**T E N D E R  S P E C I F I C A T I O N**

# NO: BHE/PW/PUR/HONGI-PILE/1571

**JOB:** Piling Work (Job piles as well as test piles), excavation upto pile cut off level, breaking of piles upto pile cut off level and exposing the reinforcement , testing of piles, PCC and handing over the piles to the next agency complete in all respect **at 1x51 MW Combined Cycle Captive Power Plant, ONGC Hazira Site, Gujarat**

# VOLUME – IE

# Technical Specifications & Drawings

**Bharat Heavy Electricals Limited**
(*A Government of India Undertaking*)
Power Sector - Western Region
345-Kingsway, Nagpur-440001

# TENDER SPECIFICATION

# NO: BHE/PW/PUR/HONGI-PILE/1571

**JOB:** Piling Work (Job piles as well as test piles), excavation upto pile cut off level, breaking of piles upto pile cut off level and exposing the reinforcement , testing of piles, PCC and handing over the piles to the next agency complete in all respect **at 1x51 MW Combined Cycle Captive Power Plant, ONGC Hazira Site, Gujarat**

EARNEST MONEY DEPOSIT: Refer Notice Inviting Tender

LAST DATE FOR TENDER SUBMISSION: Refer Notice Inviting Tender

THESE TENDER SPECIFICATION DOCUMENTS CONTAINING VOLUME-I AND VOLUME- II ARE ISSUED TO:

M/s. ……

…….

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THESE TENDER SPECS DOCUMENTS ARE NOT TRANSFERABLE.

For Bharat Heavy Electricals Limited

AGM (Purchase)
Place: Nagpur
Date

# OIL AND NATURAL GAS CORPORATION LIMITED

## GAS BASED COMBINED CYCLE CAPTIVE POWER PLANT

**COGENERATION & STEAM SYSTEM**
**AT HAZIRA PLANT, SURAT – 394 518**
**GUJARAT**

# BID PACKAGE
# FOR
# COMBINED CYCLE CAPTIVE POWER PLANT


Consultant : **FICHTNER Consulting Engineers (India) Pvt. Ltd.**
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PROJECT :

# COMBINED CYCLE CAPTIVE POWER PLANT

## AT HAZIRA PLANT, GUJARAT

TITLE :

# BID PACKAGE FOR COMBINED CYCLE CAPTIVE POWER PLANT AT HAZIRA PLANT, GUJARAT

CLIENT :

ONGC OIL AND NATURAL GAS CORPORATION LIMITED

DOC. NO. : 5111168 ME SPC 100 001

NO. OF SHEETS : (INCLUDING COVER SHEET) 1092

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| R1 | 11.06.2012 | PGT | | SKS | | MSC | | SG | | For Tender purpose only |
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Consultant : **FICHTNER Consulting Engineers (India) Pvt. Limited, Navi Mumbai.**

# BID PACKAGE

# FOR

# COMBINED CYCLE CAPTIVE POWER PLANT

# AT HAZIRA PLANT, GUJARAT

# TECHNICAL SPECIFICATION

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FORMT9-P REV-A (MUM)

# VOLUME – II

# TECHNICAL SPECIFICATION

# SECTION - 1.0

# GENERAL TECHNICAL SPECIFICATION

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## 1.0.0 GENERAL PLANT DESCRIPTION

### 1.1.0 Intent of specification

This Technical Specification for 51 MW (Minimum) Natural gas fired Combined Cycle Captive Power Project (CCCPP) covers design, engineering, manufacture, inspection and testing at manufacturer's works, supply, packing and delivery at project site, transit insurance, port clearance, unloading, storage and in plant transportation at site, erection, supervision, pre-commissioning, testing, successful commissioning, performance testing and handing over of all equipments and facilities, forming a part of the power plant, which are deemed to be part of Contractor's scope on EPC basis, as specified in this Tender Specification. The proposed plant is located adjacent to the existing 3 X 20 MW Gas Based cogeneration power Plant.

**The plant configuration is of capacity 51 MW (Minimum) Gross Unit Power Output consisting of 1 x GT + 1 x ST + 1 x HRSG.**

This section explains General scope of supply and services, Limits of supply, Provisions by the Owner/Owner's representative, General plant design and layout requirements, Quality and testing requirements, Spare parts, Documentation and Environmental requirements.

