum 8.0 Kg/cm<sup>2</sup> (g) or more as per the requirement of Contractor

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

- |      |                     |           |
|------|---------------------|-----------|
| (i)  | Minimum temperature | 2 deg.C   |
| (ii) | Maximum temperature | 50 deg. C |

- |                                                          |                   |
|----------------------------------------------------------|-------------------|
| (iii) Design condition (temperature & Relative humidity) | 45 deg.C& 75% RH  |
| (iv) Height above MSL (m) information                    | As given in Plant |

**One number Air drying plant shall be provided for each Instrument air compressor.**

Drying shall be by adsorption process through a desiccant medium.

Air Drying (ADP) Plant shall be of "Heat of Compression (HOC) type".

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

Hot unsaturated compressed air shall be used for regeneration of exhausted desiccant in "Heat of compression type ADP".

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.

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.

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.

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/sightwindows of "Persplex" for observation of adsorbent condition. Desiccant filling and removal connections shall be provided for the adsorber vessels.

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

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

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

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 gasketed manholes/handholes and relief valves

Quantity of desiccant to be calculated shall take into account residual moisture content at the end of regeneration cycle.

Adsorption capacity and density to be considered for silica gel shall not be more than 10% and 550 kg/m<sup>3</sup> respectively. In case of activated alumina the same shall be 8% (max) and 900 kg/m<sup>3</sup> (max) respectively.

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.

Complete ADP equipment's shall preferably be mounted on a skid.

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

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

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<br>Cooler Tube sheet & tubes | Same as that in intercoolers/after coolers                      |
| (d) | Relief valves                                                   | Brass or SS                                                     |
| (e) | Desiccant                                                       | Silica gel or Activated Alumina                                 |
| (f) | Air piping                                                      | Galvanized steel                                                |
| (g) | Valves in Air Line                                              | CI or Cast steel or Forged steel body with stainless steel trim |
| (j) | Valves in water pipe lines                                      | SS/Bronze/Gunmetal                                              |



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. The control & instrumentation requirements specified are applicable for such design also.

**23.6.8 Interconnecting Piping, Fittings and Valves**

The interconnecting piping & valves within compressor house for compressed air & cooling water etc. shall be designed in line with layout requirements indicated in Chapter33: Layout Requirement of Volume III.

**23.6.9 Moisture Separator**

Moisture separator shall be of high efficiency design and provided with vent nozzle and auto drain trap system.

**23.6.10 Solenoid Valves & Multiway Valves**

The solenoid valve shall be of approved make. The solenoid valves shall have heavy duty, double impregnated tropicalised coils (single or double solenoid as required) and shall be suitable for the operating temperature and for operation continuously energised in a tropical climate.

The solenoid valves shall be of bronze body with stainless steel trim. The coil shall be of continuous duty and of epoxy moulded type, Class F. The enclosure shall be water tight, dust tight weather proof and shall conform to NEMA 4X standard. The valves shall be suitable for mounting in any position. Solenoid coils shall be Class H high temperature construction and shall be suitable for continuous operation. Type of operation and electrical ratings shall be subject to owner's approval.

**23.6.11 VOID**

**23.7.0 Control Philosophy**

**23.7.1 General**

The minimum requirements are specified herein and the same shall be elaborated by the bidder. The bidder shall include controls & instrumentation to facilitate safe, reliable and efficient operation of the system. The controls, protection, interlock and instrumentation system offered by the bidder shall be subjected to approval of the owner during post award engineering stage. For details of Control & Instrumentations, refer to C&I specification

Any of the compressor and air drying plant may be selectable for "shutdown", "working" or "standby" duty.

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

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.

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 the set time duration. Suitable interlock shall also be provided for opening the valve before starting of any of the compressor.

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

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

Unless otherwise mentioned in the relevant electrical volume, 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.

### **23.7.2 Screw Compressors**

23.7.2.1 Each compressor shall be in the control panel to operate either in base duty (Auto Load/ unload) or Standby duty (Auto On – Off) mode.

23.7.2.2 In "Base duty", 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 unload 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.

23.7.2.3 In "Standby" mode the compressor shall automatically assist base load compressors during periods of peak air demand. When air pressure in the system reaches a preset lower limit, the compressor shall be started in unloaded condition and the compressor shall be fully loaded. When the pressure in the system rises to preset high value, the compressor shall be unloaded and shall run in idling mode for a specific period (set by 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 preset time.

23.7.2.4 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.

23.7.2.5 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 of each compressor :

- a. "Air temperature high" at inlet 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 & trip
- e. Low Lube oil level in lube oil sump - Alarm & trip
- f. High inlet air filter differential pressure - Alarm & trip
- g. Low cooling water flow to air compressors - Alarm & trip

### **23.7.3 Air Drying Plant**

23.7.3.1 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 the same.

**DATA SHEET-A**

**SCREW TYPE AIR COMPRESSOR AND AUXILIARIES**

| SR. NO. | ITEM                                                                     |   | DETAIL                                                                                                                                                                           |
|---------|--------------------------------------------------------------------------|---|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.0     | PERFORMANCE DATA                                                         |   |                                                                                                                                                                                  |
| 1.1     | Free Air Delivery                                                        | : | Bidder to compute and indicate as per guidelines specified in this section.                                                                                                      |
| 1.2     | Capacity                                                                 | : | 40 Nm <sup>3</sup> /min (minimum), 8.5 Kg/cm <sup>2</sup>                                                                                                                        |
| 1.3     | Noise level near compressors                                             | : | Noise level shall not exceed 85 dBA when measured at a distance of 1.0 meter from the compressor. Acoustic enclosures as required shall be provided to meet the above condition. |
| 1.4     | Vibration limit (measured at top and bottom of main bearing)             | : | 40 microns                                                                                                                                                                       |
| 1.5     | Guaranteed Power consumption at motor input terminals at rated condition | : | Bidder to indicate                                                                                                                                                               |
| 2.0     | <b>CONSTRUCTION FEATURES</b>                                             |   |                                                                                                                                                                                  |
| 2.1     | Location                                                                 | : | Indoor                                                                                                                                                                           |
| 2.2     | Number of compressors                                                    | : | Three (3) IA compressors (2W+1S) and Three (3) SA compressors (2W+1S) connected on a common discharge manifold                                                                   |
| 2.3     | Type                                                                     | : | Oil-free, dry screw type, water cooled, horizontal, two (2) stage, rotary screw compressors                                                                                      |
| 2.4     | Service                                                                  | : | Instrument Air and Service Air                                                                                                                                                   |
| 2.5     | Duty                                                                     | : | Continuous                                                                                                                                                                       |
| 2.6     | Type of Drive                                                            | : | Electric Motor                                                                                                                                                                   |
| 2.7     | Design ambient temperature for drive                                     | : | 50°C                                                                                                                                                                             |
| 2.8     | Number of starts per hour                                                | : | 8 (equally spreaded)                                                                                                                                                             |
| 2.9     | Type of transmission                                                     | : | Gear                                                                                                                                                                             |
| 2.10    | Ant vibration arrangement required                                       | : | Yes                                                                                                                                                                              |

| SR. NO. | ITEM                                              |   | DETAIL                                                                                              |
|---------|---------------------------------------------------|---|-----------------------------------------------------------------------------------------------------|
| 2.11    | Maximum temperature for any step during the cycle | : | Bidder to indicate                                                                                  |
| 2.12    | Type of control                                   | : | Dual i.e. both load-unload and auto start/ stop                                                     |
| 2.13    | Type of Annunciation                              | : | Audio-visual                                                                                        |
| 2.14    | Flange standard                                   | : | ANSI B-16.5/equivalent                                                                              |
| 3.0     | <b>MATERIALS OF CONSTRUCTION</b>                  |   |                                                                                                     |
| 3.1     | Compressor chamber                                | : | Cast iron coated with corrosion resistant material                                                  |
| 3.2     | Rotors                                            | : | Forged carbon steel coated with corrosion resistant material, 2 <sup>nd</sup> stage Stainless steel |
| 3.3     | Bearing                                           | : | Oil lubricated Antifriction type suitable for at least 40,000 running hours.                        |
| 3.4     | Timing Gear                                       | : | Low alloy steel                                                                                     |
| 3.5     | Base Plate                                        | : | MS                                                                                                  |
| 3.6     | Inlet throttle valve & housing                    | : | Aluminium / Stainless steel                                                                         |
| 3.7     | Shaft seals                                       | : | Stainless Steel                                                                                     |
| 3.8     | Safety valves                                     | : | Brass                                                                                               |
| 3.9     | Water separator                                   | : | Cast Iron                                                                                           |
| 3.10    | Blow off valve                                    | : | Stainless Steel                                                                                     |
| 3.11    | Unloading Cylinder header                         | : | Aluminium                                                                                           |
| 3.12    | Tube of oil cooler                                | : | Stainless Steel type SS-304                                                                         |
| 3.13    | Outer casing of coolers                           | : | Carbon Steel / SG Iron                                                                              |
| 3.14    | Non Return Valve (NRV)                            |   | Stainless steel spring loaded type.                                                                 |
| 3.15    | Gear Box                                          | : | Cast Iron GGG 40 (DIN 1693) /SG Iron                                                                |
| 3.16    | Gears                                             | : | Alloy Steel                                                                                         |
| 4.0     | <b>SUPPLY OF ACCESSORIES &amp; SERVICES</b>       |   |                                                                                                     |
| 4.1     | Intake air filters with silencers                 | : | Yes                                                                                                 |

| SR. NO. | ITEM                                                                                                                                                                                  |   | DETAIL                                                                     |
|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|----------------------------------------------------------------------------|
| 4.2     | Intercoolers                                                                                                                                                                          | : | Yes                                                                        |
| 4.3     | After coolers with moisture separators                                                                                                                                                | : | Yes                                                                        |
| 4.4     | All instruments as specified, as shown in tender drawing and as required for safe and trouble- free operation of the system                                                           | : | Yes                                                                        |
| 4.5     | Coupling guards                                                                                                                                                                       | : | Yes                                                                        |
| 4.6     | Air receivers                                                                                                                                                                         | : | Yes                                                                        |
| 4.7     | Foundation bolts, nuts, sleeves, inserts etc.                                                                                                                                         | : | Yes                                                                        |
| 4.8     | All interconnecting air and cooling water piping, complete with valves, fittings as shown in relevant tender drawings and as required for reliable and smooth operation of the system | : | Yes                                                                        |
| 4.9     | Eye bolts, lifting tackle, tools, etc.                                                                                                                                                | : | Yes                                                                        |
| 4.10    | Control panels complete with all accessories                                                                                                                                          | : | Yes                                                                        |
| 4.11    | Instrument gauge panels complete with all accessories                                                                                                                                 | : | Yes                                                                        |
| 5.0     | DM COOLING WATER DATA                                                                                                                                                                 |   |                                                                            |
| 5.1     | Quality                                                                                                                                                                               | : | DM Water                                                                   |
| 5.2     | Design inlet temperature                                                                                                                                                              | : | 38°C (maximum                                                              |
| 5.3     | Design pressure                                                                                                                                                                       | : | Bidder to indicate. Shall not be less than the shut off head of DMCW pump. |
| 5.4     | Normal inlet pressure                                                                                                                                                                 | : | Bidder to indicate. Shall be equal to the rated TDH of DMCW pump           |
| 5.5     | pH value                                                                                                                                                                              | : | 8.5 to 9.5                                                                 |
| 5.6     | Maximum pressure drop allowable between inlet and outlet points                                                                                                                       | : | 6.0 to 8.0 MWC                                                             |
| 6.0     | TESTING AND INSPECTION                                                                                                                                                                |   |                                                                            |
| 6.1     | Material Testing and identification                                                                                                                                                   | : | Required                                                                   |
| 6.2     | Dye Penetration test                                                                                                                                                                  | : | Yes                                                                        |

| SR. NO. | ITEM                                                                                                                                |   | DETAIL                                                                                                                                                  |
|---------|-------------------------------------------------------------------------------------------------------------------------------------|---|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6.3     | Type of performance test to be conducted                                                                                            | : | Routine test/Type test as per relevant clause                                                                                                           |
| 6.4     | Bend Test as per BS 5169                                                                                                            | : | Yes                                                                                                                                                     |
| 6.5     | Field performance test                                                                                                              | : | Yes                                                                                                                                                     |
| 6.6     | Shop performance test                                                                                                               | : | Yes                                                                                                                                                     |
| 6.7     | MPI and UT tests                                                                                                                    | : | Yes                                                                                                                                                     |
| 6.8     | Spot Radiography for all circumferential and longitudinal butt joints                                                               | : | Yes                                                                                                                                                     |
| 6.9     | All other specific tests as specified in relevant Clause of this section                                                            |   | Yes                                                                                                                                                     |
| 7.0     | DRIVE MOTOR                                                                                                                         |   |                                                                                                                                                         |
| 7.1     | Electric motor                                                                                                                      | : | Drive motor for compressor shall comply with the requirements of relevant Clause of this section and concerned electrical volume of this Specification. |
| 8.0     | <b>COMPRESSOR ACCESSORIES</b>                                                                                                       |   |                                                                                                                                                         |
| 8.1     | INTAKE AIR FILTER                                                                                                                   | : |                                                                                                                                                         |
| 8.1.1   | Numbers required                                                                                                                    | : | One (1) with each compressor                                                                                                                            |
| 8.1.2   | Location                                                                                                                            | : | Indoor, at the suction of each air compressor                                                                                                           |
| 8.1.3   | Type                                                                                                                                | : | Dry type                                                                                                                                                |
| 8.1.4   | Silencer                                                                                                                            | : | Yes                                                                                                                                                     |
| 8.1.5   | Air flow rate                                                                                                                       | : | To suit compressor rating                                                                                                                               |
| 8.1.6   | Particle removing efficiency                                                                                                        | : | 99.9% up to particle size of 2 Micron                                                                                                                   |
| 8.1.7   | Maximum allowable pressure drop at stated air flow rate in new condition of filter (viscosity of air at normal ambient temperature) | : | 150 mm WG                                                                                                                                               |
| 8.1.8   | Test requirement                                                                                                                    | : | No separate test. Compressor performance testing shall include the filters in test set up. Capacity, pressure drop and efficiency shall be measured.    |
|         |                                                                                                                                     |   |                                                                                                                                                         |

| SR. NO.       | ITEM                                        |   | DETAIL                                                                                                                                                                                |
|---------------|---------------------------------------------|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 8.2           | <b>AIR RECEIVER</b>                         |   |                                                                                                                                                                                       |
| 8.2.1         | Numbers required                            | : | One (1) for each IA compressor + (1) for each SA compressor at the Compressor Outlet. Further, dedicated receivers at specified locations as per Flow diagram shall also be provided. |
| 8.2.2         | Installation                                | : | Outdoor                                                                                                                                                                               |
| 8.2.3         | Type                                        | : | Vertical cylindrical with torispherical dished ends.                                                                                                                                  |
| 8.2.4         | Design pressure / Temperature               | : | Minimum 1.5 times compressor discharge pressure (or 12.75 kg/cm <sup>2</sup> (g) minimum) / 80° C (minimum )                                                                          |
| 8.2.5         | Hydraulic test Pressure                     | : | 150 % design pressure.                                                                                                                                                                |
| 8.2.6         | Design code                                 | : | ASME Sec-VIII or IS-2825/IS-7938/ Approved equal                                                                                                                                      |
| 8.2.7         | Capacity of each air receiver               | : | Bidder to compute. However, the water filled volume shall not be less than 15 m <sup>3</sup> under any circumstances for receivers at Compressor Outlet                               |
| 8.2.8         | Material of construction of shell           | : | MS to IS-2062                                                                                                                                                                         |
| 8.2.9         | Material of construction of dished ends     | : | MS to IS-2062                                                                                                                                                                         |
| 8.2.10        | Material of construction of flanges         | : | MS to IS-2062                                                                                                                                                                         |
| 8.2.11        | Corrosion allowance                         |   | 3.0 mm (minimum)                                                                                                                                                                      |
| <b>8.2.12</b> | <b>Supply of Accessories &amp; Services</b> | : |                                                                                                                                                                                       |
| 8.2.12.1      | Flanges with nuts, bolts and gaskets        | : | Yes                                                                                                                                                                                   |
| 8.2.12.2      | Pressure gauge with snubber                 | : | Yes                                                                                                                                                                                   |
| 8.2.12.3      | Pressure Transmitter                        | : | Yes                                                                                                                                                                                   |
| 8.2.12.4      | Temperature gauge                           | : | Yes                                                                                                                                                                                   |
| 8.2.12.5      | Relief valve                                | : | Yes, set pressure shall be at least 10% above working pressure                                                                                                                        |
| 8.2.12.6      | Trap station                                | : | Yes                                                                                                                                                                                   |
| 8.2.12.7      | Level gauge                                 | : | NA                                                                                                                                                                                    |
| 8.2.12.8      | Vent valve/plug                             | : | Yes                                                                                                                                                                                   |



| SR. NO.          | ITEM                                                                       |   | DETAIL                                                          |
|------------------|----------------------------------------------------------------------------|---|-----------------------------------------------------------------|
| 8.2.12.9         | Level Transmitter                                                          | : | NA                                                              |
| 8.2.12.10        | Supporting stand with necessary foundation bolts, nuts, sleeves etc        | : | Yes                                                             |
| 8.2.12.11        | Eye bolts, lifting tackle etc.                                             | : | Yes                                                             |
| 8.2.12.12        | Automatic Drain Trap                                                       |   | Yes                                                             |
| 8.2.12.13        | Painting                                                                   | : |                                                                 |
| A                | External                                                                   | : | Two coats of epoxy Primer and two finish coats of epoxy paints. |
| B                | Internal                                                                   | : | Cleaned and one coat of black bituminous paint applied.         |
| <b>8.2.12.14</b> | <b>Inspection and Testing</b>                                              |   |                                                                 |
| A                | Material testing and identification                                        | : | Yes                                                             |
| B                | Bend test as per BS-5169                                                   | : | Yes                                                             |
| C                | Spot radiography of circumferential and longitudinal butt welds            | : | Yes                                                             |
| D                | Field performance test                                                     | : | Yes                                                             |
| E                | D.P. test where radiography cannot be done                                 | : | Yes                                                             |
| F                | Hydraulic Test                                                             | : | Yes                                                             |
| G                | Other specific tests as specified in relevant Clause of this specification | : | Yes                                                             |
| <b>8.3</b>       | <b>INTERCOOLER, AFTERCOOLER, MOISTURE SEPARATOR, PIPING, VALVES ETC:</b>   |   |                                                                 |
| <b>8.3.1</b>     | <b>After cooler :</b>                                                      |   |                                                                 |
| A                | Installation                                                               | : | Indoor                                                          |
| B                | Type                                                                       | : | Shell and Tube                                                  |
| C                | Relief Valve                                                               | : | Yes                                                             |
| D                | Moisture Separator                                                         | : | Yes                                                             |
| E                | Trap Station                                                               | : | Yes                                                             |
| F                | Temperature Indicator                                                      | : | Yes                                                             |

| SR. NO.      | ITEM                                                       |   | DETAIL                              |
|--------------|------------------------------------------------------------|---|-------------------------------------|
| G            | Temperature Switch                                         | : | Yes                                 |
| H            | Temperature Transmitter                                    | : | Yes                                 |
| I            | Level Gauge                                                | : | Yes                                 |
| <b>8.3.2</b> | <b>Intercooler :</b>                                       |   |                                     |
| A            | Installation                                               | : | Indoor                              |
| B            | Type                                                       | : | Shell and Tube                      |
| C            | Relief Valve                                               | : | Yes                                 |
| D            | Trap Station                                               | : | Yes                                 |
| E            | Pressure Gauge                                             | : | Yes                                 |
| F            | Temperature Indicator                                      | : | Yes                                 |
| G            | Temperature Switch                                         | : | Yes                                 |
| H            | Temperature Transmitter                                    | : | Yes                                 |
| I            | Moisture Separator                                         | : | Yes                                 |
| <b>8.3.3</b> | <b>Supply of Accessories and Services</b>                  | : |                                     |
| A            | Supporting stands with bolts, nuts and gaskets             | : | Yes                                 |
| B            | Eye bolts, lifting tackle etc with tools and tackle        | : | Yes                                 |
| C            | Flanged connections for supply and return of cooling water | : | Yes                                 |
| <b>8.3.4</b> | <b>Material of Construction :</b>                          |   |                                     |
| A            | Tube                                                       | : | Stainless steel within star profile |
| B            | Shell                                                      | : | Mild Steel                          |
| C            | Tube Sheet                                                 | : | IS 2002 Gr 2                        |
| D            | Baffles                                                    | : | IS 2062                             |
| E            | Flanges                                                    | : | IS 2062                             |
| <b>8.3.5</b> | <b>Cooling Water Data</b>                                  | : | <b>Same as mentioned earlier</b>    |

| SR. NO.      | ITEM                                                            |   | DETAIL                                                                                                          |
|--------------|-----------------------------------------------------------------|---|-----------------------------------------------------------------------------------------------------------------|
| <b>8.3.6</b> | <b>Piping, Valves and Fittings for Compressed Air System :</b>  |   |                                                                                                                 |
| A            | Pipes for cooling water line                                    | : | IS-1239 (Heavy grade) upto 150 NB.<br>IS-3589 for sizes above 150 NB with minimum pipe thickness of 6 mm.       |
| B            | Pipes for compressed air line & interconnecting air line        | : | ASTM A-53 type E Gr. B galvanized /IS 1239 heavy galvanized/IS 3589 Gr 410 Galvanized to IS-4736 or equivalent. |
| <b>8.3.7</b> | <b>Fittings</b>                                                 |   |                                                                                                                 |
| A            | Fittings for cooling water line                                 | : | ASTM A-234 Gr. WPB for sizing including 65 NB and above.<br>And ASTM A105 for sizes up to 50 NB                 |
| B            | Fittings for compressed air piping & interconnecting air piping | : | IS-1239 Part-2 galvanized to IS-4736 or equivalent. /ANSI B16.5 galvanized to IS-4736 or equivalent.            |
| C            | Valves for air line                                             | : | Stainless Steel                                                                                                 |
| D            | Testing and inspection                                          | : | As per relevant clause of this section.                                                                         |
| E            | Valves for cooling water line                                   | : | As per respective volume in LP Piping                                                                           |