Main Plant Package (MPP) is used extensively in this Technical Specifications, Main Plant Package (MPP) means those supply of equipment and services which are sourced from OEM's such as Gas Turbines, Steam Turbines, Generators and their associated auxiliaries.

It is not the intent to completely specify all details of design and construction, but only to lay down broad sizing and quality criteria for the major equipment and systems and it is expected that the equipments shall conform in all respects to high standards of engineering, design and workmanship and shall be capable of performing in continuous commercial operation up to the contractor's guarantee in a specified manner acceptable to the Owner/Owner's representative..

**Brief Description of Existing Facility**

Hazira Plant of ONGC is the largest of its kind in India with an installed processing capacity of 46 MMSCMD of sour gas and 7900 MT of sour condensate everyday. It receives sour natural gas and condensate from South Basin and Satellite (B&S) and JV PMT Fields (which is a sub-sea reservoir). The gas and condensate are transported to HGPC (Hazira Gas Processing Complex) through two (36" & 42") sub-sea pipelines. The gas and condensate are received at the gas terminal in a slug catcher where gas and slug containing HC condensate, moisture and chemicals (like corrosion inhibitors) are separated. Gas and associated condensate are sent further in separate system for processing. The various processing units are Gas Receipt Terminal, Gas Sweetening Unit (GSU), Gas Dehydration Unit (GDU), Dew Point Depression Unit (DPDU), Sulphur Recovery Unit, Sour Condensate Processing Unit, Gas Based LPG Recovery Unit and Kerosene Recovery Unit.

Major Systems in the Existing Capitive power Plant-

| Description | Make | Capacity |
|---|---|---|
| Gas Turbines 1 &2 | GE-Frame-V | Site rating -19.2 MW at 11 kV each |
| Gas Turbine 3 | BHEL | Site rating -19.2 MW at 11 kV |
| 66 kV Feeders 1 &2 | | 25 MVA each |
| 11 kV Substation 1 | NGEF | 3000 A CONT & 750 MVA SC |
| HRSG 1 & 2 **( HP +LP)** | BHEL | HP-18.5 TPH at 38 $kg/cm^2$ LP- 105 TPH at 9 $kg/cm^2$ each |
| HRSG 3 **(HP**) | BHEL | HP-50 TPH at 38 $kg/cm^2$ |
| DM Plant | WATCO/PARA MOUNT | 3 Trains of 75 $m^3/hr$ each ( 3600 $m^3/day$) |
| IAEC Boielrs 1, 2 & 3 **(MP)** | IAEC | 25 TPH at 22 $kg/cm^2$ capacity each |
| KTI Boiler **(HP +LP)** | KTI | HP-20 TPH at 38 $kg/cm^2$ LP- 105 TPH at 9 $kg/cm^2$ each |
| Thermax Boiler **(MP)** | Thermax | 37 TPH at 22 $kg/cm^2$ capacity each |

**Proposed Cogeneration Plant**

The Combined Cycle Captive Power Plant (CCCPP) of Hazira Gas Processing Complex (HGPC) of ONGC is intended to meet the internal steam and power requirement.

CCCPP is to be designed to generate 51 MW ( Minimum) power. The CCPP shall be based on specified power and associated steam requirement.

**1.2.0 Plant Components and Major Equipment (Broad scope of work)**

The Gas Turbine and Steam Turbine unit shall be established with generators coupled to the respective turbine units.

The EPC works for the proposed Combined Cycle Power Plant with support facilities shall include one (1) Gas Turbine generator as Prime Mover; one (1) Waste Heat Recovery Steam Generator; one (1) Steam Turbine generator and complete with required integral facilities, but not limited to the following:

**Mechanical**

- **Gas Turbine Generator (GTG)**

  a. Type - Industrial Heavy Duty Type

  b. Quantity - 1 No.

  c. Capacity – suitable for minimum 51 MW Gross Unit Power Output of the CCCPP.

  d. Medium for NOx control – DLN burners

  e. Guarantee fuel - Natural Gas

- **Heat Recovery Steam Generators (HRSGs)**

  a. Quantity - 1 No. (Associated with GTG) along with bypass stack and HRSG stack.

  ~~b.~~ Type - Horizontal, Natural circulation

  c. Steam Parameters. – HP/–/LP (as required for the STG) and to suit the Process steam parameter at tap-off point as specified.

  d. Capacity (Min.) / HRSG – Based on specified power and associated steam requirement.

  Design Code - Indian Boiler Regulation (IBR) latest Edition.

- **GAS CONDITIONING SKID**:-

  Gas conditioning skid shall be suitable for CCCPP & existing one Gas Turbine requirement. Gas conditioning skid shall consists of 1x100% Knock out drum (gas Scrubber) 1 x 100% gas heater by steam, 2 x 100% pressure reduction valves, 2 x 100% GT final filters, gas metering etc. for fuel system i.e. new proposed GTG & HRSG and gas line supply for one existing GT.

  Gas line from gas conditioning skid to Gas turbine inlet shall be properly insulated. Suitable
  Steam / Electric tracing system shall be provided .

- **Steam Turbine and Auxiliaries**

  a. Quantity - 1 No. (Associated with GTG)

  b. Type -Straight condensing type with HP and LP steam injection preferably with axial exhaust

- **Condenser / Auxiliary / Closed Cooling Water System and Mechanical draft cooling tower**

  a. Three, 3 (2W+1S), 50% capacity CCW pumps

  b. Two, 2(1W+1S),100 % capacity ACW pumps.

c. Cooling tower cells 3 (2W+1S).

d. Cooling water treatment systems for biocide & anti scalant / anti corrosion dosing, side stream filter and dosing for alkalinity control etc.

- Fuel gas (Natural Gas) Handling system
- De-Mineralised, Filter, Potable & Service Water system.
- EOT cranes & hoists
- Elevator
- Instrument and Service Air system
- Heating, Ventilation and Air conditioning system
- Fire detection and Protection System
- Piping, Valves, fittings, specialties (strainer, expansion bellow, air release valve etc.),, supports for all inplant and interconnection piping system.
- Workshop equipments

**Electrical**

- Generators (GTG & STG)
- Generator Transformers, Station Transformers
- Segregated Phase HT & Non segregated phase LT Bus ducts
- Control and Relay panels
- 66 kV indoor type GIS
- Sub-station automation system (SAS)
- 66kV cables
- Replacement of existing 66kV transmission line conductor with special heat resistant aluminium alloy steel reinforced conductor
- HT and LT switchgear
- LT Transformers
- Batteries and battery chargers
- Electric motors and actuators
- Plant illumination system
- Earthing and lightning protection
- Plant Communication system
- CCTV
- 11kV connection shifting of existing GTG-3
- Uninterrupted Power Supply (UPS)
- Power and control cabling
- Cable trays and other miscellaneous electrical items

- Black start, emergency DG set.

**Control and Instrumentation System**

- Microprocessor based gas turbine generator control & protection system, vibration monitoring system, fire detection and protection system
- Microprocessor based steam turbine generator control system, protection system and turbo supervisory instrumentation
- Plant Distributed Control System (DCS)
- Vibration monitoring system for plant HT drives GPS-based Master and Slave clock system
- SWAS (Steam and Water Analysis System)
- SEMS (Stack Emission Monitoring System)
- HART Management System (HMS)
- PLC-based control systems and necessary local control panels for all BOP offsite facilities Instrumentation Lab Equipment

**Civil Structural and Architectural Works**

- Earthwork and filling in proposed power plant area and its surrounding as per site grading requirements.
- Main power house Building for Gas Turbine and Steam Turbine Generator.
- Equipment foundation for GT, ST, Generator, HRSG, 66 kV GIS, Transformers and other Auxiliary equipment foundation.
- Plant roads and Storm Water Drainage System, Sewerage System with necessary interconnections to the existing plant system.
- Pipe and Cable Trenches and Racks as required within and outside the plant area.
- BOP Buildings, Pump houses, Control and SWGR rooms.
- All other civil works required for the power plant and detailed elsewhere.
- Corrosion protection, Painting and Insulation.
- Conditions stipulated by AAI (Airport Authority of India – Chimney NOC) / SPCB, State Pollution Control Board) for construction of plant.
- Cutting of tree, shrubs and other matters in proposed CCCPP area and leveling.