**DATA SHEET-B**

**AIR DRYING PLANT AND AUXILIARIES**

| <b><u>SR. NO.</u></b> | <b><u>ITEM</u></b>                                              |   |                                                                 |
|-----------------------|-----------------------------------------------------------------|---|-----------------------------------------------------------------|
| <b>1.0</b>            | <b><u>GENERAL INFORMATION</u></b>                               |   |                                                                 |
| 1.1                   | Numbers of Air drying Plant                                     | : | Three (3) (2W + 1S)<br>One (1) for each IA compressor           |
| 1.2                   | Duty                                                            | : | Continuous                                                      |
| 1.3                   | Operation                                                       | : | Fully Automatic                                                 |
| 1.4                   | Service                                                         | : | Instrument Air                                                  |
| 1.5                   | Installation                                                    | : | Indoor                                                          |
| 1.6                   | Type                                                            | : | HOC                                                             |
| 1.7                   | Outlet dew point                                                | : | At least (-) 40 °Cat atmospheric pressure                       |
| 1.8                   | Annunciation                                                    | : | Local and remote                                                |
| 1.9                   | Location                                                        | : | Indoor skid mounted                                             |
| <b>2.0</b>            | <b><u>MATERIAL OF CONSTRUCTION</u></b>                          |   |                                                                 |
| 2.1                   | Adsorber vessel                                                 |   | Carbon steel                                                    |
| 2.2                   | All internals of adsorber vessels                               |   | SS 304                                                          |
| 2.3                   | Cooler shells, channels and covers<br>Cooler Tube sheet & tubes |   | Same as that in intercoolers/after coolers                      |
| 2.4                   | Relief valves                                                   |   | Brass or SS                                                     |
| 2.5                   | Desiccant                                                       |   | Silica gel or Activated Alumuna                                 |
| 2.6                   | Air piping                                                      |   | Galvanized steel                                                |
| 2.7                   | Valves in Air Line                                              |   | CI or Cast steel or Forged steel body with stainless steel trim |
| 2.8                   | Valves in water pipilines                                       |   | SS/Bronze/Gunmetal                                              |
| <b>3.0</b>            | <b><u>PERFORMANCE SPECIFICATION</u></b>                         |   |                                                                 |
| 3.1                   | Air drying capacity                                             | : | 1.10 times the instrument air compressor capacity               |

| <b><u>SR. NO.</u></b> | <b><u>ITEM</u></b>                                                                                         |   |                                                                                                            |
|-----------------------|------------------------------------------------------------------------------------------------------------|---|------------------------------------------------------------------------------------------------------------|
| 3.2                   | Inlet air pressure                                                                                         | : | To suit compressor rating                                                                                  |
| 3.3                   | Air flow (Free Air delivery)                                                                               | : | To suit compressor rating                                                                                  |
| 3.4                   | Inlet air temperature                                                                                      | : | Refer met data in Volume II,<br>However, shall be suitable to handle<br>air inlet temperature of 60 °C.    |
| 3.5                   | Maximum allowable air pressure drop                                                                        | : | 0.5 kg/cm <sup>2</sup>                                                                                     |
| 3.6                   | Design Requirement                                                                                         | : | (-) 40 °C dew point at outlet (at<br>atmospheric pressure). Dust laden,<br>not more than 0.1 ppm, oil free |
| <b>4.0</b>            | <b><u>SUPPLY OF ACCEESSORIES AND SERVICES FOR EACH ADP</u></b>                                             |   |                                                                                                            |
| 4.1                   | Pre-filters and After Filters                                                                              | : | 2 x 100% with automatic drain trap<br>filter arrangement & with ceramic<br>candle type                     |
| 4.2                   | Dew point indicator on line                                                                                | : | Yes                                                                                                        |
| 4.3                   | Instruments as per specification,<br>Tender drawing and as required for<br>safe and trouble free operation | : | Yes                                                                                                        |
| 4.4                   | Control panel with accessories                                                                             | : | Yes                                                                                                        |
| 4.5                   | Tools and tackle                                                                                           | : | Yes                                                                                                        |
| 4.6                   | Spare parts                                                                                                | : | Yes                                                                                                        |
| 4.7                   | All interconnecting piping complete<br>with fittings, valves etc.                                          | : | Yes                                                                                                        |
| 4.8                   | Insulation                                                                                                 | : | Yes                                                                                                        |
| 4.9                   | Base frame, foundation bolts, nuts,<br>sleeves etc.                                                        | : | Yes                                                                                                        |
| 4.10                  | Vessel internal paint                                                                                      | : | Anti-corrosive                                                                                             |
| 4.11                  | <b><u>SHOP PAINTING</u></b>                                                                                |   |                                                                                                            |
| 4.11.1                | Internal                                                                                                   | : | Anti-corrosive heat resistant paint.<br>Epoxy based                                                        |
| 4.11.2                | External                                                                                                   | : | 2 coats of epoxy primer                                                                                    |
| <b>5.0</b>            | <b><u>INSPECTION AND TESTING</u></b>                                                                       |   |                                                                                                            |
| 5.1                   | Non-destructive material test                                                                              | : | Yes                                                                                                        |
| 5.2                   | Hydrostatic test                                                                                           | : | Yes                                                                                                        |

| <b><u>SR. NO.</u></b> | <b><u>ITEM</u></b>                           |   |                                          |
|-----------------------|----------------------------------------------|---|------------------------------------------|
| 5.3                   | Performance tests at shop                    | : | Yes                                      |
| 5.4                   | Performance tests at site                    | : | Yes                                      |
| 5.5                   | Spot Radiography of welds parts to be tested | : | All pressure parts and vessels           |
| 5.6                   | Dye Penetration test                         | : | Yes                                      |
| <b>6.0</b>            | <b>POWER SUPPLY</b>                          | : | <b>415 V/3 phase (3 wire)/50 Hz ± 5%</b> |
| 6.1                   | Variation in supply voltage                  | : | ± 10%                                    |
| <b>7.0</b>            | Air flow variations                          | : | 0 to 100%                                |
| <b>8.0</b>            | Condensate removal                           | : | Automatic without air loss               |
| <b>9.0</b>            | Maximum operating air pressure               | : | 16 bar (g)                               |
| <b>10.0</b>           | Auto drain trap                              | : | No air loss type                         |

1X660 MW PANKI TPS

COMPRESSED AIR SYSTEM

SECTION IA

(GENERAL TECHNICAL REQUIREMENT INCLUDING LP PIPING)



BHARAT HEAVY ELECTRICALS LTD  
POWER SECTOR PROJECT ENGINEERING MANAGEMENT  
NOIDA-INDIA

**CHAPTER 5 : GENERAL TECHNICAL REQUIREMENTS****1.0 INTRODUCTION**

This part covers technical requirements, which will form an integral part of the Contract. The following provisions shall supplement all the detailed technical requirements brought out in the Technical Specifications and the Technical Data Sheets.

**2.0 BRAND NAME**

Whenever a material or article is specified or described by the name of a particular brand, manufacturer or vendor, the specific item mentioned shall be understood to be indicative of the function and quality desired, and not restrictive; other manufacturer's products may be considered provided sufficient information is furnished to enable the Owner to determine that the products proposed are equivalent or superior to those named.

**3.0 BASE OFFER & ALTERNATE PROPOSALS**

The Bidder's proposal shall be based upon the use of equipment and material complying fully with the requirements specified herein. It is recognized that the Bidder may have standardized on the use of certain components, materials, processes or procedures different than those specified herein. Alternate proposals offering similar equipment based on the manufacturer's standard practice may also be considered, provided the base offer is in line with technical specifications and such proposals meet the specified design standards and performance requirement and are acceptable to the Owner. Sufficient amount of information for justifying such proposals shall be furnished to Owner along with the bid to enable the Owner to determine the acceptability of these proposals.

**4.0 COMPLETENESS OF FACILITIES**

- 4.1 Bidders may note that this is a contract inclusive of the scope as indicated elsewhere in the specification. Plant shall be engineered and designed in accordance with the specification requirement. All engineering and associated services are required to ensure that a completely engineered plant is provided.
- 4.2 All equipments furnished by the Bidder shall be complete in every respect, with all mountings, fittings, fixtures and standard accessories normally provided with such equipment and/or those needed for erection, completion and safe operation & maintenance of the equipment and for the safety of the operating personnel, as required by applicable codes, though they may not have been specifically detailed in the respective specifications, unless included in the list of exclusions.
- 4.3 All similar standard components/ parts of similar standard equipment provided shall be interchangeable with one another.

**5.0 Codes & Standards**

- 5.1 In addition to the codes and standards specifically mentioned in the relevant technical specifications for the equipment / plant / system, all equipment parts, systems and works covered under this specification shall comply with all currently applicable statutory regulations and safety codes of the Republic of India as well as of the locality where they will be installed, including the following:





- (a.) Bureau of Indian Standards (BIS)
- (b.) Indian Electricity Act (2003)
- (c.) Indian Electricity Rules
- (d.) Indian Explosives Act
- (e.) Indian Factories Act and State Factories Act
- (f.) Indian Boiler Regulations (IBR)
- (g.) Regulation of Central Electricity Authority
- (h.) Regulations of the Central Pollution Control Board, India
- (i.) Regulations of the Ministry of Environment & Forest (MoEF), Government of India
- (j.) Pollution Control Regulations by Department of Environment, Government of India
- (k.) State Pollution Control Board.
- (l.) Building and other construction workers (Regulation of Employment and Conditions of services) Central Rules, 1998
- (m.) Explosive Rules, 1983
- (n.) Petroleum Rules, 1976,
- (o.) Gas Cylinder Rules, 1981
- (p.) Static and Mobile Pressure Vessels (Unified) Rules, 1981
- (q.) Workmen's Compensation Rules, 1924
- (r.) Rules for Electrical installation by Tariff Advisory Committee (TAC) and appropriate Electrical Inspectorate.
- (s.) Owner's Safety Policy
- (t.) Any other statutory codes / standards / regulations, as may be applicable.

5.2 Unless covered otherwise by Indian codes & standards and in case nothing to the contrary is specifically mentioned elsewhere in the specifications, the latest editions (as applicable as on date of bid opening), of the codes and standards given below shall also apply:

- (a.) British Standards (BS)
- (b.) Japanese Industrial Standards (JIS)
- (c.) American National Standards Institute (ANSI)
- (d.) American Society of Testing and Materials (ASTM)
- (e.) American Society of Mechanical Engineers (ASME)
- (f.) American Petroleum Institute (API)
- (g.) Standards of the Hydraulic Institute, U.S.A.
- (h.) International Organisation for Standardization (ISO)
- (i.) Tubular Exchanger Manufacturer's Association (TEMA)
- (j.) American Welding Society (AWS)
- (k.) Cooling Tower Institute (CTI)
- (l.) National Electrical Manufacturers Association (NEMA)
- (m.) National Fire Protection Association (NFPA)
- (n.) International Electro-Technical Commission (IEC)
- (o.) Expansion Joint Manufacturers Association (EJMA)
- (p.) Heat Exchange Institute (HEI)
- (q.) IEEE standard
- (r.) JEC standard

5.3 Other International/ National standards such as DIN, VDI, BS, etc. shall also be accepted for only material codes and manufacturing standards, subject to the Owner's approval, for which the Bidder shall furnish, along with the offer, adequate information to justify that these standards are equivalent or superior to the standards mentioned above. In all such cases the Bidder shall furnish



specifically the variations and deviations from the standards mentioned elsewhere in the specification together with the complete word to word translation of the standard that is normally not published in English.

- 5.4 As regards highly standardized equipments such as Steam Turbine and Generator, National /International standards such as JIS, DIN, VDI, ISO, SEL, SEW, VDE, IEC & VGB shall also be considered as far as applicable for Design, Manufacturing and Testing of the respective equipment. In addition, these standards shall be referred for the design of machine foundations, wherever specifically mentioned in the specifications. However, for those of the above equipment not covered by these National / International standards, established and proven standards of manufacturers shall also be considered.
- 5.5 In the event of any conflict between the codes and standards referred to in the above clauses and the requirement of this specification, the requirement of Technical Specification shall govern.
- 5.6 Two (2) English language copies of all-national and international codes and/or standards used in the design of the plant, equipment, civil and structural works shall be provided by the Bidder to the Owner within two calendar months from the date of the Notification of Award.
- 5.7 In case of any change in codes, standards & regulations between the date of bid opening and the date when vendors proceed with fabrication, the Owner shall have the option to incorporate the changed requirements or to retain the original standard. It shall be the responsibility of the Bidder to bring to the notice of the Owner such changes and advise Owner of the resulting effect.

## **6.0 EQUIPMENT FUNCTIONAL GUARANTEE**

- 6.1 The Equipment and Auxiliaries shall be capable of continuous operation in frequency range of 47.5 to 51.5 Hz.
- 6.2 The functional guarantees of the equipment under the scope of the Contract shall be as per "Chapter 8 - Functional Guarantee & LD", Volume-II. These guarantees shall supplement the general functional guarantee provisions covered under General Conditions of Contract.
- 6.3 Liquidated damages for shortfall in meeting functional guarantee(s) during the performance and guarantee tests shall be assessed and recovered from the Bidder as specified elsewhere in this specification.

## **7.0 DESIGN OF FACILITIES / MAINTENANCE & AVAILABILITY CONSIDERATIONS**

### **7.1 Design of Facilities**

- 7.1.1 All the design procedures, systems and components proposed shall have already been adequately developed and shall have demonstrated good reliability under similar conditions elsewhere.
- 7.1.2 The Bidder shall be responsible for the selection and design of appropriate equipments to provide the best co-ordinate performance of the entire system. The basic requirements are detailed out in various clauses of the Technical Specifications. The design of various components, assemblies and subassemblies shall be done so that it facilitates easy field assembly and dismantling. All the



rotating components shall be so selected that the natural frequency of the complete unit is not critical or close to the operating range of the unit.

## 7.2 Maintenance and Availability Considerations

- 7.2.1 Equipment/facilities offered shall be designed for high availability, low maintenance and ease of maintenance. The Bidder shall specifically state the design features incorporated to achieve high degree of reliability/ availability and ease of maintenance. The Bidder shall also furnish details of availability records in the reference plants stated in his experience list.
- 7.2.2 Bidder shall state in his offer the various maintenance intervals, spare parts and man-hour requirement during such operation. The intervals for each type of maintenance namely inspection of the furnace, inspection of the entire hot gas path and the minor and major overhauls shall be specified in terms of fired hours, clearly defining the spare parts and man-hour requirement for each stage.
- 7.2.3 Lifting devices i.e. hoists and chain pulley jacks, etc. shall be provided by the Bidder for handling of any equipment or any of its part having weight in excess of 500 Kgs during erection and maintenance activities.
- 7.2.4 Lifting devices like lifting tackles, slings, etc. to be connected to hook of the hoist / crane shall be provided by the Bidder for lifting the equipment and accessories covered under the specification.

## 8.0 DOCUMENTS, DATA AND DRAWINGS TO BE FURNISHED BY BIDDER

- 8.1 Plant and equipment shall be fully integrated, engineered and designed to perform in accordance with the technical specification. All engineering and technical services required ensuring a completely engineered plant shall be provided in respect of mechanical, electrical, control & instrumentation, civil & structural works as per the scope.

The Contractor shall furnish engineering data/drawings in accordance with the schedule of information as specified in Technical Specification and data sheets.

A comprehensive engineering and quality coordination procedure shall be finalized with the successful bidder covering salient features as described in this section of specifications.

- 8.2 The number of copies/prints/CD-ROMs/manuals to be furnished for various types of documents is given in Annexure-I attached with Chapter 5, Volume-II.
- 8.3 The documentation that shall be provided by the Bidder is indicated in various sections of specification. The documentation shall include but not be limited to the following:

### 8.3.1 Basic Engineering Documentation

Prior to commencement of the detailed engineering work, the Bidder shall furnish a Plant Definition Manual within 4-6 weeks from the date of the Notification of Award. This manual shall contain the following as a minimum:-

- 1) System description of all the mechanical, electrical, control & instrumentation & civil systems.



- 2) Technology scans for each system / sub-system & equipment.
- 3) Selection of appropriate technology / schemes for various systems/ subsystems including techno-economic studies between various options.
- 4) Optimization studies including thermal cycle optimization.
- 5) Sizing criteria of all the systems, sub-systems including various piping systems/ equipments/ structures/ equipment foundations along with all calculations justifying and identifying the sizing and the design margins.
- 6) Schemes and Process & Instrumentation diagrams for the various systems/ sub-system with functional write-ups.
- 7) Operation Philosophy and the control philosophy of the Main Plant and other plants.
- 8) General Layout plan of the power station incorporating all facilities in Bidder's as well as those in the Owner's scope. This drawing shall also be furnished in native (Word, Excell, ACAD etc) in the form of CD discs to the Owner for engineering of areas not included in Bidder's scope.
- 9) Basic layouts and cross sections of the main plant building (various floor elevations), boiler, fuel oil area and other areas included in the scope of the Bidder.
- 10) Documentation in respect of Quality Assurance System as listed out elsewhere in this specification.

The successful bidder shall furnish within three (3) weeks from the date of Notification of Award, a list of contents of the Plant Definition Manual (PDMs) including techno-economic studies, which shall then be mutually discussed & finalised with the Owner.

After approval of Plant Definition Manual / Design Basis Report, Bidder shall furnish detailed technical specification of all system / packages of the Plant.

### 8.3.2 Detailed Engineering Documentation

- 1) Layouts, general arrangements, elevations and cross-sections drawings for all the equipment and facilities of the plant.
- 2) Flow diagrams, Process & Instrumentation Diagrams along with write-up and system description.
- 3) Start-up curves for turbine, boiler and both turbine and boiler combined together as a unit for various start-ups, viz. cold, warm and hot start-up.
- 4) Piping isometric, composite layout and fabrication drawings.
- 5) Piping engineering diagrams, pipe and fittings schedules, valve schedules, hanger and support schedules, insulation schedules.
- 6) Technical data sheets for all bought out and manufactured items. Bidder shall use the specifications as a base for placement of orders on their sub-vendors.



- 7) Detailed design calculations for components, system/sub-system, piping etc., wherever applicable including sizing calculations for all auxiliaries as per criteria specified elsewhere in specification.
- 8) Boiler pressure part schedule and sizing calculations. Boiler performance data and boiler design dossier.
- 9) Transient, hydraulic and thermal stress analysis of piping and system wherever applicable & input and output data along with stress analysis isometrics showing nodes.
- 10) Thermal cycle information (heat balance diagrams, boiler performance calculations, condenser and heat exchanger thermal calculations etc.).
- 11) Characteristic Curves/ Performance Correction Curves. Hydraulic & Mechanical design calculations for condensers & heaters.
- 12) Model Studies/ CFD analysis for ESP, CW sump etc and furnishing report with recommendations.
- 13) Characteristic Curves/ Performance Correction Curves and thermal design calculations for Cooling Tower.
- 14) Composite Water Balance for total Plant.
- 15) Hydraulic calculation/profile for Water Treatment Plant.
- 16) Comprehensive list of all terminal points which interface with Owner's facilities giving details of location, terminal pressure, temperature, fluid handled & end connection details, forces, moments etc.
- 17) Power supply single line diagram, block logics, control schematics, electrical schematics, etc.
- 18) Protection systems diagrams and relay settings. Load Flow study.
- 19) Interconnection diagrams.
- 20) Cable routing plan.
- 21) Instrument schedule, measuring point list, I/O list, Interconnection & wiring diagram, functional write-ups, installation drawings for field mounted instruments, logic diagrams, control schematics, wiring and tubing diagrams of panels and enclosures etc. Drawings for open loop and close loop controls (both hardware and software). Motor list and valve schedule including type of actuator etc.
- 22) Alarm and annunciation list and alarms & trip set points.
- 23) Sequence and protection interlock schemes.
- 24) Type test reports and power system stability study report.
- 25) Control system configuration diagrams and card circuit diagrams and maintenance details.



- 26) Detailed software manuals & source software listing.
- 27) Detailed flow chart for digital control system.
- 28) Mimic diagram layout.
- 29) Civil Task drawings (for the Engineering by Owner), Design and Drawings for the Civil & Structural works in the scope of the Bidder.
- 30) Model study reports wherever applicable.
- 31) Functional & guarantee test procedures and test reports.
- 32) Documentation in respect of Quality Assurance System as listed out elsewhere in this specification.
- 33) Documentation in respect of commissioning as listed out elsewhere in this specification.

The Bidder while submitting the above documents / drawings for approval / reference as the case may be, shall mark on each copy of submission the reference letter along with the date vide which the submissions are made.

### 8.3.2 Instruction Manuals

The Bidder shall submit to the Owner, draft Instruction Manuals for all the equipments covered under the Contract by the end of one year from the date of his acceptance of the Letter of Award. The Instruction manuals shall contain full details required for erection, commissioning, operation and maintenance of each equipment. The manual shall be specifically compiled for this project. After finalization and approval of the Owner the Instruction Manuals shall be submitted as indicated in Annexure-IV. The Contract shall not be considered to be completed for purposes of taking over until the final Instructions manuals have been supplied to the Owner. The Instruction Manuals shall comprise of the following.

#### A) Erection Manuals

The erection manuals shall be submitted at least three (3) months prior to the commencement of erection activities of particular equipment/system. The erection manual should contain the following as a minimum.

- 1) Erection strategy.
- 2) Sequence of erection.
- 3) Erection instructions.
- 4) Critical checks and permissible deviation/tolerances.
- 5) List of tool, tackles, heavy equipments like cranes, dozers, etc.
- 6) Bill of Materials
- 7) Procedure for erection.



- 8) General safety procedures to follow during erection/installation.
- 9) Procedure for initial checking after erection.
- 10) Procedure for testing and acceptance norms.
- 11) Procedure / Check list for pre-commissioning activities.
- 12) Procedure / Check list for commissioning of the system.
- 13) Safety precautions to be followed in electrical supply distribution during erection

**B) Operation & Maintenance Manuals**

- a) The manual shall be a two rim PVC bound stiff sided binder able to withstand constant usage or where a thicker type is required it shall have locking steel pins, the size of the manual shall not be larger than international size A3. The cover shall be printed with the Project Name, Services covered and Volume / Book number Each section of the manual shall be divided by a stiff divider of the same size as the holder. The dividers shall clearly state the section number and title. All written instructions within the manual not provided by the manufacturers shall be typewritten with a margin on the left hand side.

- b) The arrangement and contents of O&M manuals shall be as follows :

**1) Chapter 1 - Plant Description :**

To contain the following sections specific to the equipment/system supplied

- i.) Description of operating principle of equipment / system with schematic drawing / layouts.
- ii.) Functional description of associated accessories / controls. Control interlock protection writes up.
- iii.) Integrated operation of the equipment alongwith the intended system. (The is to be given by the supplier of the Main equipment by taking into account the operating instruction given by the associated suppliers).
- iv.) Exploded view of the main equipment, associated accessories and auxiliaries with description. Schematic drawing of the equipment alongwith its accessories and auxiliaries.
- v.) Design data against which the plant performance will be compared.
- vi.) Master list of equipments, Technical specification of the equipment/ system and approved data sheets.
- vii.) Identification system adopted for the various components, (it will be of a simple process linked tagging system).





- viii.) Master list of drawings (as built drawing - Drawings to be enclosed in a separate volume).

## **2) Chapter 2.0 - Plant Operation:**

To contain the following sections specific to the equipment supplied

- i.) Protection logics provided for the equipment alongwith brief philosophy behind the logic, Drawings etc.
- ii.) Limiting values of all protection settings.
- iii.) Various settings of annunciation/interlocks provided.
- iv.) Start-up and shut down procedure for equipment alongwith the associated systems in step mode.
- v.) Do's and Don'ts related to operation of the equipment
- vi.) Safety precautions to be taken during normal operation. Emergency instruction on total power failure condition/lubrication failure/any other conditions.
- vii.) Parameters to be monitored with normal value and limiting values.
- viii.) Equipment isolating procedures.
- ix.) Trouble shooting with causes and remedial measures.
- x.) Routine testing procedure to ascertain healthiness of the safety devices alongwith schedule of testing.
- xi.) Routine Operational Checks, Recommended Logs and Records
- xii.) Change over schedule if more than one auxiliary for the same purpose is given.
- xiii.) System/plant commissioning procedure.
- xiv.) Preservation procedure on long shut down.

## **3) Chapter 3.0 - Plant Maintenance**

To contain the following sections specific to the equipment supplied

- i.) Exploded view of each of the equipments. Drawings alongwith bill of materials including name, code no. & population.
- ii.) Exploded view of the spare parts and critical components with dimensional drawings (In case of Electronic cards, the circuit diagram to be given) and spare parts catalogue for each equipment
- iii.) List of Special T/ P required for Overhauling /Trouble shooting including special testing equipment required for calibration etc





- iv.) Stepwise dismantling and assembly procedure clearly specifying the tools to be used, checks to be made, records to be maintained etc. Clearance to be maintained etc.
  - v.) Preventive Maintenance schedules linked with running hours/calendar period alongwith checks to be carried out
  - vi.) Overhauling schedules linked with running hours/calendar period alongwith checks to be done
  - vii.) Long term maintenance schedules
  - viii.) Consumables list alongwith the estimated quantity required during normal running and during maintenance like Preventive Maintenance and Overhauling
  - ix.) List of lubricants with their Indian equivalent, Lubrication Schedule including charts showing lubrication checking, testing and replacement procedure to be carried daily, weekly, monthly & at longer intervals to ensure trouble free operation and quantity required for complete replacement
  - x.) Tolerance for fitment of various components
  - xi.) Details of sub vendors with their part no. in case of bought out items
  - xii.) List of spare parts with their Part No, total population, life expediency & their interchange ability with already supplied spares to OWNER.
  - xiii.) List of mandatory and recommended spare list along with manufacturing drawings, material specification & quality plan for fast moving consumable spares.
  - xiv.) Lead time required for ordering of spares from the equipment supplier, instructions for storage and preservation of spares
  - xv.) General information on the equipment such as modification carried out in the equipment from its inception, equipment population in the country / foreign country and list of utilities where similar equipments have been supplied.
- 8.3.2.2 After finalization and approval of the Employer, the O & M Manuals shall be submitted as indicated in Annexure-VI. The Contract shall not be considered to be completed for purposes of taking over until the final Instructions manuals (both erection and O & M manuals have been supplied to the Employer.
- 8.3.2.3 If after the commissioning and initial operation of the plant, the instruction manuals (Erection and /or O&M manuals) require modifications/additions/ changes, the same shall be incorporated and the updated final instruction manuals shall be submitted by the Contractor to the Employer for records and number of copies shall be as mentioned in Annexure-VI.

### 8.3.3 Plant Handbook and Project Completion Report



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**8.3.3.1 Plant Handbook**

The Bidder shall submit to the Owner a preliminary plant hand book preferably in A-4 size sheets which shall contain the design and performance data of various plants, equipments and systems covering the complete project including

- 1) Design and performance data.
- 2) Process & Instrumentation diagrams.
- 3) Single line diagrams.
- 4) Sequence & Protection Interlock Schemes.
- 5) Alarm and trip values.
- 6) Performance Curves.
- 7) General layout plan and layout of main plant building and auxiliary buildings.
- 8) Important Do's & Dont's

The plant handbook shall be submitted within twelve (12) months from the date of award of contract. After the incorporation of Owner's comments, the final plant handbook complete in all respects shall be submitted three (3) months before start-up and commissioning activities.

**8.3.3.2 Project Completion Report**

The Bidder shall submit a Project Completion Report at the time of handing over the plant.

**8.3.4 Drawings**

- a)
  - i) All the plant layouts shall be made in computerised 3D modelling system. The Employer reserves the right to review the 3D model at different stages during the progress of engineering. The layout drawings submitted for Employer's review shall be fully dimensioned and extracted from 3D model after interference check.
  - ii) All documents submitted by the Contractor for Employer's review shall be in electronic form (soft copies) along with the desired number of hard copies as per Annexure-VI (GTR)-Vol-II.

The soft copies of identified drawings/documents shall be in pdf format, whereas the attachments/reply to the submitted document(s) can be in .doc, .xls, .pdf, .dwg or .std formats.

- iii) Final copies of the approved drawings along with requisite number of hard copies shall be submitted as per Annexure-VI (GTR), Vol-II.
- iv) The completed plant documentation including integrated 3-D model with equipment drawings, data sheets, P&ID, BOQ, schematics, logic diagrams, test reports and quality plan, etc. attached to the respective equipments / systems in the 3D model shall be furnished to Employer,



along with the design review software (network ready) which shall include interference check, walk-through animation, simulation, visual effect, photo realism etc. loaded on a server with four (4) work stations (latest configuration for server & workstation) with one A4 size colored laser printer and one A0 size colored plotter. The software shall include facility for obtaining hard copies of all the drawings/documents on standard plotter / printer.

The requisite hardware and software shall be supplied and commissioned by the Contractor at Employer's Head Office at Lucknow & Site Office at Panki as per mutually agreed schedule.

All softwares provided shall necessarily include the cost for perpetual license(s) for use on all the machines and an Annual Maintenance Contract (AMC) which shall include software upgrades as & when released by the software agency for a period of three (3) years after warranty/guarantee period.

- b) All documents/text information shall be in latest version of MS Office or MS Excel as applicable.
- c) All drawings submitted by the Contractor including those submitted at the time of bid shall be in sufficient detail indicating the type, size, arrangement, weight of each component for packing and shipment, the external connection, fixing arrangement required, the dimensions required for installation and interconnections with other equipments and materials, clearance and spaces required between various portions of equipment and any other information specifically requested in the drawing schedules.
- d) Each drawing submitted by the Contractor (including those of sub vendors) shall bear a title block at the right hand bottom corner with clear mention of the name of the Employer, the system designation, the specifications title, the specification number, the name of the Project, drawing number and revisions. If standard catalogue pages are submitted the applicable items shall be indicated therein. All titles, notings, markings and writings on the drawing shall be in English. All the dimensions should be in metric units.
- e) The drawings submitted by the Contractor (or their subvendor) shall bear Employer's drawing number in addition to contractor's (their sub-vendor's) own drawing number. Employer's drawing numbering system shall be made available to the successful bidder so as to enable him to assign Employer's drawing numbers to the drawings to be submitted by him during the course of execution of the Contract.
- f) The Contractor shall also furnish a "Master Drawing List" which shall be a comprehensive list of all drawings/ documents/ calculations envisaged to be furnished by him during the detailed engineering to the Employer. Such list should clearly indicate the purpose of submission of these drawings i.e. "FOR APPROVAL" or "FOR INFORMATION ONLY".
- g) Similarly, all the drawings/ documents submitted by the Contractor during detailed engineering stage shall be marked "FOR APPROVAL" or "FOR INFORMATION" prior to submission. Further, space shall be identified on each drawing for Approval stamp and electronic signature



- h) The furnishing of detailed engineering data and drawings by the Contractor shall be in accordance with the time schedule for the project. The review of these documents/ data/ drawings by the Employer will cover only general conformance of the data/ drawings/ documents to the specifications and contract, interfaces with the equipments provided by others and external connections & dimensions which might affect plant layout. The review by the Employer should not be construed to be a thorough review of all dimensions, quantities and details of the equipments, materials, any devices or items indicated or the accuracy of the information submitted. The review and/ or approval by the Employer/ Project Manager shall not relieve the Contractor of any of his responsibilities and liabilities under this contract.
- i) After the approval of the drawings, further work by the Contractor shall be in strict accordance with these approved drawings and no deviation shall be permitted without the written approval of the Employer.
- j) All manufacturing, fabrication and execution of work in connection with the equipment / system, prior to the approval of the drawings, shall be at the Contractor's risk. The Contractor is expected not to make any changes in the design of the equipment /system, once they are approved by the Employer.
- k) However, if some changes are necessitated in the design of the equipment/system at a later date, the Contractor may do so, but such changes shall promptly be brought to the notice of the Employer indicating the reasons for the change and get the revised drawing approved again in strict conformance to the provisions of the Technical Specification.
- l) Drawings shall include all installations and detailed piping layout drawings. Layout drawings for all piping of 65 mm and larger diameter shall be submitted for review/ approval of Owner prior to erection. Small diameter pipes shall however be routed as per site conditions in consultation with site authority/representative of Owner based on requirements of such piping indicated in approved / finalized Flow Scheme / Process & Instrumentation Diagrams and/or the requirements cropping up for draining & venting of larger diameter piping or otherwise after their erection as per actual physical condition for the entire scope of work of this package.
- m) Assessing & anticipating the requirement and supply of all piping and equipment shall be done by the Bidder well in advance so as not to hinder the progress of piping & equipment erection, subsequent system charging and its effective draining & venting arrangement as per site suitability.
- n) As Built Drawings**  
After final acceptance of individual equipment/system by the Owner, the Bidder will update all original drawings and documents for the equipment/ system to "as built" conditions in requisite number.
- o) Drawings must be checked by the Bidder in terms of its completeness, data adequacy and relevance with respect to engineering schedule prior to submission to the Owner. In case drawings are found to be submitted without proper endorsement for checking by the Bidder, the same shall



not be reviewed and returned to the Bidder for re-submission. The Bidder shall make a visit to site to see the existing facilities and understand the layout completely and collect all necessary data/drawings at site which are needed as an input to the engineering. The Bidder shall do the complete engineering including interfacing and integration of all his equipment, systems & facilities within his scope of work as well as interface engineering & integration of systems, facilities, equipment & works under Owner's scope and submit all necessary drawings/documents for the same.

- p) The Bidder shall submit adequate prints of drawing/data/document for Owner's review and approval. The Owner shall review the drawings and return one (1) copy to the Bidder authorizing either to proceed with manufacture or fabrication, or marked to show changes desired. When changes are required, drawings shall be re-submitted promptly, with revisions clearly marked, for final review. Any delays arising out of the failure of the Bidder to submit/rectify and resubmit in time shall not be accepted as a reason for delay in the contract schedule.
- q) All engineering data submitted by the Bidder after final process including review and approval by the Project Manager/Owner shall form part of the contract documents and the entire works covered under these specification shall be performed in strict conformity with technical specifications unless otherwise expressly requested by the Project Manager in writing.

#### 8.4 Engineering Information Submission Schedule

Prior to the award of Contract, a Detailed Engineering Information Submission Schedule shall be tied up with the Owner. For this, the bidder shall furnish a detailed list of engineering information alongwith the proposed submission schedule. This list would be a comprehensive one including all engineering data / drawings / information for all bought out items and manufactured items. The information shall be categorised into the following parts.

- a) Information that shall be submitted for the approval of the Owner before proceeding further, and
- b) Information that would be submitted for Owner's information only.

The Master Drawing List (MDL) shall be updated periodically and submitted to the employer, highlighting the changes made in MDL.

The schedule should allow adequate time for proper review and incorporation of changes/ modifications, if any, to meet the contract without affecting the equipment delivery schedule and overall project schedule. The early submission of drawings and data is as important as the manufacture and delivery of equipment and hardware and this shall be duly considered while determining the overall performance and progress.

#### 8.5 Engineering Progress and Exception Report

##### 8.5.1 Report giving the status of each engineering information including

- a) A list of drawings/engineering information which remains unapproved for more than four (4) weeks after the date of first submission



- b) Drawings which were not submitted as per agreed schedule including those for revision after commenting last revision .
- 8.5.2 The draft format for this report shall be furnished to the Owner within four (4) weeks of the award of the contract, which shall then be discussed and finalized with the Owner.

## 8.6 Engineering Co-ordination Procedure

- 8.6.1 The following principal coordinators will be identified by respective organizations at time of award of contract:

### Project Manager (UPRVUNL EC):

Name :  
Designation :  
Address  
a) Postal :  
b) Telegraphic /e-Mail :  
c) FAX : TELEPHONE (Land & Mobile):

### Contractor's/ Vendor's Engineering Coordinator (VENDOR EC):

Name :  
Designation :  
Address :  
a) Postal :  
b) Telegraphic /e-Mail :  
c) FAX : TELEPHONE(Land & Mobile) :

- 8.6.2 All engineering correspondence shall be in the name of above coordinators on behalf of the respective organizations.

- 8.6.3 Contractor's/Vendor's Drawing Submission and Approval Procedure:

- a) All data/information furnished by Vendor in the form of drawings/ documents/catalogues or in any other form for OWNER'S information/ interface and or review and approval are referred by the general term "drawings".
- b) The 'Master drawings list' indicating titles, Drawing Number, Date of submission and approval etc. shall be finalised mutually between Contractor and Owner before the award of contract. This list shall be updated if required at suitable interval during detailed engineering.
- c) All drawings (including those of subvendor's) shall bear at the right hand bottom corner the 'title plate' with all relevant information duly filled in. The Contractor shall furnish this format to his subvendor along with his purchase order for subvendor's compliance.
- d) Owner shall intimate the contractor, OWNER drawing number procedure. Vendor, thereafter, shall indicate OWNER drawing number in MDL and in subsequent Submission of drawing, in the space provided for this purpose in



title plate, in addition to his own drawing number, if any.

- e) The contractor shall make a visit to site to see the existing facilities and understand the layout completely and collect all necessary data / drawings at site which are needed as an input to the engineering. The contractor shall do the complete engineering including interfacing and integration of all his equipment, systems & facilities within his scope of work as well as interface engineering & integration of systems, facilities, equipment & works under Owner's scope and submit all necessary drawings/ documents for the same.
- f) Drawings must be checked by the Contractor in terms of its completeness, data adequacy and relevance with respect to engineering schedule prior to submission to the Owner. In case drawings are found to be submitted without proper endorsement for checking by the Contractor, the same shall not be reviewed and returned to the Contractor for re-submission.
- g) The Contractor shall submit adequate prints of drawing / data / document for Owner's review and approval. The drawings submitted by the Contractor/vendor shall be reviewed by OWNER and their comments shall be forwarded within four (4) weeks of receipt of drawings. Upon review of each drawing, depending on the correctness and completeness of the drawing, the same will be categorized and approval accorded in one of the following categories/action:

CATEGORY/Action - 1 : Distributed  
CATEGORY/Action - 2 : Approved

CATEGORY/Action - 3 : Approved, subject to incorporation of comments/ modification as noted. Forward final drawing Resubmit revised drawing incorporating the comments

CATEGORY/Action - 4 Approved, subject to incorporation of comments/ modification as noted. Resubmit revised drawing incorporating the comments

CATEGORY/Action - 5: Not approved. Resubmit revised drawings for approval after incorporating comments/ modification as noted in accompanying memo.

CATEGORY/Action - 6 : For information and records.

- h) Contractor shall resubmit the drawings marked/stamped under Category/Action 3,4 & 5 within two(2) weeks of receipt of comments on the drawings, incorporating all comments. Every revision of the drawing shall





bear a revision index wherein such revisions shall be highlighted in the form of description or marked up in the drawing identifying the same with relevant revision Number enclosed in a triangle (e.g. 1, 2, 3 etc). Contractor shall not make any changes in the portions of the drawing other than those commented. If changes are required to be made in the portions already approved, the Contractor shall resubmit the drawing identifying the changes for Owner's review and approval. **Drawings resubmitted shall show clearly the portions where the same are revised marking the relevant revision numbers and Owner shall review only such revised portion of documents.**

- i) In case, the Contractor/ Vendor does not agree with any specific comment, he shall furnish the explanation for the same to OWNER for consideration. In all such cases the Contractor shall necessarily enclose explanations along with the revised drawing (taking care of balance comments) to avoid any delay and/or duplication in review work.
- j) It shall be the responsibility of the Contractor/ Vendor to get all the drawings approved as the case may be and complete the engineering activities within the agreed schedule. Any delay arising out of submission and modification of drawings shall not alter the contract completion schedule.
- k) If Contractor/ Vendor fails to resubmit the drawings as per the schedule, construction work at site will not be held up and work will be carried out on the basis of comments furnished on previous issues of the drawing.
- l) These comments will be taken care by the contractor while submitting the revised drawing.
- m) The contractor shall use a single transmittal for drawings Submission. This shall include transmittal numbers and date, number of copies being sent, names of the agencies to whom copies being sent, drawing number and titles, remarks or special notes if any etc.

## 9.0 Technical Co-Ordination Meetings

- 9.1 The Bidder shall be called upon to organize and attend monthly Design/ Technical Co-ordination Meetings with the Owner / Owner's representatives / OWNER Consultant during the period of contract. The Bidder shall attend such meetings at his own cost at mutually agreed venue as and when required and fully co-operate with such persons and agencies involved during the discussions.
- 9.2 The Contractor should note that Time is the essence of the contract. In order to expedite the early completion of engineering activities, the Bidder shall submit all drawings as per the agreed Engineering Information Submission Schedule. The drawings submitted by the Bidder will be reviewed by the Owner as far as practicable within three (3) weeks from the date of receipt of the drawing. The comments of the Owner shall then be discussed across the table during the above co-ordination Meetings wherein best efforts shall be made by both sides to ensure the approval of the drawing.





- 9.2.1 The Contractor shall ensure availability of the concerned experts / consultants/ personnel who are empowered to take necessary decisions during these meetings. The Bidder shall be equipped with necessary tools and facilities so that the drawings/documents can be resubmitted after incorporating necessary changes and approved during the meeting itself.
- 9.2.2 Should any drawing remain unapproved for more than six (6) weeks after it's first submission, this shall be brought out in the monthly Engineering Progress and Exception Report with reasons thereof.
- 9.3 Any delays arising out of failure by the Bidder to incorporate Owner's comments and resubmit the same during the TCM shall be considered as a default and in no case shall entitle the Bidder to alter the Contract completion date.

#### **10.0 Design Improvements**

The Owner or the Contractor may propose changes in the specification of the equipment or quality thereof and if the parties agree upon any such changes the specification shall be modified accordingly.

If any such agreed upon change is such that it affects the price and schedule of completion, the parties shall agree in writing as to the extent of any changing the price and/or schedule of completion before the Bidder proceeds with the change. Following such agreement, the provision thereof, shall be deemed to have been amended accordingly.

#### **11.0 Equipment Bases**

A cast iron or welded steel base plate shall be provided for all rotating equipment which is to be installed on a concrete base, unless otherwise specifically agreed to by the Owner. Each base plate which support the unit and its drive assembly, shall be of a neat design with pads for anchoring the units, shall have a raised lip all around, and shall have threaded drain connections.

#### **12.0 Protective Guards**

Suitable guards shall be provided for protection of personnel on all exposed rotating and/or moving machine parts. All such guards shall be designed for easy installation and removal for maintenance purpose.

#### **13.0 Lubricants, Servo Fluids and Chemicals**

- 13.1 The Bidder's scope includes all the first fill and one year's topping, requirements of consumables such as oils, lubricants including grease, servo fluids, gases and essential chemicals etc. Consumption of all these consumables during the initial operation and final filling after the initial operation shall also be included in the scope of the Bidder. Bidder shall also supply a quantity not less than 10% of the full charge of each variety of lubricants, servo fluids, gases, chemicals etc. used which is expected to be utilised during the first year of operation. This additional quantity shall be supplied in separate Containers.
- 13.2 As far as possible lubricants marketed by the Indian Oil Corporation shall be used. The variety of lubricants shall be kept to a minimum possible.



Detailed specifications for the lubricating oil, grease, gases, servo fluids, control fluids, chemicals etc. required for the complete plant covered herein shall be furnished. On completion of erection, a complete list of bearings/ equipment giving their location and identification marks shall be furnished to the Owner along with lubrication requirements.

#### **14.0 Lubrication & Chemicals**

Equipment shall be lubricated by systems designed for continuous operation. Lubricant level indicators shall be furnished and marked to indicate proper levels under both standstill and operating conditions.

##### **14.1 Chemicals for Water System**

Bidder's scope include Chemical required for complete water system up to final handing over EPC package and further two (2) months plant operational requirement.

#### **15.0 Material of Construction**

All materials used for the construction of the equipment shall be new and shall be in accordance with the requirements of this specification. Materials utilized for various components shall be those which have established themselves for use in such applications.

#### **16.0 Rating Plates, Name Plates & Labels**

- 16.1 Each main and auxiliary item of plant including instruments shall have permanently attached to it in a conspicuous position, a rating plate of non-corrosive material upon which shall be engraved manufacturer's name, equipment, type or serial number together with details of the ratings, service conditions under which the item of plant in question has been designed to operate, and such diagram plates as may be required by the Owner.
- 16.2 Each item of plant shall be provided with nameplate or label designating the service of the particular equipment. The inscriptions shall be approved by the Owner or as detailed in appropriate section of the technical specifications.
- 16.3 Such nameplates or labels shall be of white non-hygroscopic material with engraved black lettering or alternately, in the case of indoor circuit breakers, starters, etc. of transparent plastic material with suitably coloured lettering engraved on the back. The name plates shall be suitably fixed on both front and rear sides.
- 16.4 Items of plant such as valves, which are subject to handling, shall be provided with engraved chromium plated nameplate or label with engraving filled with epoxy. The name plates for valves shall be marked in accordance with MSS standard SP-25 and ANSI B 16.34 as a minimum.
- 16.5 Hanger/ support numbers shall be marked on all pipe supports, anchors, hangers, snubbers and restraint assemblies. Each constant and variable spring support shall also have stamped upon it the designed hot and cold load which it is intended to support. Suitable scale shall also be provided to indicate load on support/hanger.

- 16.6 Valves, steam traps and strainers shall be identified by Owner's tag number of a metal tap permanently attached to non pressure parts such as the yoke by a stainless steel wire. The direction of flow shall also be marked on the body.
- 16.7 Safety and relief valves shall be provided with the following:
- a) Manufacturer's identification.
  - b) Nominal inlet and outlet sizes in mm.
  - c) Set pressure in Kg/cm<sup>2</sup> (abs).
  - d) Blowdown and accumulation as percentage of set pressure.
  - e) Certified capacity in Kg of saturated steam per hour or in case of liquid certified capacity in litres of water per minute.
- 16.8 All such plates, instruction plates, etc. shall be bilingual with Hindi inscription first, followed by English. Alternatively, two separate plates one with Hindi and the other with English inscriptions may be provided.
- 16.9 All segregated phases of conductors or bus ducts, indoor or outdoor, shall be provided with coloured phase plates to clearly identify the phase of the system

#### 17.0 Tools and Tackles

The Bidder shall supply with the equipment one complete set of all special tools and tackles and other instruments required for the erection, assembly, disassembly and proper maintenance of the plant and equipment and systems (including software). These special tools will also include special material handling equipment, jigs and fixtures for maintenance and calibration / readjustment, checking and measurement aids etc. A list of such tools and tackles shall be submitted by the Bidder alongwith the offer.

The price of each tool / tackle shall be deemed to have been included in the total bid price. These tools and tackles shall be separately packed and sent to site. The Bidder shall also ensure that these tools and tackles are not used by him during erection, commissioning and initial operation. For this period the Bidder should bring his own tools and tackles. All the tools and tackles shall be of reputed make acceptable to the Owner.

#### 18.0 Welding

- 18.1 If the manufacturer has special requirements relating to the welding procedures for welds at the terminals of the equipments to be per formed by others the requirements shall be submitted to the Owner in advance of commencement of erection work.

#### 19.0 Colour Code for all Equipments/ Pipings/ Pipe Services

- 19.1 All equipment/ piping/ pipe services are to be painted by the Bidder in accordance with Owner's standard colour coding scheme, which will be furnished to the Bidder during detailed engineering stage.

#### 20.0 Protection and Preservative Shop Coating



**20.1 Protection**

All coated surfaces shall be protected against abrasion, impact, discoloration and any other damages. All exposed threaded portions shall be suitably protected with either metallic or a non-metallic protection device. All ends of all valves and piping and conduit equipment connections shall be properly sealed with suitable devices to protect them from damage. The parts which are likely to get rusted, due to exposure to weather, should also be properly treated and protected in a suitable manner. All primers/paints/coatings shall take into account the hot humid, corrosive & alkaline, subsoil or over ground environment as the case may be. The requirements for painting specification shall be complied with as detailed out in Chapter 9, Volume II.

**20.2 Preservative Shop Coating**

20.2.1 All exposed metallic surfaces subject to corrosion shall be protected by shop application of suitable coatings. All surfaces which will not be easily accessible after the shop assembly, shall be treated beforehand and protected for the life of the equipment. All surfaces shall be thoroughly cleaned of all mill scales, oxides and other coatings and prepared in the shop. The surfaces that are to be finish-painted after installation or require corrosion protection until installation, shall be shop painted with at least two coats of primer.

20.2.2 Transformers and other electrical equipments if included shall be shop finished with one or more coats of primer and two coats of high grade epoxy. The finished colours shall be as per manufacturer's standards, to be selected and specified by the Owner at a later date.

20.3 Shop primer for all steel surfaces which will be exposed to operating temperature below 95 degrees Celsius shall be selected by the Bidder after obtaining specific approval of the Owner regarding the quality of primer proposed to be applied. Special high temperature primer shall be used on surfaces exposed to temperature higher than 95 degrees Celsius and such primer shall also be subject to the approval of the Owner.

20.4 All other steel surfaces which are not to be painted shall be coated with suitable rust preventive compound subject to the approval of the Owner.

20.5 All piping shall be cleaned after shop assembly by shot blasting or other means approved by the Owner. Lube oil piping or carbon steel shall be pickled.

20.6 Painting for Civil structures shall be done as per relevant part of technical specification.

**21.0 QUALITY ASSURANCE PROGRAMME**

To ensure that the equipment and services under the scope of contract whether manufactured or performed within the Contractor's works or at his sub-contractor's premises or at the Employer's site or at any other place of work are in accordance with the specifications, the Contractor shall adopt suitable quality assurance program to control such activities at all points, as necessary. Such programs shall be outlined by the Contractor and shall be finally accepted by the Employer/authorised representative after discussions before the award of the contract. The QA program shall be generally in line



with ISO-9001/IS-14001. A quality assurance program of the contractor shall generally cover the following:

- a) His organization structure for the management and implementation of the proposed quality assurance program
- b) Quality System Manual
- c) Design Control System
- d) Documentation and Data Control System
- e) Qualification data for bidder's key personnel.
- f) The procedure for purchase of materials, parts, components and selection of sub-Bidder's services including vendor analysis, source inspection, incoming raw-material inspection, verification of materials purchased etc.
- g) System for shop manufacturing and site erection controls including process, fabrication and assembly.
- h) Control of non-conforming items and system for corrective actions and resolution of deviations.
- i) Inspection and test procedure both for manufacture and field activities.
- j) Control of calibration and testing of measuring testing equipment.
- k) System for Quality Audits.
- l) System for identification and appraisal of inspection status.
- m) System for authorising release of manufactured product to the Owner.
- n) System for handling, storage and delivery.
- o) System for maintenance of records, and
- p) Furnishing of quality plans for manufacturing and field activities detailing out the specific quality control procedure adopted for controlling the quality characteristics relevant to each item of equipment/component as per formats enclosed as Annexure-I and Annexure-II respectively.

## 22.0 General Requirements - Quality Assurance

- 22.1 All materials, components and equipment covered under this specification shall be procured, manufactured, erected, commissioned and tested at all the stages, as per a comprehensive Quality Assurance Programme. An indicative programme of inspection/tests to be carried out by the Bidder for some of the major items is given in the respective technical specification. This is, however, not intended to form a comprehensive programme as it is the Bidder's responsibility to draw up and implement such programme duly approved by the Owner. The detailed Quality Plans for manufacturing and field activities shall be drawn up by the Bidder and will be submitted to Owner for approval. Schedule



- of finalisation of such quality plans will be finalised before award. Monthly progress reports on MQP/FQP submission/approval shall be furnished.
- 22.2 Manufacturing Quality Plan will detail out for all the components and equipment, various tests/inspection, to be carried out as per the requirements of this specification and standards mentioned therein and quality practices and procedures followed by Bidder's/ Sub-Bidder's/ sub-supplier's Quality Control Organisation, the relevant reference documents and standards, acceptance norms, inspection documents raised etc., during all stages of materials procurement, manufacture, assembly and final testing/performance testing. The Quality Plan shall be submitted on electronic media e.g. CD or E-mail in addition to hard copy, for review and approval. After approval the same shall be submitted in compiled form on CD-ROM.
- 22.3 Field Quality Plans will detail out for all the equipment, the quality practices and procedures etc. to be followed by the Bidder's "Site Quality Control Organisation", during various stages of site activities starting from receipt of materials/equipment at site.
- 22.4 The Bidder shall also furnish copies of the reference documents/plant standards/acceptance norms/tests and inspection procedure etc., as referred in Quality Plans along with Quality Plans. These Quality Plans and reference documents/standards etc. will be subject to Owner's approval without which manufacturer shall not proceed. These approved documents shall form a part of the contract. In these approved Quality Plans, Owner shall identify customer hold points (CHP), i.e. test/checks which shall be carried out in presence of the Owner's Project Manager or his authorised representative and beyond which the work will not proceed without consent of Owner in writing. All deviations to this specification, approved quality plans and applicable standards must be documented and referred to Owner along with technical justification for approval and dispositioning.
- 22.5 No material shall be despatched from the manufacturer's works before the same is accepted, subsequent to predespatch final inspection including verification of records of all previous tests/inspections by Owner's Project Manager/Authorised representative and duly authorised for despatch by issuance of Material Despatch Clearance Certificate (MDCC).
- 22.6 All material used for equipment manufacture including casting and forging etc. shall be of tested quality as per relevant codes/standards. Details of results of the tests conducted to determine the mechanical properties; chemical analysis and details of heat treatment procedure recommended and actually followed shall be recorded on certificates and time temperature chart. Tests shall be carried out as per applicable material standards and/or agreed details.
- 22.7 The Bidder shall submit to the Owner Field Welding Schedule for field welding activities in the format enclosed at Annexure-V. The field welding schedule shall be submitted to the Owner along with all supporting documents, like welding procedures, heat treatment procedures, NDT procedures etc. at least ninety days before schedule start of erection work at site.
- 22.8 All welding and brazing shall be carried out as per procedure drawn and qualified in accordance with requirements of ASME Section IX/BS-4870 or other International equivalent standard acceptable to the Owner.