The detailed scope of supply and services are indicated in the following sections:

| VOLUME NO. | SECTION NO. | DESCRIPTION |
|---|---|---|
| II | 1. | GENERAL TECHNICAL SPECIFICATION |
| III | 2. | DETAILED TECHNICAL SPECIFICATION - MECHANICAL |
| | 3. | DETAILED TECHNICAL SPECIFICATION - ELECTRICAL |
| | 4. | DETAILED TECHNICAL SPECIFICATION – CONTROL & INSTRUMENTATION |
| | 5. | DETAILED TECHNICAL SPECIFICATION – CIVIL,STRUCTURAL AND ARCHITECTURAL WORKS |
| IV | 6. | LIST OF TENDER DRAWINGS |
| | 7. | TECHNICAL DATA SHEETS AND SCHEDULES TO BE FILLED IN BY THE BIDDERS |
| | 8 | Annexure-1<br><br>Suggested vendor list |
| | | Annexure -2<br><br>List of Mandatory Spares |
| | | Annexure-3 (Colour code for Piping and Fire equipment) |
| | | Annexure-4 (Guide for coding equipment, documents and drawings). |
| | | Annexure-5 - (Geotechnical Investigation Report - Inside Area) |

**1.3.0 Discrepancies in this Tender document**

Any contradiction among various sections of this EPC Tender document,between text and drawings shall be raised by the Bidder and clarified during pre-bid conference clarification meetings. In any case, as regards basis for the scope of supply to be supplied by the Contractor and the design requirements to be followed is concerned, the document giving the more extended scope or requirement shall be considered to be within the Contractor's scope of supply.

All interfaces etc. shall be in contractor scope of work.

In the event of any conflict between the Detailed Technical specification and Specified design data of the equipment, the later shall govern. In the event of conflict between the

General technical specification and the detailed technical specification, the later shall govern. In the event of conflict between the General technical specification and General conditions of contract, the latter shall govern.

**1.4.0 Special Conditions**

The following are the gist of special conditions required to be met under this Bid and further details are mostly indicated in Volume IV. The Bidder shall comply to the following condition without fail :-

**1.4.1 Combined Cycle Gross Power Output related**

The Guaranteed Gross Power Output of 51 MW (Minimum) and maximum 60 MW at site Reference Conditions meeting the emission limits specified.

**1.4.2 Duration for successfully completing Tests on Completion related**

The duration for execution until successful completion of Trial operation (including reliability run and Performance guarantee tests from the date of LOI shall not be more than 24 months.

**1.4.3 Gas Turbine and its Generator related**

The Gas Turbine offered shall be Heavy Duty Type and shall utilize Dry Low NOx type of burners meeting the Nox emission requirements specified.

The Gas Turbine type/model offered for the subject project should have been in commercial operation in Combined Cycle mode at least for the last five (5) years, in two separate sites or higher capacity shall be acceptable.

The Site Reference Conditions considered for arriving at the Combined cycle Gross Power Output shall be the same as that specified.

The Gas turbine Gross Power Output considered for arriving at the Combined Cycle Guaranteed Gross Power Output shall not consider any power augmentation measures such as GT intake air cooling / chilling, steam or water injection into the combustor.

Bids shall consider only the suggested vendor list specified in the Bidding Document (Vol -IV, Section- 8, Annexure -1).

**1.4.4 HRSG related**

The HRSG type / model / rating offered for the subject project should have been in commercial operation in Combined Cycle mode at least in two separate sites for the last five years or higher rating shall be acceptable.

The source of heat input for the HRSG shall be only the Gas Turbine exhaust Gases and the same only is to be considered for arriving at the Combined Cycle Guaranteed Gross Power Output.

Fired HRSG can be considered to achieve the steam output (required for process steam) at part load of gas turbine.

Bid shall consider only the OEM's specified in the Bidding Document.

### 1.4.5 Steam Turbine and Its Generator related

The Steam Turbine type/model/rating offered for the subject project should have been in commercial operation in Combined Cycle mode at least in two separate sites for the last five years.

The Site Reference Conditions considered for arriving at the combined cycle Gross Power Output shall be the same as that specified.

Bid shall consider only the OEM's specified in the Bidding Document.

### 2.0.0 LIMITS OF SUPPLY AND CONDITIONS AT LIMITS OF SUPPLY

The limit of supply and conditions at supply terminals of various utilities to be provided by the Owner/Owner's representative for the proposed plant is provided below. Refer Plot Plan Drg. no 00-5111168-G-001 (Rev C) , P & ID for HP/MP/LP Process Steam System Drg. No. 20-5111168-M-022 (Rev C), Hook –up points Dwg. No 20-5111168-M-023 (Rev B), enclosed with the specification for location & other details.

### 2.1.0 Fuels – Natural Gas

Natural gas shall be extended by means of pipeline from existing Natural Gas supply piping system in ONGC complex near to the gas conditioning skid module 1 (upstream of Emergency Shutdown Valves). The supplied gas pressure shall be in the range of **33 to 56 Kg / cm$^2$ (g) @ 35 Deg. C in ONGC Natural Gas** supply **header.** Analysis of Natural Gases is given in the following tables.

**FUEL - NATURAL GAS ANALYSIS ( TYPICAL )**
**ONGC, HAZIRA PLANT**

| Sl. No. | Composition | Vol. (%) | | |
|---|---|---|---|---|
| 1 | Methane | 95.82 | 87.51 | |
| 2 | Ethane | 1.482 | 5.30 | |
| 3 | Propane | 1.314 | 2.19 | |
| 4 | I-Butane | 0.183 | 0.09 | |
| 5 | N-Butane | 0.125 | 0.06 | |
| 6 | I-Pentane | 0.113 | ..... | |
| 7 | N-Pentane | 0.087 | ….. | |
| 8 | Hexane | 0.135 | …… | |
| 9 | Carbon Dioxide | 0.229 | 4.85 | |
| 10 | Nitrogen | 0.413 | ….. | |
| 11 | Hydrogen Sulphide | <0.1 | …… | |
| 12 | Heptane | 0.051 | …… | |
| 13 | Octane | 0.034 | ….. | |
| 14 | Nonane | 0.011 | ….. | |
| 15 | Decane | 0.003 | ……. | |
| 16 | Specific Gravity (with respect to Air) | 0.5867 | 0.65119 | (ASTM D3588) |
| 17 | Thermal Property (in kcal/ cu.m) | | ….. | |
| 17.1 | Gross Calorific Value , kCal/SCM | 9345.63 | 9257.69 | (ASTM D3588) |
| 17.2 | Net Calorific Value , kCla/SCM | 8421.72 | 8358.33 | (ASTM D3588) |
| 18 | Undecane, Dodecane, Tridecane, Acetylene, C2 Monoxide, Aromatics Not detected | | | |

**Note:** Gas Turbine operation fuel gas specification, limiting values shall be as per MPP package**.**

**2.2.0 WATER ANALYSIS ( TYPICAL )**

2.2.1 **Filtered Water Analysis**

| Sr. No. | Characters | Unit | Filtered water Analysis |
|---|---|---|---|
| 1 | pH | | 8.3 |
| 2 | Total Hardness | Mg/l as CaCO3 | 115 |
| 3 | Ca Hardness | Mg/l as CaCO3 | 60 |
| 4 | Sodium | Mg/l as CaCO3 | 78 |
| 5 | Iron | As Fe | Traces |
| 6 | Total Cation | Mg/l as CaCO3 | 193 |
| 7 | Turbidity | NTU | <2 |
| 8 | Total Alkalinity | Mg/l as CaCO3 | 130 |
| 9 | Sulphate | Mg/l as CaCO3 | 6 |
| 10 | Chloride | Mg/l as CaCO3 | 57 |
| 11 | EMA | Mg/l as CaCO3 | 63 |
| 12 | Total Anion | Mg/l as CaCO3 | 193 |
| 13 | Silica | Mg/l as SiO2 | 20 |
| 14 | KMnO4 Value | Mg/l as CaCO3 | 15 |

Note : Bidder shall consider 20% deterioration in the above values while considering the same for Cooling tower make up purpose as well as service water purpose.