- 22.9 All welding/brazing procedures shall be submitted to the Owner or its authorised representative for approval prior to carrying out the welding/brazing.
- 22.10 All brazers, welders and welding operators employed on any part of the contract either in Bidder's/sub-Bidder's works or at site or elsewhere shall be qualified as per ASME Section-IX or BS-4871 or other equivalent International Standards acceptable to the Owner.
- 22.11 Welding procedure qualification & Welder qualification test results shall be furnished to the Owner for approval. However, where required by the Owner, tests shall be conducted in presence of Owner/authorised representative.
- 22.12 For all pressure parts and high pressure piping welding, the latest applicable requirements of the IBR (Indian Boiler Regulations) shall also be essentially complied with. Similarly, any other statutory requirements for the equipment/systems shall also be complied with. On all back-gauged welds MPI/LPI shall be carried before seal welding.
- 22.13 Unless otherwise proven and specifically agreed with the Owner, welding of dissimilar materials and high alloy materials shall be carried out at shop only.
- 22.14 No welding shall be carried out on cast iron components for repair.
- 22.15 All the heat treatment results shall be recorded on time temperature charts and verified with recommended regimes.
- 22.16 All non-destructive examination shall be performed in accordance with written procedures as per International Standards, The NDT operator shall be qualified as per SNT-TC-IA (of the American Society of non-destructive examination). NDT shall be recorded in a report, which includes details of methods and equipment used, result/evaluation, job data and identification of personnel employed and details of co-relation of the test report with the job.
- 22.17 All plates of thickness above 40mm & all bar stock/Forging above 40mm dia shall be ultrasonically tested. For pressure parts, plate of thickness equal to or above 25mm shall be ultrasonically tested.
- 22.18 The Bidder shall list out all major items/ equipment/ components to be manufactured in house as well as procured from sub-contractors bought out items (BOI). All the sub-Bidder proposed by the Bidder for procurement of major bought out items including castings, forging, semi-finished and finished components/equipment etc., list of which shall be drawn up by the Bidder and finalised with the Owner, shall be subject to Owner's approval. The Bidder's proposal shall include vendor's facilities established at the respective works, the process capability, process stabilization, QC systems followed, experience list, etc. along with his own technical evaluation for identified sub-contractors enclosed and shall be submitted to the Owner for approval within the period agreed at the time of pre-awards discussion and identified in review category prior to any procurement. Monthly progress reports on sub-Bidder detail submission / approval shall be furnished. Such vendor approval shall not relieve the Bidder from any obligation, duty or responsibility under the contract.
- 22.19 For components/equipment procured by the contractors for the purpose of the contract, after obtaining the written approval of the Owner, the Bidder's





purchase specifications and inquiries shall call for quality plans to be submitted by the suppliers. The quality plans called for from the sub-Bidder shall set out, during the various stages of manufacture and installation, the quality practices and procedures followed by the vendor's quality control organisation, the relevant reference documents/standards used, acceptance level, inspection of documentation raised, etc. Such quality plans of the successful vendors shall be finalised with the Owner and such approved Quality Plans shall form a part of the purchase order/contract between the Bidder and sub-Bidder. Within three weeks of the release of the purchase orders /contracts for such bought out items /components, a copy of the same without price details but together with the detailed purchase specifications, quality plans and delivery conditions shall be furnished to the Owner on the monthly basis by the Bidder along with a report of the Purchase Order placed so far for the contract.

22.20 Owner reserves the right to carry out quality audit and quality surveillance of the systems and procedures of the Bidder's or their sub-Bidder's quality management and control activities. The Bidder shall provide all necessary assistance to enable the Owner carry out such audit and surveillance.

22.21 The Bidder shall carry out an inspection and testing programme during manufacture in his work and that of his sub-Bidder's and at site to ensure the mechanical accuracy of components, compliance with drawings, conformance to functional and performance requirements, identity and acceptability of all materials parts and equipment. Bidder shall carry out all tests/inspection required to establish that the items/equipment conform to requirements of the specification and the relevant codes/standards specified in the specification, in addition to carrying out tests as per the approved quality plan.

22.22 Quality audit/surveillance/approval of the results of the tests and inspection will not, however, prejudice the right of the Owner to reject the equipment if it does not comply with the specification when erected or does not give complete satisfaction in service and the above shall in no way limit the liabilities and responsibilities of the Bidder in ensuring complete conformance of the materials/equipment supplied to relevant specification, standard, data sheets, drawings, etc.

22.23 For all spares and replacement items, the quality requirements as agreed for the main equipment supply shall be applicable.

22.24 Repair/rectification procedures to be adopted to make the job acceptable shall be subject to the approval of the Owner/ authorised representative.

#### **22.25 Environmental Stress Screening**

All solid state electronic system / equipment / sub assembly shall be free from infant mortile components. For establishing the compliance to this requirement, the contractor / sub – contractor should meet the following

- 1) The Contractor / Sub – contractor shall furnish the established procedure being followed for eliminating infant mortile components. The procedure followed by the Contractor / Sub – contractor should be substantiated along with the statistical figures to validate the procedure being followed. The necessary details as required under this clause shall be furnished at the stage of QP finalization.





**OR**

In case the Contractor / Sub – contractor do not have any established procedure to eliminate infant mortile components then two number or 10% whichever is less, most densely populated Panels shall be tested for Elevated Temperature Cycle Test as per the following procedure.

**Elevated Temperature Test Cycle**

During the elevated temperature test which shall be for 48 hours of the total 168 hours of testing, the ambient temperature shall be maintained at 50 deg.C. The equipment shall be interconnected with devices which will cause it to repeatedly perform all operations it is expected to perform in actual service with load on various components being equal to those which will be experienced in actual service.

During the elevated temperature test the cubicle doors shall be closed (or shall be in the position same as they are supposed to be in the field) and inside temperature in the zone of highest heat dissipating components/modules shall be monitored. The temperature rise inside the cubicle should not exceed 10 deg.C above the ambient temp. at 50 deg.C.

In case of any failure during the test cycle, the further course of action should be mutually discussed for demonstrating the intent of the above requirement.

**2) Burn in Test Cycle**

The 48 hours elevated temperature test shall be followed by 120 hours of burn in test as above except that the temperature shall be reduced to the ambient temperature prevalent at that time.

During the above tests, the process I/O and other load on the system shall be simulated by simulated inputs and in the case of control systems, the process which is to be controlled shall also be simulated. Testing of individual components or modules shall not be acceptable.

In case the Bidder/ sub-Bidder is having any alternate established procedure of eliminating infant mortile components, the detail procedures followed by the Bidder/ sub- Bidder along with the statistical figures to validate the alternate procedure to be forwarded.

- 22.26 The Bidder/Sub-Bidder shall carry out routine test on 100% item at Bidder/sub-Bidder's works. The quantum of check/test for routine & acceptance test by Owner shall be generally as per criteria/sampling plan defined in referred standards. Wherever standards have not been mentioned quantum of check/test for routine / acceptance test shall be as agreed during detailed engineering stage.

**23.0 QA Documentation Package**

- 23.1 The Bidder shall be required to submit the QA Documentation in two hard copies and two CD ROMs, as identified in respective quality plan with tick (✓) mark.



- 23.1.1 Each QA Documentation shall have a project specific Cover Sheet bearing name & identification number of equipment and including an index of its contents with page control on each document.

The QA Documentation file shall be progressively completed by the Supplier's sub-supplier to allow regular reviews by all parties during the manufacturing.

The final quality document will be compiled and issued at the final assembly place of equipment before despatch. However CD-Rom may be issued not later than three weeks.

- 23.2 Typical contents of QA Documentation are as below:-

- a) Quality Plan
- b) Material mill test reports on components as specified by the specification and approved Quality Plans.
- c) Manufacturer / works test reports/results for testing required as per applicable codes and standard referred in the specification and approved Quality Plans.
- d) Non-destructive examination results /reports including radiography interpretation reports. Sketches/drawings used for indicating the method of traceability of the radiographs to the location on the equipment.
- e) Heat Treatment Certificate/Record (Time- temperature Chart)
- f) All the accepted Non-conformance Reports (Major/Minor) / deviation, including complete technical details / repair procedure).
- g) CHP / Inspection reports duly signed by the Inspector of the Owner and Bidder for the agreed Customer Hold Points.
- h) Certificate of Conformance (COC) wherever applicable.
- i) MDCC

- 23.3 Similarly, the Bidder shall be required to submit two sets (two hard copies and two CD ROMs), containing QA Documentation pertaining to field activities as per Approved Field Quality Plans and other agreed manuals/ procedures, prior to commissioning of individual system.

- 23.4 Before despatch / commissioning of any equipment, the Supplier shall make sure that the corresponding quality document or in the case of protracted phased deliveries, the applicable section of the quality document file is completed. The supplier will then notify the Inspector regarding the readiness of the quality document (or applicable section) for review.

- a) If the result of the review carried out by the Inspector is satisfactory, the Inspector shall stamp the quality document (or applicable section) for release.
- b) If the quality document is unsatisfactory, the Supplier shall endeavor to correct the incompleteness, thus allowing to finalize the quality



document (or applicable section) by time compatible with the requirements as per contract documents. When it is done, the quality document (or applicable section) is stamped by the Inspector.

- c) If a decision is made despatch, whereas all outstanding actions cannot be readily cleared for the release of the quality document by that time. The supplier shall immediately, upon shipment of the equipment, send a copy of the quality document Review Status signed by the Supplier Representative to the Inspector and notify of the committed date for the completion of all outstanding actions & submission. The Inspector shall stamp the quality document for applicable section when it is effectively completed. The submission of QA documentation package shall not be later than 3 weeks after the despatch of equipment.

### 23.5 Transmission of QA Documentation

On release of QA Documentation by Inspector, one set of quality document shall be forwarded to Quality Assurance Department (@ Head Office) and other set to respective Project Site of Owner.

For the particular case of phased deliveries, the complete quality document to the Owner shall be issued not later than 3 weeks after the date of the last delivery of equipment.

### 24.0 Project Manager's Supervision

24.1 To eliminate delays and avoid disputes and litigation, it is agreed between the parties to the Contract that all matters and questions shall be referred to the Project Manager and without prejudice to the provisions of 'Arbitration' clause in Section General Conditions of Contract, the Bidder shall proceed to comply with the Project Manager's decision.

24.2 The work shall be performed under the supervision of the Project Manager. The scope of the duties of the Project Manager pursuant to the Contract, will include but not be limited to the following:

- a) Interpretation of all the terms and conditions of these documents and specifications:
- b) Review and interpretation of all the Bidder's drawing, engineering data, etc:
- c) Witness or his authorised representative to witness tests and trials either at the manufacturer's works or at site, or at any place where work is performed under the contract :
- d) Inspect, accept or reject any equipment, material and work under the contract.
- e) Issue certificate of acceptance and/or progressive payment and final payment certificates
- f) Review and suggest modifications and improvement in completion schedules from time to time, and



- g) Supervise Quality Assurance Programme implementation at all stages of the works.

**25.0 Inspection, Testing and Inspection Certificates**

- 25.1 The word 'Inspector' shall mean the Project Manager and/or his authorized representative and/or an outside inspection agency acting on behalf of the Owner to inspect and examine the materials and workmanship of the works during its manufacture or erection.
- 25.2 The Project Manager or his duly authorized representative and/or an outside inspection agency acting on behalf of the Owner shall have access at all reasonable times to inspect and examine the materials and workmanship of the works during its manufacture or erection and if part of the works is being manufactured or assembled on other premises or works, the Bidder shall obtain for the Project Manager and for his duly authorized representative permission to inspect as if the works were manufactured or assembled on the Bidder's own premises or works.
- 25.3 The Bidder shall give the Project Manager/Inspector fifteen (15) days written notice of any material being ready for testing. Such tests shall be to the Bidder's account except for the expenses of the Inspector's. The Project Manager/Inspector, unless the witnessing of the tests is virtually waived and confirmed in writing, will attend such tests within fifteen (15) days of the date on which the equipment is noticed as being ready for test/inspection failing which the Bidder may proceed with test which shall be deemed to have been made in the inspector's presence and he shall forthwith forward to the inspector duly certified copies of test reports in two (2) copies.
- 25.4 The Project Manager or Inspector shall within fifteen (15) days from the date of inspection as defined herein give notice in writing to the Bidder, or any objection to any drawings and all or any equipment and workmanship which is in his opinion not in accordance with the contract. The Bidder shall give due consideration to such objections and shall either make modifications that may be necessary to meet the said objections or shall inform in writing to the Project Manager/Inspector giving reasons therein, that no modifications are necessary to comply with the contract.
- 25.5 When the factory tests have been completed at the Bidder's or sub-Bidder's works, the Project Manager /Inspector shall issue a certificate to this effect fifteen (15) days after completion of tests but if the tests are not witnessed by the Project Manager /Inspectors, the certificate shall be issued within fifteen (15) days of the receipt of the Bidder's test certificate by the Project Manager /Inspector. Project Manager /Inspector to issue such a certificate shall not prevent the Bidder from proceeding with the works. The completion of these tests or the issue of the certificates shall not bind the Owner to accept the equipment should it, on further tests after erection be found not to comply with the contract.
- 25.6 In all cases where the contract provides for tests whether at the premises or works of the Bidder or any sub-Bidder, the Bidder, except where otherwise specified shall provide free of charge such items as labour, material, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Project Manager /Inspector or his authorized representatives to carry out effectively such tests on the equipment in accordance with the

Bidder and shall give facilities to the Project Manager/Inspector or to his authorized representative to accomplish testing.

- 25.7 The inspection by Project Manager / Inspector and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Bidder in respect of the agreed Quality Assurance Programme forming a part of the contract.
- 25.8 To facilitate advance planning of inspection in addition to giving inspection notice as specified at clause no 9.05.03 of this chapter, the Bidder shall furnish quarterly inspection programme indicating schedule dates of inspection at Customer Hold Point and final inspection stages. Updated quarterly inspection plans will be made for each three consecutive months and shall be furnished before beginning of each calendar month.
- 25.9 All inspection, measuring and test equipment used by Bidder shall be calibrated periodically depending on its use and criticality of the test/measurement to be done. The Bidder shall maintain all the relevant records of periodic calibration and instrument identification, and shall produce the same for inspection by the Owner. Wherever asked specifically, the Bidder shall re-calibrate the measuring/test equipment in the presence of Project Manager/Inspector.

#### **25.10 Associated document for quality assurance programme:**

- 25.10.1 List of items requiring quality plan and sub supplier approval. (Annexure-III).
- 25.10.2 Status of items requiring Quality Plan and sub supplier approval (Annexure-IV)
- 25.10.3 Field Welding Schedule (Annexure-V).
- 25.10.4 Manufacturing Quality Plan (Annexure-I).
- 25.10.5 Field Quality Plan (Annexure-II).

#### **25.11 TESTING OF MAJOR DESIGN FEATURES OF I&C SYSTEM:**

The major design features of the system shall be demonstrated by the Contractor at the Contractor's works or any other place mutually agreed within four months from the date of LOA. These are the system function tests, which have a major impact on the detailed system design & finalization of important engineering documents like configuration, functional grouping, BOM etc., but do not require a fully engineered system for conductance. Bidder shall identify these features & include detailed test procedures in the bid, which shall be finalized during discussions with the bidder before award. The developments and any augmentation of standard features undertaken by the Bidder to fulfil the various specification requirements, shall be also be tested during these major design tests. This shall include but not be limited to the following

- A) System accuracy tests of DDCMIS for the various type of inputs identified in Part-B.
- B) Loop reaction time for sample loops/ logics
- C) SOE functionality tests
- D) Server changeover
- E) Various response times, having serious implication on operation & maintenance philosophy



- F) Duty cycle of controller/ HMIPIS with simulated load, representative of the final engineered load.
- G) Unified HMI for DDCMIS

The results of the above tests, after its acceptance by the Owner, shall be properly documented and submitted to Owner.

## 25.12 DEMONSTRATION OF APPLICATION ENGINEERING

2.12.1 Based on UPRVUNL inputs, the Contractor shall prepare and submit typical implemented scheme in their system (Control system & HMI) on sample basis. The typical cases to be covered shall include but not be limited to the following

### i) Logics/Loops:

- a) Drive logics implementation for each type of binary drive along with its display in HMI.
- b) Sequence implementation along with its display in HMI.
- c) Single non-cascade controller implementation.
- d) Cascade loop implementation.
- e) Master slave implementation with different slave combination.
- f) Temperature & pressure compensation for flow signals & pressure compensation for level signals as applicable

### ii) HMI Functions:

- a) LVS Annunciation.
- b) Graphics.
- c) HSR
- d) Logs/Reports.
- e) Calculations (Basic & Performance Calculations).

25.12.2 The above typical cases shall be finalized with the Owner through Technical Co-ordination meetings.

After review and finalization of the typical cases, the implementation of each logic & control loop shall be carried out by the Contractor based on UPRVUNL inputs. After implementation of these logics & loops, the Contractor shall test each logic /loop and record the observations in a format to be provided by the Owner and demonstrate to Owner at Owner premises during engineering finalization. Any modifications as a result of the demonstration shall be done and documented as part of the test report along with the final scheme. Similarly, HMI functions shall also be demonstrated by the Contractor at Owner premises & the results shall be documented as part of test report.

25.12.3 During the integrated testing at the Contractor's works, only sample checks shall be done by the Owner for the items covered in above application engineering demonstration.



**26.0 PRE-COMMISSIONING, COMMISSIONING, TRIAL OPERATION, PERFORMANCE TEST**

- 26.1 a) As soon as the facilities or part thereof has been completed operationally and structurally and before start-up, each item of the equipment and systems forming part of facilities shall be thoroughly cleaned and then inspected jointly by the Owner and the Bidder for correctness of and completeness of facility or part thereof and acceptability for initial pre-commissioning tests, commissioning and start-up at Site. The list of pre-commissioning tests to be performed shall be as mutually agreed and included in the Bidder's quality assurance programme as well as those included elsewhere in the Technical Specifications.
- b) The Bidder's pre-commissioning/ commissioning/start-up engineers, specially identified as far as possible, shall be responsible for carrying out all the pre-commissioning tests at Site. On completion of inspection, checking and after the pre-commissioning tests are satisfactorily over, the commissioning of the complete facilities shall be commenced during which period the complete facilities, equipments shall be operated integral with sub-systems and supporting equipment as a complete plant.
- c) It will be the responsibility of the Bidder to assess and furnish a list of all commissioning spars required for successful commissioning of all the equipment covered under the contract. Such a list shall be furnished by the Bidder within 12 months from the date of LOA, separately for each equipment and shall be reviewed by the Owner and discussed for mutual agreement. The commissioning spares will be so identified as not to allow the trial operation to suffer for want of such commissioning spares. The identification of commissioning spares will not in any way relieve the Bidder of any of his responsibilities of satisfactory performance under the provisions of other conditions of contract. All the commissioning spares shall be deemed to be included in scope of the Bidder as a part of the respective equipment package at no extra cost to the Owner.
- d) All piping system shall be flushed, steam blown, air blown as required and cleanliness demonstrated using acceptable industry standards. Procedures to accomplish this work shall be submitted for approval to the Owner six months prior to the respective implementations. The Owner will approve final verification of cleanliness.
- e) The time consumed in the inspection and checking of the units shall be considered as a part of the erection and installation period.
- f) The check outs during the pre - commissioning period should be programmed to follow the construction completion schedule. Each equipment/system, as it is completed in construction and turned over to Owner's commissioning (start-up) Engineer(s), should be checked out and cleaned. The checking and inspection of individual systems should then follow a prescribed commissioning documentation [SLs (Standard Check List) / TS (Testing Schedule) / CS (Commissioning Schedule)] approved by the Owner.
- g) The Bidder during initial operation and performance testing shall conduct vibration testing to determine the 'base line' of performance of all plant rotating equipment. These tests shall be conducted when the equipment is running at



the base load, peak load as well as lowest sustained operating condition as far as practicable.

26.1.1 Bidder shall furnish the commissioning organization chart for review & acceptance of Owner at least eighteen months prior to the schedule date of synchronization of 1st unit. The chart should contain:

- a) Biodata including experience of the Commissioning Engineers.
- b) Role and responsibilities of the Commissioning Organisation members.
- c) Expected duration of posting of the above Commissioning Engineers at site.

## 26.2 Initial Operation / Trail Operation Test

- a) On completion of all pre-commissioning activities / tests and as a part of commissioning the complete facilities shall be put on 'Initial Operation' during which period all necessary adjustments shall be made while operating over the full load range enabling the facilities to be made ready for the Guarantee Tests.
- b) The 'Initial Operation' of the complete facility as an integral unit shall be conducted for 720 continuous hours. During the period of initial operation of 720 hours, the unit shall operate continuously at full rated load for a period not less than 72 hours.

**The Initial Operation Test shall be considered successful, if during the above period of initial operation, the 660MW unit shall generates a minimum of 451 million kWhrs\*, as measured a generator terminals.**

- c) The Initial Operation shall be considered successful, provided that each item/ part of the facility has operate continuously at the specified operating characteristics, for the period of Initial Operation with all operating parameters within the specified limits and at or near the predicted performance of the equipment/ facility.
- d) The Bidder shall intimate the Owner about the commencement of initial operation and shall furnish adequate notice to the Owner in this respect.
- e) Any loss of generation due to constraints attributable to the Owner shall be construed as Deemed Generation.
- f) An Initial Operation report comprising of observations and recordings of various parameters to be measured in respect of the above Initial Operation shall be prepared by the Bidder. This report, besides recording the details of the various observations during initial operation shall also include the dates of start and finish of the Initial Operation and shall be signed by the representatives of both the parties. The report shall have sheets, recording all the details of interruptions occurred, adjustments made and any minor repairs done during the Initial Operation. Based on the observations, necessary modifications / repairs to the plant shall be carried out by the Bidder to the full satisfaction of the Owner to enable the latter to accord permission to carry out the Guarantee tests on the facilities. However, minor defects which do not endanger the safe





operation of the equipment, shall not be considered as reasons for withholding the aforesaid permission.

(\* - shall be appropriately adjusted for any generation loss attributable to Employer.)

### 26.3 Guarantee Tests

- a) The final test as to prove the Functional Guarantees shall be conducted at Site by the Contractor in presence of the Employer. The contractor's Commissioning, start-up and initial operation shall make the unit ready to conduct such test. Such test will be commenced, within a period of **three (3) months** after the successful completion of Initial Operations. Any extension of time beyond the above **three (3) months** shall be mutually agreed upon.
- b) These tests shall be binding on both the parties of the Contract to determine compliance of the equipment with the functional guarantee.
- c) For performance/ demonstration tests instrumentations, of accuracy class, to the approval of the Owner shall be used. The numbers and location of the instruments shall be as per the specified test codes. In addition the values of parameters shall be logged from the information system provided under Owner's Distributed Digital Control Monitoring and Information system. Test will be conducted at specified load points.
- d) Any special equipment, tools and tackles required for the successful completion of the Guarantee Tests shall be provided by the Bidder, free of cost.
- e) The Guarantee tests and specific tests to be conducted on equipments have been brought out in detail elsewhere in the specification.

### 27.0 TAKING OVER

Upon successful completion of Initial Operations and all the tests (including all PG test) conducted to the Employer's satisfaction, the Employer shall issue to the Contractor a Taking over Certificate as a proof of the final acceptance of the equipment. Such certificate shall not unreasonably be withheld nor will the Employer delay the issuance thereof, on account of minor omissions or defects which do not affect the commercial operation and/or cause any serious risk to the equipment. Such certificate shall not relieve the Contractor of any of his obligations which otherwise survive, by the terms and conditions of the Contract after issuance of such certificate.

### 28.0 TRAINING OF OWNER'S PERSONNEL

28.1 The scope of service under training of Owner shall include a training module in the areas of Operation & Maintenance.