2.2.2 **DM water analysis at the outlet of existing DM plant ( TYPICAL )**

| Sr. No. | Characters | Unit | Filtered water Analysis |
|---|---|---|---|
| 1 | pH | | 6.50 - 7.00 |
| 2 | Conductivity | µ/cm | 1.0 |
| 3 | SiO2 | mg/l | 0.05 |
| 4 | Hardness | mg/l | Nil |
| 5 | Fe | mg/l | < 0.03 |
| 6 | Cu | mg/l | < 0.005 |

Note: Bidder shall consider 20% deterioration in the above values while designing of the Mixed Bed unit

**2.3.0 Water System**

De-Mineralised (DM) water, Filter water System (FWS), Potable water (PW) & Service water (SW) shall be taken from existing Water Treatment Plant (WTP) facility in ONGC complex, Hazira. Refer Key Plan showing Terminal Points Drg. no. 00-5111168-G-02, Rev. B. All water system lines shall be extended up to proposed power plant area as per routing in

consultation and permission of ONGC Engineers .Fire hydrant system shall be extended from existing plant area upto the proposed power plant area.

- Make-up for cooling water system- To be sourced from existing cooling water header
- Service water system: - To be sourced from existing filtered water system.
- Potable water system: - To be sourced from existing system.
- Fire water - To be sourced from existing fire water system.
- DM water - To be sourced from existing DM water plant for further polishing.

**2.4.0 Waste Water**

The effluents generated from the power plant after collection in the guard pond shall be forwarded to existing Effluent treatment facility in ONGC complex via the OWS & PWS drain pits located near the CCCPP area as marked in the drawing no 5111168-M-SK-001,Rev-B Flow scheme for effluent discharge .

- Oily Waste water – To be routed to existing PWS drain pit
- HRSG Blowdown - To be routed to existing PWS drain pit
- Cooling Tower Blowdown - To be routed to existing OWS
- Gas condensate – To be routed to existing slop oil tank

**2.5.0 Process Steam**

The steam generated from new Heat Recovery Steam Generator (HRSG) is to be hooked up to existing process steam headers located in existing cogeneration plant. All existing HRSG's / utility boiler's are connected to this header. -

- HP steam generated shall be exported to the existing HP steam export header to the complex after reducing pressure and temperature
- MP steam generated from the HP steam after reducing pressure and temperature shall be exported to the existing MP steam export header of the complex
- LP steam from LP system of HRSG and also generated from HP steam after reducing pressure and temperature shall be exported to the existing LP steam export header of the complex

**Steam Parameters at Hook-Up Point (at Existing Cogeneration plant)**

| Service | | Operating | Design | Remark |
|---|---|---|---|---|
| HP steam | Pressure kg/cm$^2$ | 30 | 38 | Flow rate mentioned is downstream of respective Service PRDS. |
| | Temperature °C | Saturation | | |
| | Flow TPH | - | minimum 40 | |
| MP steam | Pressure kg/cm$^2$ | 18 | 22 | |
| | Temperature °C | Saturation | | |
| | Flow TPH | - | minimum 40 | |
| LP steam | Pressure kg/cm$^2$ | 8 | 9 | |
| | Temperature °C | Saturation | | |
| | Flow TPH | - | minimum 40 | |

Bidder to note that all Service PRDS shall be in operation at a time when steam is supplied to process steam header.

**2.6.0 Inert Gas**

The inert gas required for the purging of gas lines shall be tapped from the existing inert gas header

**2.7.0 Treated natural gas**

The natural gas after the proposed gas conditioning skid shall also be interconnected to the gas supply line of the existing gas turbine.

**2.8.0 Instrument Air / Compressed Air System**

The Compressed Air System (CAS) for the CCCPP shall be designed to to meet total instrument air (IA) and service air (SA) contingency of new power plant requirement when existing plant air supply is not available. This new compressor shall be standby in the proposed power plant area and shall automatically start if there is no supply of instrument and plant air from the existing plant area.

**2.9.0 Roads**

The roads in the scope of Contractor are shown in Plot plan Drg.No.10-5111168–G-001, (Rev C). All internal roads as required in the proposed plant layout and interconnection with the existing (one point boundary of the existing plant) shall be in the scope of the EPC Contractor.