Such training should cover the following areas as a minimum in order to enable these personnel to individually take the responsibility of operating and maintaining the power station in a manner acceptable to the Owner:



- a) Training for Steam Generator & ESP Equipment, TG & Auxiliaries and related equipments.
- b) Training for Electric Systems including VFD and Electric power supply system.
- c) Training for other SG/TG related C&I systems/equipments including training on Flame Monitoring System, Furnace and Flame Viewing System, Turbine Supervisory System (TSS) including vibration analyzer, vibration monitoring system axial shift, eccentricity measurements etc. for Main Turbine, BFP Turbine etc. Burner management study, control loop study, misc system for SG C&I, EHTC, Turbine stress control system, Turbine protection system, ATRS, instrumentation etc.
- d) Training for special packages for various PC based systems.
- e) Training for various C&I systems/equipment supplied includes the following:
  - i. DDCMIS - Human Machine Interface – Hardware & Operating System
  - ii. DDCMIS-Human Machine Interface System Engineering & Application Software.
  - iii. DDCMIS – Control System Hardware and Control system Application Software.
  - iv. DDCMIS – Operator Training: Use of the system at Works + at site.
  - v. DDCMIS – Specialized Network security.
- f) Training for power cycle piping/critical piping.
- g) Training for UPS systems Annunciation system, SWAS, PA system, flue gas analysers, CCTV and 24 VDC systems.
- h) Training for numerical relays & networking systems supplied under MV & LT switchgear system.
- i) Details of training modules for Mechanical, Electrical and C&I systems are given at Annexure – VII,

The exact details, extent and schedule for training shall be as finalised during detailed engineering and shall be subject to Owner's approval.

- 28.2 The scope of services under training shall also necessarily include training of Owner's Engineering personnel covering a training module as indicated in Annexure – VII. This shall cover all disciplines viz, Mechanical, Electrical, C&I, & QA etc. and shall include all the related areas like Design familiarization, training on product design features and product design softwares of major equipment and systems, engineering, manufacturing, erection, commissioning, training on operating features of equipment, quality assurance and testing, plant visits and visits to manufacturer's works, exposure to various kinds of problems which may be encountered in fabrication, manufacturing, erection, welding etc.
- 28.3 Contractor shall also arrange for training of Employer's personnel in respect of fire detection and protection systems and other Balance of Plant equipments.



- 28.4 Four (4) man month and two (2) man month training for OWNER Engineering Personnel on the offered CFD modelling code for SG & ESP including alternative geometry modeling technique shall be provided.
- 28.5 Bidder shall furnish in his offer, details of training module(s) covering above requirements which shall be subject to Owner's approval. Consolidated training period included above (Annexure – VII for O&M and Engineering) is indicative only. Owner reserves the right to reappropriate the training period between O&M and engineering depending upon the details of training module proposed by the Bidder.
- 28.6 Exact details, extent of training and the training schedule shall be finalised based on the Bidder's proposal within two (2) months from placement of award.
- 28.7 In all the above cases, wherever the training of Owner's personnel is arranged at the works of the manufacturer's (within Employer's Country) it shall be noted that the lodging and boarding of the Owner's personnel shall be at the cost of Bidder. The Bidder shall make all necessary arrangements towards the same.
- 28.8 In case the training of Owner's personnel is arranged at the works of the manufacturer's (outside Employer's Country) it shall be noted that the all the expenses including travel, air fare, application processing fees, lodging and boarding of the Owner's personnel shall be at the cost of Bidder. The Bidder shall make all necessary arrangements towards the same.
- 28.9 Take off prices (product wise) should be indicated by the Bidder in the Bid Proposal Sheets. Owner reserves the right to include or exclude these item(s) during place of Award.
- 28.10** In addition to above, the contractor shall also arrange for training of 30 Owner's Personnel at a running 660 MW unit on operation of power station, for a period of six (6) months. The training shall be conducted before commissioning of the unit. The lodging and boarding of the Owner's personnel shall be at the cost of Bidder. The Bidder shall make all necessary arrangements towards the same

**Note:** For training purposes, one (1) man month implies 30 working days (excluding all intervening holidays) per person.

## **29.0 SAFETY ASPECTS DURING CONSTRUCTION AND ERECTION**

In addition to the requirements given in Erection Conditions of Contract (ECC) the following shall also cover:

- a) Working platforms should be fenced and shall have means of access.
- b) Ladders in accordance with Owner's safety rules for construction and erection shall be used. Rungs shall not be welded on columns. All the stairs shall be provided with handrails immediately after its erection.

## **30.0 Noise level**



The equivalent 'A' weighted sound pressure level measured at a height of 1.0 m above floor level in elevation and at a distance of one (1) meter horizontally from the nearest surface of any equipment / machine, furnished and installed under these specifications, expressed in decibels to a reference of 0.0002 microbar, shall not exceed 85 dBA except for

- a) Safety valves and associated vent pipes for which it shall not exceed 105 dBA.
- b) Regulating drain valves in which case it shall be limited to 90 dBA.
- c) TG unit in which case it shall not exceed 90 dBA.
- d) For HP-LP bypass valves and other intermittently operating control valves, the noise level shall be within the limit of 85 dBA.
- e) Mill noise which will be limited to 85-90 dBA.

### 31.0 PACKAGING AND TRANSPORTATION

All the equipments & spares shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. Each spare shall be clearly marked or labelled on the outside of the packing with its description. When more than one spare part is packaged in a single case, a general description of the contents shall be shown on the outside of such a case and other packages must be suitably marked and numbered for the purpose of identification. All cases, containers or packages, are liable to be opened for such examination as may be considered reasonable by the Engineer. In case of equipment supplied with grease/lubricants from imported origin, the supplied shall clearly indicate the indigenous equivalent of the grease/lubricant and source of supply so as to enable the Owner to procure these items from indigenous sources. While packing all the materials, the limitation from the point of view of the sizes of railway wagons available in India should be taken account of. The Bidder shall be responsible for any loss or damage during transportation, handling and storage due to improper packing. The Bidder shall ascertain the availability of Railway wagon sizes from the Indian Railways or any other agency concerned in India well before effecting dispatch of equipment. Before dispatch it shall be ensured that complete processing and manufacturing of the components is carried out at shop, only restricted by transport limitation, in order to ensure that site works like grinding, welding, cutting & pre-assembly to bare minimum. The Owner's Inspector shall have right to insist for completion of works in shops before dispatch of materials for transportation.

### 32.0 ELECTRICAL EQUIPMENTS/ENCLOSURES

All electrical equipments and devices, including insulation, heating and ventilation devices shall be designed for ambient temperature and a maximum relative humidity as specified elsewhere in the specification.

### 33.0 Instrumentation and Control

All instrumentation and control systems/ equipment/ devices/ components, furnished under this contract shall be in accordance with the requirements stated herein, unless otherwise specified in the detailed specifications.



- 33.1 All instrument scales and charts shall be calibrated and printed in metric units and shall have linear graduation. The ranges shall be selected to have the normal reading at 75% of full scale.

All scales and charts shall be calibrated and printed in Metric Units as follows:

|    |               |   |                                                                                                                                                                                                                                    |
|----|---------------|---|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| a) | Temperature   | - | Degree centigrade (deg C)                                                                                                                                                                                                          |
| b) | Pressure      | - | Kilograms per square centimeter (Kg/cm <sup>2</sup> ). Pressure instrument shall have the unit suffixed with 'a' to indicate absolute pressure. If nothing is there, that will mean that the indicated pressure is gauge pressure. |
| c) | Draught       | - | Millimeters of water column (mm wc).                                                                                                                                                                                               |
| d) | Vacuum        | - | Millimeters of mercury column (mm Hg) or water column (mmWcl).                                                                                                                                                                     |
| e) | Flow (Gas)    | - | Tonnes/ hour                                                                                                                                                                                                                       |
| f) | Flow (Steam)  | - | Tonnes/ hour                                                                                                                                                                                                                       |
| g) | Flow (Liquid) | - | Tonnes / hour                                                                                                                                                                                                                      |
| h) | Flow base     | - | 760 mm Hg. 15 deg.C                                                                                                                                                                                                                |
| i) | Density       | - | Grams per cubic centimeter.                                                                                                                                                                                                        |

- 33.2 All instruments and control devices provided on panels shall be of miniaturized design, suitable for modular flush mounting on panels with front draw out facility and flexible plug-in connection at rear.

- 33.3 All electronic modules shall have gold plated connector fingers and further all input and output modules shall be short circuit proof. These shall also be tropicalized & components shall be of industrial grade or better.

#### 34.0 ELECTRICAL NOISE CONTROL

The equipment furnished by the Bidder shall incorporate necessary techniques to eliminate measurement and control problems caused by electrical noise. Areas in Bidder's equipment, which are vulnerable to electrical noise shall be hardened to eliminate possible problems. Any additional equipment, services required for effectively eliminating the noise problems shall be included in the proposal. The equipment shall be protected against ESD as per IEC-801- 2. Radio Frequency interference (RFI) and Electro Magnetic Interference (EMI) protection against hardware damage and control system mal-operations/errors shall be provided for all systems.

#### 35.0 SURGE PROTECTIONS FOR SOLID STATE EQUIPMENT

All solid state systems /equipment shall be able to withstand the electrical noise and surge as encountered in actual service conditions and inherent in a power plant and shall meet the requirements of surge protection as defined in ANSI C37.90.1-1989 on its suitable equivalent class of IEC 254-4. Details of the features incorporated and relevant tests carried out. The test certificates etc. shall be submitted by the Bidder.

#### 36.0 Instrument Air System

The instrument air supply system as supplied by the Bidder for various pneumatic control & instrumentation devices like pneumatic actuators, power



cylinders, E/P converters, piping / tubing etc. shall be as per the details furnished elsewhere.

Each pneumatic instrument shall have an individual air shut - off valve. The pressure-regulating valve shall be equipped with an internal filter, a 50 mm pressure gauge and a built-in filter housing blow down valve.

### 37.0 TAPPING POINTS FOR MEASUREMENTS

Tapping points shall include probes, wherever applicable, for analytical measurements and sampling.

For direct temperature measurement of all working media, one stub with internal threading of approved pattern shall be provided along with suitable plug and washer. The Bidder will be intimated about thread standard to be adopted.

The following shall be provided on equipment by the Bidder. The standard which is to be adopted, will be intimated to the Bidder.

- a) Temperature test pockets with stub and thermowell.
- b) Pressure test pockets

### 38.0 SYSTEM DOCUMENTATION (DDCMIS)

The Bidder shall provide drawings, system overview & description, hardware/software details, technical literature, functional & hardware schemes, bill of material, parts list, interconnection diagrams, data sheets, erection/installation/ commissioning procedures, instruction/ operating manuals, etc. for each of the C&I system / sub-systems/ equipment supplied under this package. The documentation shall include complete details of the C&I systems/ sub-systems/ equipment to enable review by Owner during detailed engineering stage and to provide information to plant personnel for operation & Maintenance (including quick diagnostics & trouble shooting) of these C&I systems/ sub-systems/ equipment at site. The minimum documentation requirements for C&I systems shall be as stipulated under C&I "Technical Data Sheets" Part of specifications. In addition to this, system documentation for DDCMIS shall include as a minimum to that specified elsewhere in the Technical Specification.

The exact format, submission schedule and contents of various documents shall be as finalised during detailed engineering stage.

- 38.1 Bill of material (instrument list) for all C&I equipment/ devices shall be furnished by the bidder in standard formats as approved by the Owner.

### 39.0 MAINTENANCE MANUALS OF ELECTRONIC MODULES

The Contractor shall have to furnish two(2) sets of all maintenance manual of each and every electronic card/module as employed on the various systems and equipment including peripherals etc., offered by him. The Contractor will also have to furnish the data regarding the expected failure rate of various modules and other system components. Further, the contractor shall furnish a set of operating manuals which should include block diagrams, make,



model/type, details wiring and external connection drawings etc as required to do the testing and maintenance of the electronic modules.

#### 40.0 ENVIRONMENTAL MONITORING & CONTROL MEASURES

- 40.1 The Power Plant will be developed based on the guidelines of the State Environmental Authorities and that of MoEF. Suitable provisions will be incorporated in the design of buildings, structures, and selection of equipment, so that there are no adverse effects due to emissions, noise, and contamination of soil, water and air.
- 40.2 One single flue stack of 275 meter will be provided for 660 MW unit for wider dispersion of pollutant as per environmental guidelines.

#### 41.0 LIST OF CODES AND STANDARDS

| ←---    | Indian Standards<br>Title                                                                                                                                                                                                                                                                                                        | --> | ← International and international<br>recognized Standards →                         |
|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-------------------------------------------------------------------------------------|
| IS: 277 | Galvanised steel sheets<br>(plain or corrugated)                                                                                                                                                                                                                                                                                 |     |                                                                                     |
| IS: 655 | Specification for metal<br>air duct                                                                                                                                                                                                                                                                                              |     |                                                                                     |
| IS: 800 | Code of practice for<br>use of structural<br>steel in general<br>building construction 1-1952                                                                                                                                                                                                                                    |     | BS 449:1969<br>BS 5950<br>ASA A57,                                                  |
| IS: 807 | Code of practice for<br>design, manufacture,<br>erection and testing<br>(Structural portion)<br>of cranes and hoists<br>6588 (Issued by<br>Standards Association of<br>Australia) DIN 120:1936<br>(Sheet 1) DIN 120:1936<br>(Sheet 2) 327 part-I, 1951<br>BS 466 part-II, 1960<br>BS 644:1960BS 1757:1951<br>BS 2573:part-I:1960 |     | Draft Revision,<br>A.S. NO. CS.2<br>SAA Crane and<br>Hoist code<br>Doc:No. BU/4 Rev |
| IS:875  | Code of practice for<br>design loads (other than<br>Canadaearthquake) for buildings<br>and structures<br>Leading standards<br>(issued by Canadian<br>Standard)<br>DIN-1055-1955 (Issued by ASA)                                                                                                                                  |     | National Building<br>code of<br>(1953)-Part-IV<br><br>Design section 4.1            |





|                    |                                                                                                                                   |                                                                                                                                                     |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| IS:1239<br>Part-I  | Mild steel tubes                                                                                                                  | (ISO/R 65-1957)<br>(ISO/R-64-1958)<br>(ISO/R-65-1958)<br>(BS 1387 : 1957)                                                                           |
| IS:1239<br>Part-II | Mild steel tubulars and<br>other wrought steel pipe<br>fittings                                                                   | BS 1387 : 1967<br>BS 1387 :1967<br>BS 1740 :1965                                                                                                    |
| IS:2825            | Code for unfired vessels                                                                                                          |                                                                                                                                                     |
| IS:1520            | Horizontal centrifugal pumps<br>for clear cold and fresh water                                                                    |                                                                                                                                                     |
| IS:1600            | Code for practice for performance<br>of constant speed IC Engines for<br>general purpose                                          |                                                                                                                                                     |
| IS:1601            | Specification for performance of<br>constant speed IC Engines for<br>general Purpose                                              |                                                                                                                                                     |
| IS:1893            | Criteria for earthquake resistant<br>design of structures                                                                         |                                                                                                                                                     |
| IS1978-1971        | Line Pipe<br>April 1969.                                                                                                          | API Standards 5L                                                                                                                                    |
| IS:2254-1970       | Dimensions of vertical<br>shaft motor for pumps                                                                                   | IEC Pub 72-1 part I<br>NEMA Pub MG 1 1954                                                                                                           |
| IS:2266            | Steel wire ropes for<br>general engineering<br>purposes                                                                           | BS :302 : 1968                                                                                                                                      |
| IS:2312            | Propellant type<br>Ventilation fans                                                                                               |                                                                                                                                                     |
| IS:2365            | Steel wire suspension<br>ropes for lifts and hoists                                                                               | BS : 1957                                                                                                                                           |
| IS:3346            | Method for the determination<br>of thermal conductivity of thermal<br>insulation materials (two<br>slab guarded hot plate method) | DIN 52612 (Deutscher<br>Normenausschuss)<br>ASTM C 163-1964<br>(American Society of<br>Testing and materials)<br>ASTM C 167-1974<br>ASTM C 177-1963 |
| IS:3354            | Outline dimensions for electric lifts.                                                                                            |                                                                                                                                                     |
| IS:3401            | Silica gel                                                                                                                        |                                                                                                                                                     |
| IS:3588            | Specification for electrical axial                                                                                                |                                                                                                                                                     |





|                   |                                                                                                                    |                                                                         |
|-------------------|--------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
|                   | flow fans                                                                                                          |                                                                         |
| IS:3589           | Electrically welded steel pipes for water, gas and sewage (200mm to 2000 mm Nominal Diameter)                      |                                                                         |
| IS:3677           | Unbonded rock and slag wool for thermal insulation                                                                 |                                                                         |
| IS:3815           | Point hook with shank for general engineering purposes                                                             | BS 482 - 1968<br>Doc.:67/3 1284<br>(Revision of BS 2903)<br>(Issued BS) |
| IS:3895           | Specification for monocrystallines semiconductor rectifier cells and stacks                                        |                                                                         |
| IS:3963           | Roof extractor unit                                                                                                |                                                                         |
| IS:3975           | Mild steel wires, strips and tapes for armouring cables                                                            |                                                                         |
| IS:4503           | Shell and tube type heat Exchanger                                                                                 |                                                                         |
| IS:4540           | Specification for monocrystallines rectifier assembly equipment                                                    |                                                                         |
| IS:4671           | Expanded polystyrene for thermal insulation purpose                                                                |                                                                         |
| IS:4736           | Hot dip zinc coating on steel tubes                                                                                |                                                                         |
| IS:4894           | Centrifugal fans                                                                                                   |                                                                         |
| IS:5456           | Code of practice for testing of positive displacement type air compressors and exhauster (For Test Tolerance Only) |                                                                         |
| IS:5749           | Forged ramshorn hooks                                                                                              | Entwurf DIN 15402<br>Blett 1<br>Entwurf DIN 15402<br>BS 3017-1958       |
| IS:6392           | Steel pipe flanges                                                                                                 | BS 4504 : 1969                                                          |
| IS:6524<br>Part-I | Code of practice for design of tower cranes Static and rail mounted                                                | BS 2799 : 1956                                                          |
| IS:7098           | Cross linked Polyethylene insulated PVC sheathed                                                                   | Standard No. 1 to<br>IPCEA (USA) Pub.                                   |



|                                  |                                                                                        |
|----------------------------------|----------------------------------------------------------------------------------------|
|                                  | cables No. 5-66-524                                                                    |
| IS:7373                          | Specification for wrought aluminium and aluminium sheet and strips                     |
| IS:7938                          | Air receivers for compressed air installation                                          |
| ISO:1217                         | Displacement compressor-Acceptance test                                                |
| ASHRAE-33                        | Methods of testing for rating of forced circulation air cooling and air heating coils. |
| ASHRAE-52-76                     | Air cleaning device used in general ventilation for removing particle matter.          |
| ASHRAE-22-72                     | Method of testing for rating of water cooled refrigerant condensers.                   |
| ASHRAE 23-67                     | Methods of testing for rating of positive displacement refrigerant compressors.        |
| ARI-450-6                        | Standard for water cooled refrigerant condensers.                                      |
| ARI-550                          | Standard for centrifugal water chilling packages.                                      |
| ARI-410                          | Standard for forced circulation air cooling and air heating coils                      |
| ARI-430/435<br>BS:848 (Part-1,2) | Central station AHU/Application of Central Station AHU Fans                            |
| BS:400                           | Low carbon steel cylinders for the storage & transport of permanent gases.             |
| BS:401                           | Low carbon steel cylinders for the storage & transport of liquefied gases.             |
| CTI Code<br>ACT-105              | Acceptance test code for Water Cooling Tower.                                          |
| ANSI-31.5                        | Refrigerant piping                                                                     |
| ASME-PTC-<br>23-1958             | Atmospheric Water Cooling Equipment                                                    |
| AMCA A-21C                       | Test Code for air moving devices                                                       |
| API:618                          | Reciprocating Compressor for general refinery services.                                |
| HYDRAULIC INSTITUTE STANDARDS.   |                                                                                        |
| HYDRANT SYSTEM MANUALS OF TAC.   |                                                                                        |
| TAC MANUALS OF SPRAY SYSTEM      |                                                                                        |



NFPA USA/ NSC UK/ UL USA/ FM USA STANDARDS.

INDIAN EXPLOSIVES ACT.

INDIAN FACTORIES ACT.

STANDARD OF TUBULAR EXCHANGER MANUFACTURER'S ASSOCIATION.

### CODE AND STANDARD FOR CIVIL WORKS

Some of the applicable Standards, Codes and references are as follows:

#### Excavation & Filling

IS: 2720 (Part-II, IV TO VIII, XIV, XXI, XXIII, XXIV, XXVII TO XXIX, XL) Methods of test for soils-determination for water content etc.

IS: 4701 Code of practice for earth work on canals.

IS: 9758 Guide lines for Dewatering during construction.

IS: 10379 Code of practice for field control of moisture and compaction of soils for embankment and sub-grade.

#### Properties, Storage and Handling of Common Building Materials

IS: 269 Specification for ordinary Portland cement, 33 grade.

IS: 383 Specification for coarse and fine aggregates from natural sources for concrete.

IS: 432 Specification for mild steel and (Parts 1&2) medium tensile steel bars and hard-drawn steel wires for concrete reinforcement.

IS: 455 Specification for Portland slag cement.

IS: 702 Specification for Industrial bitumen.

IS: 712 Specification for building limes.

IS: 808 Rolled steel Beam channel and angle sections.

IS: 1077 Specification for common burnt clay building bricks.

IS: 1161 Specification of steel tubes for structural purposes.

IS: 1363 Hexagon head Bolts, Screws and nuts of production grade C.

IS: 1364 Hexagon head Bolts, Screws and Nuts of Production grade A & B.

IS: 1367 Technical supply conditions for Threaded fasteners.

IS: 1489 Specification for Portland-pozzolana cement:

(Part-I) Fly ash based.



|                               |                                                                            |
|-------------------------------|----------------------------------------------------------------------------|
| (Part-II)                     | Calcined clay based.                                                       |
| IS: 1542                      | Specification for sand for plaster.                                        |
| IS: 1566                      | Specification for hard-drawn steel wire fabric for concrete reinforcement. |
| IS: 1786                      | Specification for high strength deformed bars for concrete reinforcement.  |
| IS: 2062                      | Specification for steel for general structural purposes.                   |
| IS: 2116                      | Specification for sand for masonry mortars.                                |
| IS: 2386<br>(Parts-I to VIII) | Testing of aggregates for concrete.                                        |
| IS: 3150                      | Hexagonal wire netting for general purpose.                                |
| IS: 3495<br>(Parts-I to IV)   | Methods of tests of burnt clay building bricks.                            |
| IS: 3812                      | Specification for fly ash, for use as pozzolana and admixture.             |
| IS: 4031                      | Methods of physical tests for hydraulic cement.                            |
| IS: 4032                      | Methods of chemical analysis of hydraulic cement.                          |
| IS: 4082                      | Recommendations on stacking and storage of construction materials at site. |
| IS: 8112                      | Specification for 43 grade ordinary portland cement.                       |
| IS:8500                       | Medium and high strength structural steel.                                 |
| IS: 12269                     | 53 grade ordinary portland cement.                                         |
| IS: 12894                     | Specification for Fly ash lime bricks.                                     |

**Cast-In-Situ Concrete and Allied Works**

|          |                                                                                                               |
|----------|---------------------------------------------------------------------------------------------------------------|
| IS: 280  | Specification for mild steel wire for general engineering purposes.                                           |
| IS: 456  | Code of practice for plain and reinforced concrete.                                                           |
| IS: 457  | Code of practice for general construction of plain & reinforced concrete for dams & other massive structures. |
| IS: 516  | Method of test for strength of concrete.                                                                      |
| IS: 650  | Specification for standard sand for testing of cement.                                                        |
| IS:1199  | Methods of sampling and analysis of concrete.                                                                 |
| IS: 1791 | General requirements for batch type concrete mixers.                                                          |



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| IS: 1838<br>(Part-I)       | Specification for preformed fillers for expansion joints in concrete pavements and structures (non-extruding and resilient type). |
| IS: 2204                   | Code of practice for construction of reinforced concrete shell roof.                                                              |
| IS: 2210                   | Criteria for the design of reinforced concrete shell structures and folded plates.                                                |
| IS: 2438                   | Specification for roller pan mixer.                                                                                               |
| IS: 2502                   | Code of practice for bending and fixing of bars for concrete reinforcement.                                                       |
| IS: 2505                   | General requirements for concrete vibrators, immersion type.                                                                      |
| IS: 2506                   | General requirements for concrete vibrators, screed board type.                                                                   |
| IS: 2514                   | Specification for concrete vibrating tables.                                                                                      |
| IS: 2645                   | Specification for Integral cement water proofing compounds.                                                                       |
| IS: 2722                   | Specification for portable swing weigh batches for concrete.<br>(single and double bucket type)                                   |
| IS: 2750                   | Specification for Steel scaffolding.                                                                                              |
| IS: 2751                   | Code of practice for welding of mild steel plain and deformed bars for reinforced concrete construction.                          |
| IS: 3025                   | Methods of sampling and test waste water.                                                                                         |
| IS: 3366                   | Specification for Pan vibrators.                                                                                                  |
| IS: 3370<br>(Part I to IV) | Code of practice for concrete structures for the storage of liquids.                                                              |
| IS: 3414                   | Code of practice for design and installation of joints in buildings.                                                              |
| IS: 3550                   | Methods of test for routine control for water used in industry.                                                                   |
| IS: 3558                   | Code of practice for use of immersion vibrators for consolidating concrete.                                                       |
| IS: 4014<br>(Parts I & II) | Code of practice for steel tubular scaffolding.                                                                                   |
| IS: 4326                   | Code of practice for earthquake resistant design and construction of buildings.                                                   |
| IS: 4461                   | Code of practice for joints in surface hydro-electric power stations.                                                             |
| IS: 4656                   | Specification for form vibrators for concrete.                                                                                    |
| IS: 4925                   | Specification for batching and mixing plant.                                                                                      |



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|----------------------------|--------------------------------------------------------------------------------------------------------------|
| IS: 4990                   | Specification for plywood for concrete shuttering work.                                                      |
| IS: 4995<br>(Parts I & II) | Criteria for design of reinforced concrete bins for the storage of granular and powdery materials.           |
| IS: 5256                   | Code or practice for sealing joints in concrete lining on canals.                                            |
| IS: 5525                   | Recommendations for detailing of reinforcement in reinforced concrete work.                                  |
| IS: 5624                   | Specification for foundation bolts.                                                                          |
| IS: 6461                   | Glossary of terms relating to cement concrete.                                                               |
| IS: 6494                   | Code of practice for water proofing of underground water reservoirs and swimming pools.                      |
| IS: 6509                   | Code of practice for installation of joints in concrete pavements.                                           |
| IS: 7861                   | Code of practice for extreme weather concreting. (Parts I & II)                                              |
| IS: 9012                   | Recommended practice for shot concreting.                                                                    |
| IS: 9103                   | Specification for admixtures for concrete.                                                                   |
| IS: 9417                   | Recommendations for welding cold worked steel bars for reinforced concrete construction.                     |
| IS: 10262                  | Recommended guidelines for concrete mix design.                                                              |
| IS: 11384                  | Code of practice for composite construction in structural steel and concrete.                                |
| IS: 11504                  | Criteria for structural design of reinforced concrete natural draught cooling towers.                        |
| IS: 12118                  | Specification for two-parts poly sulphide.                                                                   |
| IS: 12200                  | Code of practice for provision of water stops at transverse contraction joints in masonry and concrete dams. |
| IS: 13311                  | Method of non-destructive testing of concrete.                                                               |
| Part-1                     | Ultrasonic pulse velocity.                                                                                   |
| Part-2                     | Rebound hammer.                                                                                              |
| SP: 23                     | Handbook of concrete mixes                                                                                   |
| SP: 24                     | Explanatory Handbook on IS: 456-1978                                                                         |
| SP: 34                     | Handbook on concrete reinforcement and detailing.                                                            |

### **Precast Concrete Works**

SP: 7(PartVI/Sec.7) National Building Code- Structural design of prefabrication and



1 x 660 MW - Panki Thermal Power Station

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systems building.

IS: 10297 Code of practice for design and construction of floors and roofs using precast reinforced/prestressed concrete ribbed or cored slab units.

IS: 10505 Code of practice for construction of floors and roofs using pre-cast reinforced concrete units.

### Masonry and Allied Works

IS: 1905 Code of Practice for Structural Safety of Buildings-Masonry walls.

IS: 2212 Code of Practice for Brickwork.

IS: 2250 Code of Practice for Preparation and use of Masonry Mortar.

SP: 20 Explanatory hand book on masonry code.

### Sheeting Works

IS:277 Galvanised steel sheets (plain or corrugated).

IS: 459 Unreinforced corrugated and semi-corrugated asbestos cement sheets.

IS: 513 Cold-rolled carbon steel sheets.

IS: 730 Specification for fixing accessories for corrugated sheet roofing.

IS: 1626 Specification for Asbestos cement building pipes and pipe fittings, gutters and gutter fittings and roofing fittings.

IS: 2527 Code of practice for fixing rain water gutters and down pipe for roof drainage.

IS: 3007 Code of practice for laying of asbestos cement sheets.

IS: 5913 Methods of test for asbestos cement products.

IS: 7178 Technical supply conditions for tapping screw.

IS: 8183 Bonded mineral wool.

IS: 8869 Washers for corrugated sheet roofing.

IS: 12093 Code of practice for laying and fixing of sloped roof covering using plain and corrugated galvanised steel sheets.

IS: 12866 Plastic translucent sheets made from thermosetting polyester resin (glass fibre reinforced).

IS: 14246 Specification for continuously pre-painted galvanised steel sheets and coils.



**Fabrication and Erection of Structural Steel Work**

|                        |                                                                                                |
|------------------------|------------------------------------------------------------------------------------------------|
| IS: 2016               | Specification for plain washers.                                                               |
| IS: 814                | Specification for covered Electrodes for Metal Arc Welding for weld steel.                     |
| IS: 1852               | Specification for Rolling and Cutting Tolerances for Hot rolled steel products.                |
| IS: 3502               | Specifications for chequered plate.                                                            |
| IS: 6911               | Specification for stainless steel plate, sheet and strip.                                      |
| IS: 3757               | Specification for high strength structural bolts                                               |
| IS: 6623               | Specification for high strength structural nuts.                                               |
| IS: 6649               | High Tensile friction grip washers.                                                            |
| IS: 800                | Code of practice for use of structural steel in general building construction.                 |
| IS: 816                | Code of practice for use of Metal Arc Welding for General Construction.                        |
| IS: 4000               | Code of practice for assembly of structural joints using high tensile friction grip fasteners. |
| IS: 9595               | Code of procedure of Manual Metal Arc Welding of Mild Steel.                                   |
| IS: 817                | Code of practice for Training and Testing of Metal Arc Welders.                                |
| IS: 1811               | Qualifying tests for Metal Arc Welders (engaged in welding structures other than pipes).       |
| IS: 9178               | Criteria for Design of steel bins for storage of Bulk Materials.                               |
| IS: 9006               | Recommended Practice for Welding of Clad Steel.                                                |
| IS: 7215               | Tolerances for fabrication steel structures.                                                   |
| IS: 12843              | Tolerance for erection of structural steel.                                                    |
| IS: 4353               | Recommendations for submerged arc welding of mild steel and low alloy steels.                  |
| SP: 6<br>(Part 1 to 7) | ISI Hand book for structural Engineers.                                                        |
| IS: 1608               | Method of Tensile Testing of Steel products other than sheets, strip, wire and tube.           |
| IS: 1599               | Method of Bend Tests for Steel products other than sheet, strip, wire and tube                 |





|           |                                                                                                 |
|-----------|-------------------------------------------------------------------------------------------------|
| IS : 228  | Methods of chemical Analysis of pig iron, cast iron and plain carbon and low alloy steel.       |
| IS : 2595 | Code of Practice for Radio graphic testing.                                                     |
| IS : 1182 | Recommended practice for Radiographic Examination of fusion welded butt joints in steel plates. |
| IS : 3664 | Code of practice for Ultra sonic Testing by pulse echo method.                                  |
| IS : 3613 | Acceptance tests for wire flux combination for submerged Arc Welding.                           |
| IS : 3658 | Code of practice for Liquid penetrant Flaw Detection.                                           |
| IS : 5334 | Code of practice for Magnetic Particle Flaw Detection of Welds.                                 |

**Plastering and Allied Works**

|           |                                                                               |
|-----------|-------------------------------------------------------------------------------|
| IS : 1635 | Code of practice for field slaking of Building lime and preparation of putty. |
| IS : 1661 | Application of cement and cement lime plaster finishes.                       |
| IS : 2333 | Plaster-of-paris.                                                             |
| IS : 2402 | Code of practice for external rendered finishes.                              |
| IS : 2547 | Gypsum building plaster.                                                      |
| IS : 3150 | Hexagonal wire netting for general purpose.                                   |

**Acid and Alkali Resistant Lining**

|           |                                                                                           |
|-----------|-------------------------------------------------------------------------------------------|
| IS : 158  | Ready mixed paint, brushing, bituminous, black, lead free, acid, alkali & heat resisting. |
| IS : 412  | Specification for expanded metal steel sheets for general purpose.                        |
| IS : 4441 | Code of practice for use of silicate type chemical resistant mortars.                     |
| IS : 4443 | Code of practice for use of resin type chemical resistant mortars.                        |
| IS : 4456 | Method of test for chemical resistant tiles. (Part I & II)                                |
| IS : 4457 | Specification for ceramic unglazed vitreous acid resistant tiles.                         |
| IS : 4832 | Specification for chemical resistant mortars.                                             |
|           | Part I Silicate type                                                                      |
|           | Part II Resin type                                                                        |
|           | Part III Sulphur type                                                                     |



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| IS : 4860 | Specification for acid resistant bricks.            |
| IS : 9510 | Specification for bitumasitc, Acid resisting grade. |

**Water Supply, Drainage and Sanitation**

|           |                                                                                                |
|-----------|------------------------------------------------------------------------------------------------|
| IS : 458  | Specification for concrete pipes.                                                              |
| IS : 554  | Dimensions for pipe threads, where pressure tight joints are made on thread.                   |
| IS : 651  | Specification for salt glazed stoneware pipes.                                                 |
| IS : 774  | Flushing cisterns for water closets and urinals.                                               |
| IS : 775  | Cast iron brackets and supports for wash basins and sinks.                                     |
| IS : 778  | Copperalloy gate, globe and check valves for water works purposes.                             |
| IS : 781  | Cast copper alloy screw down bib taps and stop valves for water services.                      |
| IS : 782  | Caulking lead.                                                                                 |
| IS : 783  | Code of practice for laying of concrete pipes.                                                 |
| IS : 1172 | Basic requirements for water supply, drainage and sanitation.                                  |
| IS : 1230 | Cast iron rain water pipes and fittings.                                                       |
| IS : 1239 | Mild steel tubes, tubulars and other wrought steel fittings.                                   |
| IS : 1536 | Centrifugally cast (Spun) iron pressure pipes for water, gas and sewage.                       |
| IS : 1537 | Vertically cast iron pressure pipes for water, gas and sewage.                                 |
| IS : 1538 | Cast iron fittings for pressure pipe for water, gas and sewage.                                |
| IS : 1703 | Ball valves (horizontal plunger type) including float for water supply purposes.               |
| IS : 1726 | Cast iron manhole covers and frames.                                                           |
| IS : 1729 | Sand cast iron spigot and socket, soil, water and ventilating pipes, fittings and accessories. |
| IS : 1742 | Code of practice for building drainage.                                                        |
| IS : 1795 | Pillar taps for water supply purposes.                                                         |
| IS : 1879 | Malleable cast iron pipe fittings.                                                             |
| IS : 2064 | Code of practice for selection, installation and maintenance of                                |



|                             |                                                                                                               |
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|                             | sanitary appliances.                                                                                          |
| IS : 2065                   | Code of practice for water supply in building.                                                                |
| IS : 2326                   | Automatic flushing cisterns for urinals.                                                                      |
| IS : 2470<br>(Part-I & II)  | Code of practice for installation of septic tanks.                                                            |
| IS : 2501                   | Copper tubes for general engineering purposes.                                                                |
| IS : 2548                   | Plastic seat and cover for water-closets.                                                                     |
| IS : 2556<br>(Part 1 to 15) | Vitreous sanitary appliances (vitreous china).                                                                |
| IS : 2963                   | Non-ferrous waste fittings for wash basins and sinks.                                                         |
| IS : 3114                   | Code of practice for laying of cast iron pipes.                                                               |
| IS : 3311                   | Waste plug and its accessories for sinks and wash basins.                                                     |
| IS : 3438                   | Silvered glass mirrors for general purposes.                                                                  |
| IS : 3486                   | Cast iron spigot and socket drain pipes.                                                                      |
| IS : 3589                   | Electrically welded steel pipes for water, gas and sewage (200mm to 2000mm nominal diameter).                 |
| IS : 3989                   | Centrifugally cast (Spun) iron spigot and socket soil, waste and ventilating pipes, fittings and accessories. |
| IS : 4111<br>(Part I to IV) | Code of practice for ancillary structure in sewerage system.                                                  |
| IS : 4127                   | Code of practice for laying of glazed stone-ware pipes.                                                       |
| IS : 4764                   | Tolerance limits for sewage effluents discharged into inland-surface waters.                                  |
| IS : 4827                   | Electro plated coating of nickel and chromium on copper and copper alloys.                                    |
| IS : 5329                   | Code of practice for sanitary pipe work above ground for buildings.                                           |
| IS : 5382                   | Rubber sealing rings for gas mains, water mains and sewers.                                                   |
| IS : 5822                   | Code of practice for laying of welded steel pipes for water supply.                                           |
| IS : 5961                   | Cast iron grating for drainage purpose.                                                                       |
| IS : 7740                   | Code of practice for road gullies.                                                                            |
| IS : 8931                   | Cast copper alloy fancy bib taps and stop valves for water services.                                          |



|            |                                                                              |
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| IS : 8934  | Cast copper alloy fancy pillar taps for water services.                      |
| IS : 9762  | Polyethylene floats for ball valves.                                         |
| IS : 10446 | Glossary of terms for water supply and sanitation.                           |
| IS : 10592 | Industrial emergency showers, eye and face fountains and combination units.  |
| IS : 12592 | Specification for precast concrete manhole covers and frames.                |
| IS : 12701 | Rotational moulded polyethylene water storage tanks.                         |
| SP: 35     | Hand book on water supply and drainage.                                      |
| -          | Manual on Sewerage and sewage treatment (Published by CPH & EEO) As updated. |

### **Doors, Windows and Allied Works**

|                          |                                                                                                                          |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------|
| IS : 204                 | Tower Bolts                                                                                                              |
| Part-I                   | Ferrous metals.                                                                                                          |
| Part-II                  | Nonferrous metals.                                                                                                       |
| IS : 208                 | Door Handles.                                                                                                            |
| IS : 281                 | Mild steel sliding door bolts for use with padlocks.                                                                     |
| IS : 362                 | Parliament Hinges.                                                                                                       |
| IS : 420                 | Specification for putty, for use on metal frames.                                                                        |
| IS : 1003<br>Part-I door | Specification for timber panelled and glazed shutters-<br>(Part-I) shutters.                                             |
| IS : 1038                | Steel doors, windows and ventilators.                                                                                    |
| IS : 1081                | Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators.                   |
| IS : 1341                | Steel butt hinges.                                                                                                       |
| IS : 1361                | Steel windows for industrial buildings.                                                                                  |
| IS : 1823                | Floor door stoppers.                                                                                                     |
| IS : 1868                | Anodic coatings on Aluminium and its alloys.                                                                             |
| IS : 2202<br>(Part-II)   | Specification for wooden flush door shutters (solid core type);<br>particle board face panels and hard board face panels |
| IS:2209                  | Mortice locks (vertical type).                                                                                           |



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|-----------|---------------------------------------------------------------|
| IS:2553   | Safety glass                                                  |
| IS:2835   | Flat transparent sheet glass.                                 |
| IS:3548   | Code of practice for glazing in buildings.                    |
| IS:3564   | Door closers (Hydraulically regulated).                       |
| IS : 3614 | Fire check doors; plate, metal covered and rolling type.      |
| IS:4351   | Steel door frames.                                            |
| IS:5187   | Flush bolts.                                                  |
| IS:5437   | Wired and figured glass                                       |
| IS:6248   | Metal rolling shutters and rolling grills.                    |
| IS:6315   | Floor springs (hydraulically regulated) for heavy doors.      |
| IS:7196   | Hold fasts.                                                   |
| IS:7452   | Hot rolled steel sections for doors, windows and ventilators. |
| IS:10019  | Mild steel stays and fasteners.                               |
| IS:10451  | Steel sliding shutters (top hung type).                       |
| IS:10521  | Collapsible gates.                                            |

**Roof Water Proofing and Allied Works**

|         |                                                                                                                     |
|---------|---------------------------------------------------------------------------------------------------------------------|
| IS:1203 | Methods of testing tar and bitumen.                                                                                 |
| IS:1322 | Specification for bitumen felts for water proofing and damp proofing.                                               |
| IS:1346 | Code of practice for water proofing of roofs with bitumen felts.                                                    |
| IS:1580 | Specification for bituminous compound for water proofing and caulking purposes.                                     |
| IS:3067 | Code of practice for general design details and preparatory work for damp proofing and water proofing of buildings. |
| IS:3384 | Specification for bitumen primer for use in water proofing and damp proofing.                                       |

**Floor Finishes and Allied Works**

|         |                                                                              |
|---------|------------------------------------------------------------------------------|
| IS:1237 | Specification for cement concrete flooring tiles.                            |
| IS:1443 | Code of practice for laying and finishing of cement concrete flooring tiles. |
| IS:2114 | Code of practice for laying in-situ terrazzo floor finish.                   |
| IS:2571 | Code of practice for laying in-situ cement concrete flooring.                |



|          |                                                                      |
|----------|----------------------------------------------------------------------|
| IS:3462  | Specification for unbacked flexible PVC flooring.                    |
| IS:4971  | Recommendations for selection of industrial floor finishes.          |
| IS:5318  | Code of practice for laying of flexible PVC sheet and tile flooring. |
| IS:8042  | Specification for white portland cement.                             |
| IS:13801 | Specification for chequered cement concrete flooring tiles.          |

### **Painting and Allied Works**

|         |                                                                                                |
|---------|------------------------------------------------------------------------------------------------|
| IS:162  | Specification for fire resisting silicate type, brushing, for use on wood, colour as required. |
| IS:1477 | Code of practice for painting of ferrous metals in buildings.                                  |
| Part-I  | Pretreatment.                                                                                  |
| Part-II | Painting.                                                                                      |
| IS:1650 | Specification for colours for building and decorative finishes.                                |
| IS:2074 | Specification for red oxide-zinc chrome, priming, ready mixed paint air drying.                |
| IS:2338 | Code of practice for finishing of wood and wood based materials.                               |
| Part-I  | Operations and workmanship                                                                     |
| Part-II | Schedules                                                                                      |
| IS:2395 | Code of practice for painting concrete, masonry and plaster surfaces.                          |
| Part-I  | Operations and workmanship.                                                                    |
| Part-II | Schedule.                                                                                      |
| IS:2524 | Code of practice for painting of nonferrous metals in buildings.                               |
| Part-I  | Pretreatment.                                                                                  |
| Part-II | Painting.                                                                                      |
| IS:2932 | Specification of synthetic enamel paint, exterior, under-coating and finishing.                |
| IS:2933 | Specification enamel paint, under coating and finishing.                                       |
| IS:4759 | Code of practice for hot dip zinc coating on structural steel and other allied products.       |
| IS:5410 | Specification for cement paint                                                                 |



|                     |                                                           |
|---------------------|-----------------------------------------------------------|
| IS:5411<br>(Part-I) | Specification for plastic emulsion paint-for exterior use |
| IS:6278             | Code of practices for white washing and colour washing.   |
| IS:10403            | Glossary of terms relating to building finishes.          |

**Piling and Foundation**

|                          |                                                                                                       |
|--------------------------|-------------------------------------------------------------------------------------------------------|
| IS:1080                  | Code of practice for design and construction of simple spread foundations.                            |
| IS:1904                  | Code of practice for design and construction of foundations in Soils; General Requirements.           |
| IS:2911                  | Code of practice for designs and construction of Pile foundations (Relevant Parts).                   |
| IS:2950<br>(Part-I)      | Code of practice for designs and construction of Raft foundation.                                     |
| IS:2974<br>(Part-I TO V) | Code of practice for design and construction of machine foundations.                                  |
| IS:6403                  | Code of practice for determination of Allowable Bearing pressure on Shallow foundation.               |
| IS:8009                  | Code of practice for calculation of settlement of foundation subjected to symmetrical vertical loads. |
| Part-I                   | Shallow foundations.                                                                                  |
| Part-II                  | Deep foundations.                                                                                     |
| IS:12070                 | Code of practice for design and construction of shallow foundations on rocks.                         |
| DIN:4024                 | Flexible supporting structures for machines with rotating machines.                                   |
| VDI:2056                 | Criteria for assessing mechanical vibrations of machines.                                             |
| VDI:2060                 | Criteria for assessing rotating imbalances in machines. Stop Log and Trash Rack                       |
| IS:4622                  | Recommendations for fixed - wheel gates structural design.                                            |
| IS:5620                  | Recommendations for structural design criteria for low head slide gates.                              |
| IS:11388                 | Recommendations for design of trash rack for intakes.                                                 |
| IS:11855                 | General requirements for rubber seals for hydraulic gates. Roads                                      |
| IRC:5                    | Standard specifications and Code of practice for road bridges, section-I general Features of Design.  |



|                          |                                                                                                                      |
|--------------------------|----------------------------------------------------------------------------------------------------------------------|
| IRC:14                   | Recommended practice of 2cm thick bitumen and tar carpets.                                                           |
| IRC:16                   | Specification for priming of base course with bituminous primers.                                                    |
| IRC:19                   | Standard specifications and code of practice for water bound macadam.                                                |
| IRC:21                   | Standard specifications and Code of practice for road bridges, section-III - Cement concrete (plain and reinforced). |
| IRC:34                   | Recommendations for road construction in waterlogged areas.                                                          |
| IRC:36                   | Recommended practice for the construction of earth embankments for road works.                                       |
| IRC:37                   | Guidelines for the Design of flexible pavements.                                                                     |
| IRC:56                   | Recommended practice for treatment of embankment slopes for erosion control.                                         |
| IRC:73                   | Geometric design standards for rural (non-urban) highways.                                                           |
| IRC:86                   | Geometric Design standards for urban roads in plains.                                                                |
| IRC:SP:13                | Guidelines for the design of small bridges & culverts.                                                               |
| IRC - Publication        | Ministry of Surface Transport (Roads Wing), Specifications for road and bridge works.                                |
| IS:73                    | Specification for paving bitumen                                                                                     |
| <b>Loadings</b>          |                                                                                                                      |
| IS:875<br>(Pt. I to V)   | Code of practice for design loads other than earthquake) for buildings and structures.                               |
| IS:1893                  | Criteria for earthquake resistant design of structures.                                                              |
| IS:4091                  | Code of Practice for design and construction of foundation for transmission line towers & poles.                     |
| IRC:6                    | Standard specifications & code of practice for road bridges, Section-II Loads and stresses.                          |
| M.O.T.                   | Deptt. of railways Bridge Rules.                                                                                     |
| <b>Safety</b>            |                                                                                                                      |
| IS:3696<br>(Part I & II) | Safety code for scaffolds and ladders.                                                                               |
| IS:3764                  | Safety code for excavation work.                                                                                     |
| IS:4081                  | Safety code for blasting and related drilling operations.                                                            |
| IS:4130                  | Safety code for demolition of buildings.                                                                             |





|          |                                                                         |
|----------|-------------------------------------------------------------------------|
| IS:5121  | Safety code for piling and other deep foundations.                      |
| IS:5916  | Safety code for construction involving use of hot bituminous materials. |
| IS:7205  | Safety code for erection on structural steelwork.                       |
| IS:7293  | Safety code for working with construction machinery.                    |
| IS:7969  | Safety code for handling and storage of building materials              |
| IS:11769 | Guidelines for safe use of products containing asbestos.                |
| -        | Indian Explosives Act. 1940 as updated.                                 |

**Architectural design of buildings**

|       |                                                                                     |
|-------|-------------------------------------------------------------------------------------|
| SP:7  | National Building Code of India                                                     |
| SP:41 | Hand book on functional requirements of buildings (other than industrial buildings) |

**Miscellaneous**

|          |                                                                                                                     |
|----------|---------------------------------------------------------------------------------------------------------------------|
| IS:802   | Code of practice for use of structural steel in (Relevant parts) overhead transmission line towers.                 |
| IS:803   | Code of practice for design, fabrication and erection of vertical mild steel cylindrically welded in storage tanks. |
| IS:10430 | Criteria for design of lined canals and liner for selection of type of lining.                                      |
| IS:11592 | Code of practice for selection and design of belt conveyors.                                                        |
| IS:12867 | PVC handrails covers.                                                                                               |
| CIRIA    | Design and construction of buried thin-wall pipes. Publication                                                      |

**REFERENCE CODES AND STANDARDS FOR CONTROL AND INSTRUMENTATION**

The design, manufacture, inspection, testing & installation of all equipment and system covered under this specification shall conform to the latest editions of codes and standards mentioned below and all other applicable VDE, IEEE, ANSI, ASME, NEC, NEMA, ISA AND Indian Standards and their equivalents.

**Temperature Measurements**

1. Instrument and apparatus for temperature measurement - ASME PTC 19.3 (1974).
2. Temperature measurement - Thermocouples ANSI MC 96.1 - 1982.
3. Temperature measurement by electrical Resistance thermometers - IS:2806.
4. Thermometer - element - Platinum resistance - IS:2848.

**Pressure Measurements**

1. a) Instruments and apparatus for pressure measurement - ASME PTC 19.2 (1964).



- b) Electronic transmitters BS:6447.
- 2. Bourdon tube pressure and vacuum gauges - IS:3624 - 1966.
- 3. Process operated switch devices (Pr. Switch) BS-6134.

**Flow Measurements**

Instruments and apparatus for flow measurements - ASME PTC 19.5 (1972) Interim supplement, Part-II.

Measurement of fluid flow in closed conduits - BS-1042.

**Electronic Measuring Instrument & Control Hardware/ Software**

1. Automatic null balancing electrical measuring instruments - ANSI C 39.4 (Rev. 1973): IS:9319.
2. Safety requirements for electrical and electronic measuring and controlling instrument - ANSI C 39.5 - 1974.
3. Compatability of analog signals for electronic industrial process instruments - ISA - S 50.1 (1982) ANSI MC 12.1 - 1975.
4. Dynamic response testing of process control instrumentation ISA - S 26 (1968).
5. Surge Withstand Capability (SWC) tests - ANSI C 37.90 a/IEEE-472 or suitable class of IEC-255-4 equivalent to ANSI C37.90a/IEEE-472.
6. Printed circuit boards - IPC TM - 650, IEC 326 C.
7. General requirement and tests for printed wiring boards - IS 7405 (Part-I) 1973.
8. Edge socket connectors - IEC 130-11.
9. Requirements and methods of testing of wire wrap terminations DIN 41611 Part-2.
10. Dimensions of attachment plugs & receptacles - ANSI C 73 - 1973 (Supplement ANSI C 73 a - 1980).
11. Direct acting electrical indicating instrument - IS:1248 - 1968 (R).
12. Standard Digital Interface for Programmable Instrumentation - IEEE-488.2 - 1990.
13. Information Processing Systems - Local Area Networks - Part 2 : Logical Link Control - IEEE-802.2 - 1989.
14. Standard for Local Area Networks : Carrier Sense Multiple Access with Collision Detection - IEEE-802.3 - 1985.
15. Supplements A, B, C and E to Carrier Sense Multiple Access with Collision Detection - IEEE-802.3 - 1988.



16. Standard for Local Area Networks : Token - Passing Bus Access Method - IEEE-802.4 - 1985.
17. Standard for Local Area Networks : Token - Ring Access Method and Physical Layer Specification - IEEE-802.5 - 1985.
18. IEEE Guide to Software Requirements Specifications - IEEE-830 - 1984.
19. Hardware Testing of Digital Process Computers - ISA RP55.1 - 1983.
20. Electromagnetic Susceptibility of Process Control Instrumentation - SAMA PMC 33.1 - 1978.
21. Interface Between the Data Terminal Equipment and Data Circuit - Terminating Equipment Employing Serial Binary Data Interchange - EIA-232- D-1987.
22. Electromagnetic Compatibility for Industrial Process Measurement and Control Equipment, Part 3 : Radiated Electromagnetic Field Requirements - IEC 801-3-1984.

**Instrument Switches and Contact**

1. Contact rating - AC services NEMA ICS 2 - 1978 (with revision through May 1983), Part - 2-125, A6000.
2. Contact rating - DC services NEMA ICS 2-1978 Part-2 125, N600.

**Enclosures**

1. Type of Enclosures - NEMA ICS Part - 6 - 1978 (with Rev. 1 4/80) through 110.22 (Type 4 to 13).
2. Racks, panels and associated equipment - EIA : RS - 310 C- 1983 (ANSI C 83.9 - 1972).
3. Protection class for Enclosures, cabinets, control panels & desks - IS:2147 - 1962.

**Apparatus, enclosures and installation practices in hazardous area**

1. Classification of hazardous area - NFPA 70 - 1984, Article 500.
2. Electrical Instruments in hazardous dust location - ISA - 512.11, 1973.
3. Intrinsically safe apparatus - NFPA 493 1978.
4. Purged and pressurised enclosure for electrical equipment in hazardous location - NFPA 496-1982.
5. Enclosures for Industrial Controls and Systems - NEMA IS 1.1 - 1977.

**Sampling System**

1. Stainless steel material of tubing and valves for sampling system - ASTM A 296-82, Grade 7 P 316.
2. Submerged helical coil heat exchangers for sample coolers ASTM D11 92-1977.



3. Water and steam in power cycle - ASME PTC 19.11.
4. Standard methods of sampling system - ASTM D 1066-99.

**Annunciators**

1. Specifications and guides for the use of general purpose annunciators - ISA S 19.1, 1979.
2. Surge withstand capability tests - ANSI C 37.90a - 1989/IEEE-472 or suitable class of IEC 255-4 equivalent to ANSI C37.90a 1989/IEEE-472
3. Damp heat cycling test - IS:2106
4. Specification for Electromagnetic Susceptibility - SAMA DMC 33, 1/78

**Protections**

1. Relays and relay system associated with electric power apparatus. ANSI C 37.90, 1 - 1989.
2. General requirements & tests for switching devices for control and auxiliary circuits including contactor relays - IS:6875 (Part-I) - 1973.
3. Turbine water damage prevention - ASME TDP-1-1980.
4. Boiler safety interlocks - NFPA Section 85 B - 1984, 85 C - 1991.

**UPS System**

1. Practices and requirements for semi-conductor power rectifiers - ANSI C 34.2, 1973.
2. Relays and relays system associated with electrical power apparatus - ANSI C 3.90 - 1983.
3. Surge withstand capability test - ANSI C 37.90 1 -1989.
4. Performance testing of UPS - IEC 146.
5. Stationary cells & Batteries Lead Acid type (with tubular positive plates) specification IS-1651-1991.
6. Recommended practice for sizing large lead storage batteries for generating stations & sub-stations - IEEE-485-1985.
7. Printed Circuit Board - IPC TM 650, IEC 326C.
8. General Requirements & tests for printed wiring boards, IS:7405 (Part-I) 1973.

**Control Valves**

1. Control valve sizing - Compressible & Incompressible fluids - ISA S 75.01-1985.
2. Face to face dimensions of control valves - ANSI B 16.00 - 1973.
3. ISA Hand Book of Control Valves - (ISBN : B: 1047-087664-234-2).



4. Codes for pressure piping - ANSI B 31.1
5. Control Valve leak class - ISA RP 39.6

**Process Connection & Piping**

1. Codes for pressure piping "power piping" - ANSI B 31.1.
2. Seamless carbon steel pipe ASTM - A - 106.
3. Forged & Rolled Alloy steel pipe flanges, forged fittings and valves and parts - ASTM - A - 182.
4. Material for socket welded fittings - ASTM - A - 105.
5. Seamless ferritic alloy steel pipe - ASTM - A - 335.
6. Pipe fittings of wrought carbon steel and alloy steel - ASTM - A - 234.
7. Composition bronze of metal castings - ASTM - B - 62.
8. Seamless Copper tube, bright annealed - ASTM - B - 168.
9. Seamless copper tube - ASTM - B - 75.
10. Dimension of fittings - ANSI - B - 16.11.
11. Valves flanged and butt welding ends - ANSI - B - 16.34.

**Instrument Tubing**

1. Seamless carbon steel pipe - ASTM - A 106.
2. Material of socketweld fittings - ASTM - A105.
3. Dimensions of fittings - ANSI - B - 16.11.
4. Code for pressure piping, welding, hydrostatic testing - ANSI B 31.1.

**Cables**

1. Thermocouples extension wires/cables - ANSI MC 96.1 - 1992.
2. Requirements for copper conductor-Wiring cables for telecommunications & information processing system - VDE:0815.
3. Colour coding of single or multi-pair cables - ICEA - S - 61-402 (third edition) NEMA WCS - 1979 with revisions thorough 2/83.
4. Insulation & Sheathing compounds for cables : VDE 0207 (Part-4, 5 & 6).
5. Guide design and installation of cable systems in power generating stations ( insulation, jacket materials) - IEEE Std. 422-1977.
6. Rules for Testing insulated cables and flexible cables : VVDE - 0472
7. Requirements of vertical flame propagation test - IEEE 383 - 1974 (R 1980)
8. Standard specification for tinned soft or annealed copper wire for electrical purpose



- ASTM B-33-81.
- 9. Oxygen index and temperature index test - ASTM D - 2863.
- 10. Smoke density measurement test - ASTM D - 2843.
- 11. Acid gas generation test - IEC - 754 - 1.
- 12. Swedish Chimney test - SEN - 4241475 (F3).
- 13. Teflon (FEP) insulation & sheath test - ASTM D - 2116.
- 14. Thermocouple compensating cables - Testing requirements & sampling plan IS:8784.
- 15. PVC insulated electric cables for working voltage upto and including 1100 V - IS:1554 (Part-I).

**Cable Trays, Conduits**

1. Guide for design and installation of cable systems in power generating station (Cable trays, support systems, conduits) - IEEE Std. 422, 1977, NEMA VE-1 1979, NFPA 70-1984.
2. -do- Test Standards. NEMA VE-1-1979.
3. Zinc coating "hot dip" on assembled products for galvanising of carbon steel cable trays - ASTM A - 386-78.

**Public Address System**

1. Specifications for loud speakers - IS:7741 (Part-I, II and III)
2. Code of safety requirement for electric mains operated audio amplifiers - IS:1301
3. Specification for Public Address Amplifiers - IS:10426.
4. Code of practice for outdoor installation of PA system - IS:1982.
5. Code of practice for installation for indoor amplifying and sound distribution system - IS:1881.
6. Basic environmental testing procedures for electronic and electrical items - IS:9000.
7. Characteristics and methods of measurements for sound system equipment - IS:9302
8. Code of practice of electrical wiring installations (System voltage not exceeding 650 volts) - IS:732
9. Rigid steel conduits for electric wiring - IS:9537 (Part-I and II)
10. Fittings for rigid steel conduits for electrical wiring - IS:2667
11. Degree of protection provided by enclosure for low voltage switchgear and control gear - IS:2147.



**Vibration Monitoring System**

1. API 670 - 1994
2. BS : 4675 Part-2

## ANNEXURE-I

| MFGR.'s<br>LOGO                                                                                                                                                                                                                                                                                                                                                              |  | MANUFACTURER'S NAME<br>AND ADDRESS |  | MANUFACTURING QUALITY PLAN                                             |  |           |         |                     |                       | PROJECT :           |                  |       |                     |                           |                     |                        |        |         |       |                                                                                                                                |         |              |               |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|------------------------------------|--|------------------------------------------------------------------------|--|-----------|---------|---------------------|-----------------------|---------------------|------------------|-------|---------------------|---------------------------|---------------------|------------------------|--------|---------|-------|--------------------------------------------------------------------------------------------------------------------------------|---------|--------------|---------------|
|                                                                                                                                                                                                                                                                                                                                                                              |  |                                    |  | SUB-SYSTEM:                                                            |  | ITEM :    |         | ACCEPTANCE<br>NORMS | REFERENCE<br>DOCUMENT | QUANTUM<br>OF CHECK | TYPE OF<br>CHECK | CLASS | CHARACTERI<br>STICS | COMPONENT &<br>OPERATIONS | CHARACTE<br>RISTICS | FORMAT<br>OF<br>RECORD | AGENCY | REMARKS |       |                                                                                                                                |         |              |               |
|                                                                                                                                                                                                                                                                                                                                                                              |  |                                    |  |                                                                        |  | Q.P. NO.: | REV.NO: |                     |                       |                     |                  |       |                     |                           |                     |                        |        |         | DATE: | PAGE: ... OF....                                                                                                               | PACKAGE | CONTRACT NO. | MAIN-SUPPLIER |
| 1.                                                                                                                                                                                                                                                                                                                                                                           |  | 2.                                 |  | 3.                                                                     |  | 4.        |         | 5.                  |                       | 6.                  |                  | 7.    |                     | 8.                        |                     | 9.                     |        | 10.     |       | 11.                                                                                                                            |         |              |               |
| <p><b>LEGEND:</b> * RECORDS, IDENTIFIED WITH "TICK" ( ✓ ) SHALL BE ESSENTIALLY INCLUDED BY SUPPLIER IN QA DOCUMENTATION. ** <b>M:</b> MANUFACTURER/SUB-SUPPLIER <b>C:</b> SUPPLIER/NOMINATED INSPECTION AGENCY, <b>N:</b> THE OWNER <b>P:</b> PERFORM <b>W:</b> WITNESS AND <b>V:</b> VERIFICATION. AS APPROPRIATE, <b>CHP:</b> THE OWNER SHALL IDENTIFIED IN COLUMN "N"</p> |  |                                    |  |                                                                        |  |           |         |                     |                       |                     |                  |       |                     |                           |                     |                        |        |         |       | <b>DOC. NO.:</b><br> <b>REV..... CAT.....</b> |         |              |               |
| MANUFACTURER/<br>SUB-SUPPLIER                                                                                                                                                                                                                                                                                                                                                |  | MAIN-SUPPLIER                      |  | FOR THE OWNER USE                                                      |  |           |         |                     |                       |                     |                  |       |                     |                           |                     |                        |        |         |       |                                                                                                                                |         |              |               |
| SIGNATURE                                                                                                                                                                                                                                                                                                                                                                    |  |                                    |  | <div>REVIEWED BY</div> <div>APPROVED BY</div> <div>APPROVAL SEAL</div> |  |           |         |                     |                       |                     |                  |       |                     |                           |                     |                        |        |         |       |                                                                                                                                |         |              |               |





ANNEXURE-II

| SUPPLIER'S LOGO                                                                                                                                                                                                                                                                                                                                                                                                                       |                        | SUPPLIER'S NAME AND ADDRESS   |                 | FIELD QUALITY PLAN       |                  |                    |                  |                    |         | PROJECT :<br>PACKAGE :<br>CONTRACT NO. :<br>MAIN-SUPPLIER:                        |  |                              |  |       |  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|-------------------------------|-----------------|--------------------------|------------------|--------------------|------------------|--------------------|---------|-----------------------------------------------------------------------------------|--|------------------------------|--|-------|--|
|                                                                                                                                                                                                                                                                                                                                                                                                                                       |                        |                               |                 | ITEM :                   |                  | QP NO.:            |                  | REV.NO.:           |         |                                                                                   |  |                              |  | DATE: |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                       |                        |                               |                 | SUB-SYSTEM :             |                  | PAGE: .... OF....  |                  |                    |         |                                                                                   |  |                              |  |       |  |
| S. NO                                                                                                                                                                                                                                                                                                                                                                                                                                 | ACTIVITY AND OPERATION | Characteristics / instruments | CLASS# OF CHECK | TYPE OF CHECK            | QUANTUM OF CHECK | REFERENCE DOCUMENT | ACCEPTANCE NORMS | FORMAT OF RECORD   | REMARKS |                                                                                   |  |                              |  |       |  |
| 1.                                                                                                                                                                                                                                                                                                                                                                                                                                    | 2.                     | 3.                            | 4.              | 5.                       | 6.               | 7.                 | 8.               | 9.                 | 10.     |                                                                                   |  |                              |  |       |  |
| <p><b>LEGEND: * RECORDS, IDENTIFIED WITH "TICK" (✓) SHALL BE ESSENTIALLY INCLUDED BY SUPPLIER IN QA DOCUMENTATION.</b></p> <p><b>LEGEND TO BE USED: CLASS #: A = CRITICAL, B=MAJOR, C=MINOR;</b></p> <p><b>'A'</b> SHALL BE WITNESSED BY THE OWNER FQA, <b>'B'</b> SHALL BE WITNESSED BY OWNER'S ERECTION / CONSTRUCTION DEPTT. AND <b>'C'</b> SHALL BE WITNESSED BY ERECTION SUPPLIER (A &amp; B CHECK SHALL BE OWNER CHP STAGE)</p> |                        |                               |                 |                          |                  |                    |                  |                    |         |  |  | <b>DOC. NO.:</b><br>REV..... |  |       |  |
| <b>MANUFACTURER/ SUB-SUPPLIER SIGNATURE</b>                                                                                                                                                                                                                                                                                                                                                                                           |                        | <b>MAIN-SUPPLIER</b>          |                 | <b>FOR THE OWNER USE</b> |                  | <b>REVIEWED BY</b> |                  | <b>APPROVED BY</b> |         | <b>APPROVAL SEAL</b>                                                              |  |                              |  |       |  |



## ANNEXURE-III

| Project Package Supplier Bidder No.                                                                                                                                                                                                |      | Stage :        |        | LIST OF ITEMS REQUIRING QUALITY PLAN AND SUB-SUPPLIER APPROVAL |                       |       |                                          | DOC. NO.:                                |         |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|----------------|--------|----------------------------------------------------------------|-----------------------|-------|------------------------------------------|------------------------------------------|---------|
|                                                                                                                                                                                                                                    |      |                |        |                                                                |                       |       |                                          | REV. NO.:                                |         |
|                                                                                                                                                                                                                                    |      |                |        |                                                                |                       |       |                                          | DATE :                                   |         |
|                                                                                                                                                                                                                                    |      |                |        | SUB-SYSTEM:                                                    |                       |       |                                          | PAGE : OF                                |         |
| S. N.                                                                                                                                                                                                                              | Item | QP/ Insp. Cat. | QP No. | QP Sub. Schedule                                               | Proposed sub-supplier | Place | Sub-suppliers approval status / category | Sub-supplier Details submission schedule | Remarks |
|                                                                                                                                                                                                                                    |      |                |        |                                                                |                       |       |                                          |                                          |         |
|                                                                                                                                                                                                                                    |      |                |        |                                                                |                       |       |                                          |                                          |         |
|                                                                                                                                                                                                                                    |      |                |        |                                                                |                       |       |                                          |                                          |         |
| <b>LEGENDS</b>                                                                                                                                                                                                                     |      |                |        |                                                                |                       |       |                                          |                                          |         |
| <b>1. SYSTEM SUPPLIER/SUB-SUPPLIER APPROVAL STATUS CATEGORY (SHALL BE FILLED BY the Owner)</b>                                                                                                                                     |      |                |        |                                                                |                       |       |                                          |                                          |         |
| <b>A</b> – For these items proposed vendor is acceptable to the Owner. To be indicated with letter “A” in the list alongwith the condition of approval, if any.                                                                    |      |                |        |                                                                |                       |       |                                          |                                          |         |
| <b>DR</b> – For these items “Detailed required” for the Owner review. To be identified with letter “DR” in the list.                                                                                                               |      |                |        |                                                                |                       |       |                                          |                                          |         |
| <b>NOTED</b> – For these items vendors are approved by Main Supplier and accepted by the Owner without specific vendor approval from the Owner. To be identified with “NOTED.”                                                     |      |                |        |                                                                |                       |       |                                          |                                          |         |
| <b>2. QP/INSPN CATEGORY :</b>                                                                                                                                                                                                      |      |                |        |                                                                |                       |       |                                          |                                          |         |
| <b>CAT-I:</b> For these items the Quality Plans are approved by the Owner and the final acceptance will be on physical inspection witness by the Owner.                                                                            |      |                |        |                                                                |                       |       |                                          |                                          |         |
| <b>CAT-II:</b> For these items the Quality Plans approved by the Owner. However no physical inspection shall be done by the Owner. The final acceptance by the Owner shall be on the basis review of documents as per approved QP. |      |                |        |                                                                |                       |       |                                          |                                          |         |
| <b>CAT-III:</b> For these items Main Supplier approves the Quality Plans. The final acceptance by the Owner shall be on the basis certificate of conformance by the main supplier.                                                 |      |                |        |                                                                |                       |       |                                          |                                          |         |
| <b>UNITS/WORKS:</b> Place of manufacturing Place of Main Supplier of multi units/works.                                                                                                                                            |      |                |        |                                                                |                       |       |                                          |                                          |         |



[illegible]

ANNEXURE-V

| Project Bidder System |                                                   | : Stage :                      |             | FIELD WELDING SCHEDULE<br>(To be raised by the Bidder) |                    |              |                        | DOC. NO.: |               |                |              |                    |          |               |         |
|-----------------------|---------------------------------------------------|--------------------------------|-------------|--------------------------------------------------------|--------------------|--------------|------------------------|-----------|---------------|----------------|--------------|--------------------|----------|---------------|---------|
| Bidder No.            |                                                   | :                              |             | Welding Code: .....                                    |                    |              |                        | REV. NO.: |               |                |              |                    |          |               |         |
| System                |                                                   | :                              |             |                                                        |                    |              |                        | DATE :    |               |                |              |                    |          |               |         |
|                       |                                                   |                                |             |                                                        |                    |              |                        | PAGE : OF |               |                |              |                    |          |               |         |
| Sl. No.               | DRG No. for Weld Location and Identification mark | Description of parts to welded | Matl. Spec. | Dimensions                                             | Process of welding | Type of Weld | Electrode filler spec. | WPS. No.  | Min. pre-heat | Heat treatment |              | NDT method/Quantum | REF      |               | Remarks |
|                       |                                                   |                                |             |                                                        |                    |              |                        |           |               | Temp.          | Holding time |                    | Spec No. | ACC Norm Ref. |         |
|                       |                                                   |                                |             |                                                        |                    |              |                        |           |               |                |              |                    |          |               |         |
| <b>NOTES:</b>         |                                                   |                                |             |                                                        |                    |              |                        |           |               |                |              |                    |          |               |         |
| <b>SIGNATURE</b>      |                                                   |                                |             |                                                        |                    |              |                        |           |               |                |              |                    |          |               |         |
|                       |                                                   |                                |             |                                                        |                    |              |                        |           |               |                |              |                    |          |               |         |



**ANNEXURE-VI**  
**DOCUMENTS DISTRIBUTION SCHEDULE**

| S.No. | Description of Document                                                                                                                       | DESEIN |          |      |    | UPRVUNL |          |      |          |
|-------|-----------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|------|----|---------|----------|------|----------|
|       |                                                                                                                                               | HO     |          | SITE |    | HO      |          | SITE |          |
|       |                                                                                                                                               | HC     | CC       | HC   | CC | HC      | CC       | HC   | CC       |
| 1.    | Drawings, Data Sheets, Calculation, all equipment / Instrument Schedule, BOM etc.<br>a) For Approval<br>b) Resubmission<br>c) For Information | 6*     | 1        | -    | -  | 2       | 1        | -    | -        |
| 2.    | Final Approved Documents                                                                                                                      | 2      | 1 + 1 CD | 1    | 1  | 1       | 1 + 2 CD | 4    | 1 + 1 CD |
| 3.    | Drawings / Documents 'As Built'                                                                                                               | 2      | 1 + 1 CD | 1    | 1  | 2       | 1 + 2 CD | 4    | 1 + 1 CD |
| 4.    | Type Test Reports (Initial)                                                                                                                   | 4*     | 1 + 1 CD | -    | -  | 2       | 1 + 2 CD | -    | -        |
| 5.    | Type Test Report (Final)                                                                                                                      | 2      | 1 + 1 CD | 1    | 1  | 2       | 1 + 2 CD | 4    | 1 + 1 CD |
| 6.    | Piping / Equipment Analysis (Transient) etc., Model Study Report (Draft) including Input / Output date etc.                                   | 4*     | 1        | -    | -  | 2       | 1 + 1 CD | -    | -        |
| 7.    | Piping / equipment Analysis (Transient) etc. Model Study Report (Final Approval) including Input / Output date                                | 2      | 1 + 1 CD | -    | -  | 2       | 1 + 2 CD | 2    | 1 + 1 CD |
| 8.    | Erection Manual (Draft)                                                                                                                       | 3*     | 1CD      | -    | -  | 1       | 1CD      | -    | -        |



| S.No. | Description of Document                                                                | DESEIN |          |      |    |    |    | UPRVUNL |          |      |          |      |          |
|-------|----------------------------------------------------------------------------------------|--------|----------|------|----|----|----|---------|----------|------|----------|------|----------|
|       |                                                                                        | HO     |          | SITE |    | HO |    | HO      |          | SITE |          | SITE |          |
|       |                                                                                        | HC     | CC       | HC   | CC | HC | CC | HC      | CC       | HC   | CC       | HC   | CC       |
| 9.    | Erection Manual 'Final'                                                                | 1      | 1CD      | 1    | -  | 1  | -  | 1       | 1CD      | 2    | 1CD      | 2    | 1CD      |
| 10.   | O&M Manual 'Draft'                                                                     | 3*     | 1CD      | +    | -  | 1  | -  | 1       | 1CD      | -    | -        | -    | -        |
| 11.   | O&M Manual 'Final'                                                                     | 1      | 1CD      | 1    | -  | 1  | -  | 1       | 1CD      | 2    | 1CD      | 2    | 2CD      |
| 12.   | Commissioning Procedure 'Draft'                                                        | 3*     | 1CD      | -    | -  | 1  | -  | 1       | 1CD      | -    | -        | -    | -        |
| 13.   | Commissioning Procedure 'Final'                                                        | 1      | 1CC      | 1    | -  | 1  | -  | 1       | 1CD      | 2    | 1CD      | 2    | 1CD      |
| 14.   | PG Test Procedure "Draft"                                                              | 3*     | 1        | -    | -  | 1  | -  | 1       | 1        | -    | -        | -    | -        |
| 15.   | PG Test Procedure 'Final'                                                              | 1      | 1 + 1 CD | 1    | -  | 2  | -  | 2       | 1 + 1 CD | 2    | 1 + 1 CD | 2    | 1 + 1 CD |
| 16.   | Progress Report                                                                        | 3      | 1CD      | 1    | -  | 2  | -  | 2       | 1CD      | 1    | 1CD      | 1    | 1CD      |
| 17.   | PG Test Report for Approval                                                            | 4*     | 1        | -    | -  | 2  | -  | 2       | 1 + 1 CD | -    | -        | -    | -        |
| 18.   | Approved PG Test Report                                                                | 1      | 1 + 1 CD | 1    | -  | 2  | -  | 2       | 1 + 1 CD | 4    | 1 + 1 CD | 4    | 1 CD     |
| 19.   | Project Completion Report                                                              | 1      | 1 + 1 CD | 1    | -  | 1  | -  | 1       | 1CD      | 1    | 1CD      | 1    | 1CD      |
| 20.   | Vendor Details in respect of proposed vendors including Contractor's evaluation Report | 1      | 1CD      | -    | -  | 1  | -  | 1       | 1CD      | -    | -        | -    | -        |
| 21.   | Monthly Vendor / QP Approval Status                                                    | 1      | 1        | -    | -  | 2  | -  | 2       | 1        | 1    | 1        | 1    | 1        |
| 22.   | Manufacturing QPs, Field QPs for review / comments                                     | 6*     | 1        | -    | -  | 2  | -  | 2       | 1CD      | -    | -        | -    | -        |
| 23.   | Manufacturing QPs, Field QP, Final                                                     | 1      | 1CD      | 1    | -  | 2  | -  | 2       | 1CD      | 2    | 1CD      | 2    | 1CD      |
| 24.   | QA documents Package for equipment / field activities etc.                             | 1      | 1CD      | 1    | -  | 1  | -  | 1       | 1CD      | 1    | 1CD      | 1    | 1CD      |



- \* -
- HC -
- CC -
- CD -
- HO -

Consultant will return one (1) commented document to Vendor and CE (UPRVUNL), Lucknow  
Hard Copy  
Soft Copy thru e-mail  
CD ROM  
Head Office of Consultant / UPRVUNL



| PRODUCT         | AREAS OF TRAINING REQUIREMENT                                                                                                                                                                                  |                                                   |                                                           | Operation & Maintenance Of Plant                                                                         |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|-----------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
|                 | Product Design                                                                                                                                                                                                 | Plant Visit                                       | Visit To Manufacturer's Work                              |                                                                                                          |
| STEAM GENERATOR | Thermal design and hydraulic circulation balance                                                                                                                                                               | Familiarization with various system and equipment | Manufacturing processes of pressure parts, and equipments | Control philosophy operation, notices, logic & protection schemes, O&M manual familiarization O&M issues |
|                 | Combustion and Air & gas weight calculation                                                                                                                                                                    | Performance data collection analysis and review   | Welding process                                           |                                                                                                          |
|                 | Pressure part calculation                                                                                                                                                                                      | O&M feed back                                     | Testing facilities                                        | Familiarization of special maintenance techniques.                                                       |
|                 | Pressure part and strength calculation                                                                                                                                                                         | Operation history of various equipment and system | Product development in process                            | Special tool and tackles familiarization                                                                 |
|                 | Tube metal temp. Calculation and selection.                                                                                                                                                                    | Failure analysis                                  | Future plan for technology induction                      |                                                                                                          |
|                 | Performance calculation                                                                                                                                                                                        |                                                   | R&D work in-progress                                      |                                                                                                          |
|                 | Duct design.                                                                                                                                                                                                   |                                                   |                                                           |                                                                                                          |
|                 | Pressure part                                                                                                                                                                                                  |                                                   |                                                           |                                                                                                          |
|                 | Equipment and system sizing and selection of mills, fans, airpreheater, soot blowers, dampers, valves heater, soot blowers, dampers, valves, feeders, burners start-up system, fuel firing system, draft plant |                                                   |                                                           |                                                                                                          |
|                 | Flow scheme development of air & flue gas, fuel oil, auxiliary steam, main and reheat steam feed water.                                                                                                        |                                                   |                                                           |                                                                                                          |





## ANNEXURE-VII

| PRODUCT                                                  | AREAS OF TRAINING REQUIREMENT                                                                                                                                                                                                                                                                                  |             |                                 | Operation & Maintenance<br>Of Plant |
|----------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|---------------------------------|-------------------------------------|
|                                                          | Product Design                                                                                                                                                                                                                                                                                                 | Plant Visit | Visit To<br>Manufacturer's Work |                                     |
|                                                          | Layout of overall plant, steam generator area, pressure part arrangements, platforms, equipment, piping and duct, coal pipe, flue gas ducts, bunker arrangement, valves and damper, ESP area, cable & piping tressels etc.<br>Erection strategies, erection procedures<br>Performance and demonstration tests. |             |                                 |                                     |
| <b>MANDAYS</b>                                           | <b>120</b>                                                                                                                                                                                                                                                                                                     | <b>20</b>   | <b>20</b>                       | <b>20</b>                           |
| CFD model development and validation for Steam Generator | Familiarisation of fundamentals and basis for the development of the CFD models.                                                                                                                                                                                                                               |             |                                 |                                     |
|                                                          | Solving of set of simple problems by Owner's engineers with the help of trainer.                                                                                                                                                                                                                               |             |                                 |                                     |
|                                                          | Hands on experience on the development of detailed/realistic CFD models for the steam generator and ESP. The Bidder/trainer shall develop CFD models for SG & ESPs per the Contract requirement with complete association of the Owner's engineers.                                                            |             |                                 |                                     |
|                                                          | Validation of the above CFD model for SG & ESP by Bidder in association with the Owner's Engineers.                                                                                                                                                                                                            |             |                                 |                                     |
| <b>MANDAYS</b>                                           | <b>120 for SG and 60 for ESP</b>                                                                                                                                                                                                                                                                               | <b>-</b>    | <b>-</b>                        | <b>-</b>                            |



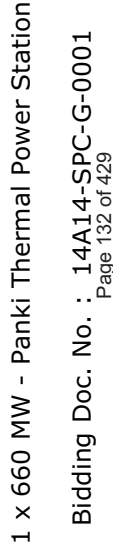
## ANNEXURE-VII

| PRODUCT                                                         | AREAS OF TRAINING REQUIREMENT                                                                                                   |                                                                                       |                                             | Visit To<br>Manufacturer's Work<br>Of Plant | Operation & Maintenance<br>Of Plant |
|-----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------|---------------------------------------------|-------------------------------------|
|                                                                 | Product Design                                                                                                                  | Plant Visit                                                                           | Visit To<br>Manufacturer's Work<br>Of Plant |                                             |                                     |
| TURBINE<br>GENERATOR<br>AND IT'S<br>INTEGRAL<br>AUXILIARIE<br>S | Turbine cycle optimization and turbine performance in off design condition.                                                     | Familiarization of power plants of various makes of turbines for super critical units | Manufacturing processes of turbine          |                                             |                                     |
|                                                                 | Rotor design and strength calculation                                                                                           | Collection of data for analysis of availability of turbines                           | Assembly of turbine                         |                                             |                                     |
|                                                                 | Rotor dynamic behaviour studies wrt natural frequency, critical speed, vibration etc.                                           | Comparative studies for integral systems of turbine                                   | Testing of turbines                         |                                             |                                     |
|                                                                 | Blade profile/root design and blade strength design, blade vibration analysis                                                   | O&M history/problems related to turbine                                               | Product development in process              |                                             |                                     |
|                                                                 | Casing & diaphragm design                                                                                                       | Failure analysis                                                                      | Future plan for technology induction        |                                             |                                     |
|                                                                 | Labyrinth seal selection & design for different turbine configurations                                                          |                                                                                       | R&D work in progress                        |                                             |                                     |
|                                                                 | Selection of turbine type (i.e. Tandem vs. cross compounding, separate HP/IP vs. combined HP/IP, material of construction etc.) |                                                                                       |                                             |                                             |                                     |
|                                                                 | Design principle for Up rating/down rating of existing design/ modules for the specific project.                                |                                                                                       |                                             |                                             |                                     |
|                                                                 | Selection of nos., type and arrangement of bearings, load calculation on bearings, bearing oil flow calculation                 |                                                                                       |                                             |                                             |                                     |
|                                                                 | Selection, design and control principle for Turbine governing system                                                            |                                                                                       |                                             |                                             |                                     |



| PRODUCT           | AREAS OF TRAINING REQUIREMENT                                                                                                 |                                                                |                                                                                                                                               | Operation & Maintenance Of Plant |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
|                   | Product Design                                                                                                                | Plant Visit                                                    | Visit To Manufacturer's Work                                                                                                                  |                                  |
| MANDAYS           | Performance calculation                                                                                                       |                                                                |                                                                                                                                               |                                  |
|                   | Steam path audit                                                                                                              |                                                                |                                                                                                                                               |                                  |
|                   | Layout principle of various equipment's of TG and its integral system                                                         |                                                                |                                                                                                                                               |                                  |
|                   | Latest technological advancements                                                                                             |                                                                |                                                                                                                                               |                                  |
|                   | 45                                                                                                                            | 10                                                             | 10                                                                                                                                            |                                  |
| Boiler Feed Pumps | Techno-economic studies for Selection of BFP Configuration and its drive                                                      | Familiarization of power plants of various makes of feed pumps | Manufacturing process of various components of BFP                                                                                            |                                  |
|                   | Criteria for selection of boiler Feed Pump parameters                                                                         | Data collection of BFP parameters and configuration            | Assembly of BFP                                                                                                                               |                                  |
|                   | Rotor design, strength calculation and rotor dynamic behavior studies wrt critical speed, vibration etc                       | Collection of data for analysis of availability of BFP         | Testing, capabilities of BFP at works wrt performance, NPSH, thermal shock, dry run, visual cavitation, string test, axial thrust measurement |                                  |
|                   | Impeller design and its hydraulic behavior                                                                                    | O&M history/problems related to BFP                            | Product development in process                                                                                                                |                                  |
|                   | Role of critical para- meters such as NPSH(R), Suction specific speed, running clearances, speed etc. in design of feed pumps | Comparative studies for various types of BFP& its features     | Future plan for technology induction                                                                                                          |                                  |
|                   | Material selection of BFP components                                                                                          |                                                                | R&D work in progress                                                                                                                          |                                  |
|                   | Guiding factors for selection of BFP seals                                                                                    |                                                                |                                                                                                                                               |                                  |

| PRODUCT                      | AREAS OF TRAINING REQUIREMENT                                                                                                  |                                                              |                                                                   | Operation & Maintenance Of Plant |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|-------------------------------------------------------------------|----------------------------------|
|                              | Product Design                                                                                                                 | Plant Visit                                                  | Visit To Manufacturer's Work                                      |                                  |
| MANDAYS                      | Computation of axial thrust under various flows                                                                                |                                                              |                                                                   |                                  |
|                              | Performance calculation                                                                                                        |                                                              |                                                                   |                                  |
|                              | Transient analysis in pump suction piping wrt NPSH margin                                                                      |                                                              |                                                                   |                                  |
|                              | Latest technological trends in BFP design                                                                                      |                                                              |                                                                   |                                  |
|                              | 20                                                                                                                             | 5                                                            | 10                                                                |                                  |
| Condenser                    | Selection of condenser type and its optimization wrt temp rise across condenser, pressure drop in condenser, surface area etc. | Comparative studies of salient features                      | Manufacturing process of various components of condenser Assembly |                                  |
|                              | Techno economic studies for Selection of condenser tube material and other parts depending on water quality                    | Collection of data for analysis of availability of Condenser | Testing capability at works                                       |                                  |
|                              | Condenser support selection & design                                                                                           | O&M history/problems related to condenser                    | Product development in process                                    |                                  |
|                              | Sizing of condenser w.r.t. super critical units                                                                                |                                                              | Future plan for technology induction                              |                                  |
|                              | Latest technological trends in condenser arrangement and design                                                                |                                                              | R&D work in progress                                              |                                  |
| MANDAYS                      | Condenser vacuum system design                                                                                                 |                                                              |                                                                   |                                  |
| Feed Regenerative Equipment' | 10                                                                                                                             | 5                                                            | 5                                                                 |                                  |
|                              | Thermal and mechanical design calculation of heaters                                                                           | Comparative studies of salient features                      | Manufacturing process of various components of heaters            |                                  |
|                              | Basis of selecting horizontal/vertical                                                                                         | Analysis of data                                             | Assembly                                                          |                                  |





| <b>CONTROL &amp; INSTRUMENTATION</b>                                   |                                                                                                                                                                                                                                   |                                                                                                                          |           |
|------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|-----------|
| DDCMIS-Man Machine Interface - Hardware & Operating System             | Hardware & Software organization of the system<br>Basis of selection of H/W memory sizing<br>Operating system features, interface with other system, openness & interoperability<br>Upgradability<br>System testing features      | Operational feedback                                                                                                     |           |
| <b>MANDAYS</b>                                                         | <b>16</b>                                                                                                                                                                                                                         | <b>6</b>                                                                                                                 |           |
| DDCMIS-Man Machine Interface System Engineering & Application Software | Specific system customization<br>Various system modules & interface with OS<br>Database organization & development<br>Development of mimics<br>Other application like calculations, logs historical storage functionalities & use | Operation feedback                                                                                                       |           |
| <b>MANDAYS</b>                                                         | <b>40</b>                                                                                                                                                                                                                         | <b>6</b>                                                                                                                 |           |
| DDCMIS - Control System Hardware                                       | Basic design features for system & its modules<br><br>System capabilities & system design techniques<br>Communication with MMI & other system                                                                                     | Operation feedback<br><br>Manufacturing processes special attention to handling of the modules<br>Maintenance facilities |           |
| <b>MANDAYS</b>                                                         | <b>20</b>                                                                                                                                                                                                                         | <b>5</b>                                                                                                                 | <b>10</b> |



## ANNEXURE-VII

| PRODUCT                                                                                             | AREAS OF TRAINING REQUIREMENT                                                                          |                                                                                                                       |                                                                                                            | Operation & Maintenance Of Plant |
|-----------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|----------------------------------|
|                                                                                                     | Product Design                                                                                         | Plant Visit                                                                                                           | Visit To Manufacturer's Work                                                                               |                                  |
| Turbine protection system & ATRS                                                                    | Implementation of failsafe philosophy in turbine protection system                                     |                                                                                                                       |                                                                                                            |                                  |
| <b>MANDAYS</b>                                                                                      | <b>10</b>                                                                                              | <b>3</b>                                                                                                              | <b>3</b>                                                                                                   |                                  |
| Furnace and Flame Viewing System.                                                                   | Theory & principle of operation<br>Details of software & methods of modification/ customisation        | Operational feedback                                                                                                  |                                                                                                            |                                  |
| Misc. systems for SG/TG C&I                                                                         |                                                                                                        |                                                                                                                       |                                                                                                            |                                  |
| Electric Power Supply System                                                                        | Theory & design features                                                                               |                                                                                                                       | Manufacturing/assembly process                                                                             |                                  |
| Wherever "DDCMIS" is indicated, it will mean SG C&I part of DDCMIS, which is in Contractor's Scope. |                                                                                                        |                                                                                                                       |                                                                                                            |                                  |
| <b>QUALITY ASSURANCE &amp; INSPECTION QA SYSTEM &amp; PROGRAMME</b>                                 | Integrated QA Management System for enhanced reliability of equipments                                 | Operational feedback<br>Co-relation of reliability and performance of the equipment with implementation of QA system. | Appreciation of implementation of QA Programmes in various manufacturing, assembly and testing activities. |                                  |
|                                                                                                     | QA system in design, procurement, manufacturing, installation and operation of the equipments/ systems |                                                                                                                       |                                                                                                            |                                  |
|                                                                                                     | QA system for developing and establishing new processes and vendors.                                   | Appreciation of use of                                                                                                | Appreciation of developmental                                                                              |                                  |
|                                                                                                     |                                                                                                        |                                                                                                                       |                                                                                                            |                                  |





## ANNEXURE-VII

| PRODUCT                                                         | AREAS OF TRAINING REQUIREMENT                                            |                                                                                                                 |                                                                                                          | Operation & Maintenance<br>Of Plant |
|-----------------------------------------------------------------|--------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|-------------------------------------|
|                                                                 | Product Design                                                           | Plant Visit                                                                                                     | Visit To<br>Manufacturer's Work                                                                          |                                     |
|                                                                 |                                                                          | structured Engg./QA<br>documentation during<br>Operational phase of<br>plant and during RLA<br>studies of plant | activities for new<br>processes and<br>vendors.<br>System of<br>prequalification of<br>special processes |                                     |
|                                                                 | System of structured documentation<br>of Engg. And test records          |                                                                                                                 |                                                                                                          |                                     |
| <b>MANDAYS</b>                                                  | <b>16</b>                                                                | <b>3</b>                                                                                                        |                                                                                                          |                                     |
| PLC                                                             | Hardware organization                                                    |                                                                                                                 | Manufacturing process<br>of PLC hardware                                                                 |                                     |
|                                                                 | Operating system features                                                |                                                                                                                 | Integration & testing<br>facilities                                                                      |                                     |
|                                                                 | Data base organization                                                   |                                                                                                                 |                                                                                                          |                                     |
|                                                                 | Logic/loop algorithm                                                     |                                                                                                                 |                                                                                                          |                                     |
|                                                                 | Development of control logic & loop<br>s/w & MMI application development |                                                                                                                 |                                                                                                          |                                     |
| <b>MANDAYS</b>                                                  | <b>16</b>                                                                | <b>-</b>                                                                                                        | <b>2</b>                                                                                                 |                                     |
| Electric<br>Power Supply<br>System (UPS<br>& 24 V DC<br>system) | Theory & design features                                                 |                                                                                                                 | Manufacturing/assembly<br>process<br>Testing methodology                                                 |                                     |
| <b>MANDAYS</b>                                                  | <b>10</b>                                                                | <b>2</b>                                                                                                        |                                                                                                          |                                     |
| PRODUCT<br>(ELECTRICAL)<br>GENERATOR                            | AREAS OF TRAINING REQUIREMENT                                            |                                                                                                                 |                                                                                                          |                                     |
|                                                                 | (a) Design aspects of the following<br>areas                             | - Operational feed<br>back                                                                                      | (a) Manufacturing<br>process for                                                                         |                                     |

## ANNEXURE-VII

| PRODUCT                                                                    | AREAS OF TRAINING REQUIREMENT                                                                                                                            |                                                                          |                                                             | Operation & Maintenance Of Plant                                                                                            |
|----------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|-------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
|                                                                            | Product Design                                                                                                                                           | Plant Visit                                                              | Visit To Manufacturer's Work                                |                                                                                                                             |
|                                                                            | - Insulation system                                                                                                                                      | - Familiarisation with different sub-systems                             | - Core                                                      |                                                                                                                             |
|                                                                            | - Cooling medium & arrangement                                                                                                                           |                                                                          | - Winding bars                                              |                                                                                                                             |
|                                                                            | - Winding & core support systems                                                                                                                         |                                                                          | - Assembly                                                  |                                                                                                                             |
|                                                                            | b) Design aspects of other auxiliary systems                                                                                                             |                                                                          | (b) Testing facilities                                      |                                                                                                                             |
|                                                                            | <b>MANDAYS</b>                                                                                                                                           | <b>15</b>                                                                | <b>15</b>                                                   |                                                                                                                             |
|                                                                            | Generator Excitation System including AVR.                                                                                                               | Design features of various sub-systems                                   | - Operational feed back                                     | - Manufacturing process& testing facilities for various equipment of excitation system                                      |
| Excitor                                                                    |                                                                                                                                                          | - Familiarisation with various equipment functioning at reference plants |                                                             |                                                                                                                             |
| PMG                                                                        |                                                                                                                                                          |                                                                          |                                                             |                                                                                                                             |
| Transformer                                                                |                                                                                                                                                          |                                                                          |                                                             |                                                                                                                             |
| Controllers & different limiters etc.                                      |                                                                                                                                                          |                                                                          |                                                             |                                                                                                                             |
| PSS & associated system studies                                            |                                                                                                                                                          |                                                                          |                                                             |                                                                                                                             |
| <b>400 KV Switchyard Equipments</b>                                        |                                                                                                                                                          |                                                                          | Concepts and operational aspects for the offered equipments |                                                                                                                             |
| Substation Automation System                                               |                                                                                                                                                          |                                                                          |                                                             | Training for site personnel for operation, maintenance & troubleshooting of total system for 5 working days at UPRVUNL site |
| <b>MV AND LT Switchgear:</b><br>Numerical relays & Switchgear SCADA system | Numerical relay engineering & associated training for relay software & O&M<br><br>SCADA system design, engineering & associated training for SCADA & O&M |                                                                          |                                                             |                                                                                                                             |

## ANNEXURE-VII

| PRODUCT                                                         | AREAS OF TRAINING REQUIREMENT                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                      |                                                                                                                          | Operation & Maintenance<br>Of Plant |
|-----------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|                                                                 | Product Design                                                                                                                                                                                                                                                                                                 | Plant Visit                                                                                                                                                                          | Visit To<br>Manufacturer's Work                                                                                          |                                     |
| <b>MDBFP<br/>motor CW<br/>motor &amp;<br/>BWCP<br/>motor</b>    | Design criteria for the stator core and winding, rotor core & winding, Insulation system & Cooling arrangement<br><br>Study of forces & vibration<br><br>Diagnostic & testing of large Electrical machines                                                                                                     | Operational feedback                                                                                                                                                                 | Manufacturing process & testing facilities                                                                               |                                     |
| <b>MANDAYS</b>                                                  | <b>30</b>                                                                                                                                                                                                                                                                                                      | <b>15</b>                                                                                                                                                                            | <b>15</b>                                                                                                                |                                     |
| Boiler Feed pump H.T. Motor                                     | Design Criteria for the Stator core & wdg<br>Rotor core & wdg<br>Insulation system<br>Cooling arrangement                                                                                                                                                                                                      | Operational feed back                                                                                                                                                                | Manufacturing process & test facilities                                                                                  |                                     |
| <b>MANDAYS</b>                                                  | <b>10</b>                                                                                                                                                                                                                                                                                                      | <b>5</b>                                                                                                                                                                             | <b>5</b>                                                                                                                 |                                     |
| <b>CRITICAL<br/>PIPING &amp;<br/>POWER<br/>CYCLE<br/>PIPING</b> | Design familiarization for critical piping of supercritical Plant<br><br>Optimization study for sizing including pressure drop calculation and selection of single or double lead together with Owner's engineers<br>Design and stress analysis of lines with Expansion Joints together with Owner's engineers | Familiarization with feedback (in super critical plant) on failure analysis and vibration analysis of piping.<br>Study of Feed back regarding hanger setting strategies and practice | Cold Setting of spring hanger<br><br>Cyclic tests carried on spring hangers.<br>Cyclic tests carried on expansion joints |                                     |

| PRODUCT | AREAS OF TRAINING REQUIREMENT                                                                                                                                                                   |             |                                                                                                          |  | Operation & Maintenance Of Plant |
|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|----------------------------------------------------------------------------------------------------------|--|----------------------------------|
|         | Product Design                                                                                                                                                                                  | Plant Visit | Visit To Manufacturer's Work                                                                             |  |                                  |
|         | Design and stress analysis of piping systems with two phase flow involving Owner's engineers                                                                                                    |             | Manufacturing process of critical piping components and appreciation of their testing facilities at shop |  |                                  |
|         | Transient analysis and optimum sizing of feed suction piping together with Owner's engineers.                                                                                                   |             |                                                                                                          |  |                                  |
|         | Static and dynamic analysis of critical piping including seismic and other occasional load analysis (safety valve blowing condition). A joint activity together with Owner's engineers.         |             |                                                                                                          |  |                                  |
|         | Study and collection of data pertaining to special welding requirements (pre and post weld heat treat ment and electrode selection criteria etc.) of materials used in high temp piping system. |             |                                                                                                          |  |                                  |
|         | Study and collection of data on special requirements in case of welding dissimilar metals and electrode selection criteria                                                                      |             |                                                                                                          |  |                                  |
| MANDAYS | 45                                                                                                                                                                                              | 10          | 10                                                                                                       |  |                                  |



## Mandays





|                                |                                                        |           |
|--------------------------------|--------------------------------------------------------|-----------|
| <b>PADO</b>                    | Theory & design features                               | <b>10</b> |
|                                | Trouble shooting and fault analysis                    |           |
| <b>CEMS</b>                    | Theory & design features                               | <b>5</b>  |
|                                | Trouble shooting and fault analysis                    |           |
| <b>AAQMS</b>                   | Theory & design features                               | <b>5</b>  |
|                                | Trouble shooting and fault analysis                    |           |
| <b>C&amp;I Lab Instruments</b> | Theory & design features                               | <b>6</b>  |
|                                | Trouble shooting and fault analysis                    |           |
| <b>DMS</b>                     | Theory & design features                               | <b>5</b>  |
|                                | Trouble shooting and fault analysis                    |           |
| <b>Station LAN &amp; MIS</b>   | Theory & design features                               | <b>5</b>  |
|                                | Trouble shooting and fault analysis                    |           |
| <b>Note</b>                    | <b>One week shall constitute of five (5) man days.</b> |           |