**2.10.0 Bulk Chemicals**

Contractor's scope includes all facilities necessary for the unloading, storage and forwarding of chemicals. Such unloading facilities shall be suitable for connection to truck discharge facilities. All required bulk chemicals shall be supplied by the Owner/Owner's representative as per contract at the unloading facility. Chemical storage facility, especially for CT / Boiler dosing shall be in the new plant. Only the DM plant chemicals shall be in the Old area.

**2.11.0 Electrical hook-up with State grid and Power Transmission**

The proposed power plant shall be provided with new 66 kV GIS which will be installed in a new building adjacent to the existing 66kV switchyard as shown in the plot plan. Existing 66kV switchyard equipment shall be demolished with their structures,except necessary gantry structures. Existing 66kV line isolators, LAs with their associated structures shall be relocated in front of new GIS room. This arrangement is required so that physical isolation of GETCO lines is possible for maintenance purpose. Existing ABT metering outdoor kiosk shall also be relocated as per GETCO guidelines. Existing 66kV transmission line conductor (DOG) for two nos. incoming feeders from GETCO, Ichhapore substation is around 4 km route length. These conductors shall be replaced with a new super heat-resistant aluminium alloy steel reinforced 66kV conductor suitable for power evacuation of minimum 50MVA at 50 deg.C ambient temperature (high temperature low sag uprating conductors) for each feeder. Any replacement of insulators, clamps, connectors or any other ancillary items required shall be considered in EPC contractor's scope. No modification or replacement of existing tower due to conductor replacement work is envisaged.Two( 2) nos. 66kV transmission line feeders will be terminated in the new 66kV GIS as grid incomer feeders. 2 nos. outgoing feeders from 66kV GIS will be connected to the primary side of the existing 25/31.5MVA, 66/11kV transformers. Any modifications in protection & metering and any control cabling requirement due to the above work shall be considered in EPC contractor's scope. Separate metering CT & PT to be considered in 66kV GIS line bays for existing ABT metering which can be used for the tariff metering.The ABT metering CT/PT shall be as specified by GEB/GETCO and the EPC contractor shall take approval from GEB/GETCO for the same.

**2.12.0 Instrumentation and control**

All services and supplies included within scope of Contractor.

**2.13.0 O & M Facilities**

O & M building is not envisaged in Contractor's scope.

**2.14.0 Other Electrical Inter Connection Points:**

- **Interconnection with Existing Plant:** Approximately 10 Nos. plant feeders presently connected to existing 11kV switchgear located in the MRSS (Main receiving substation) shall be disconnected and shall be reconnected to new 11kV switchgear of CCCPP. Feeders to be shifted will be identified by the Owner/Owner's representative. Also additional 15 Nos. breaker panel feeders on each bus (Total 30 no feeders) shall be provided in the new 11kV switchgear for future use.
- Existing required data for 66 kV switchyard, transmission line shall be furnished by Owner/Owner's representative,if available.
- Data transfer to SLDC/RLDC/Remote end: In the respective Panel with IEC Gateway.
- Startup and Pre Commissioning Power at 66 kV GIS.

## 3.0.0 GENERAL SCOPE OF SUPPLY AND SERVICES

The scope of supply and services covered shall be complete from site clearing to project take over by Owner/Owner's representative including all supplies and services. The Contractor's scope of supply and services listed in clause 1.2.0,Plant components and Major Equipment as well as listed below are to be included and shall not be limited to the following:

1. Design, Engineering, Procurement, Testing at Manufacturer's Works, painting, sea worthy Packing, Forwarding and Supply of all equipment, plants and facilities within the limits of supply and for connection at the boundary/defined limits and as specified in the relevant Detailed Technical Specification for the completion of the power plant on an EPC basis including Special Tools and Tackles, pre-commissioning/commissioning spares, and mandatory spares.

2. Intermediate site / offsite storage, transport to erection area, Receipt of material at site including unloading from carriers at site, handling**,** storage and preservation at site and intra/off site transport to site or viceversa as may be required.

3. Inspection, testing, cleaning, painting, marking at the EPC contractors and/or subcontractors workshops, delivery and transportation to the site, including insurance, unloading.

4 Overall Project management, project control, quality assurance, site management and coordination for all technical matters, interconnections, connection to off-site facilities, scheduling, contractual matters and obligations, etc. with suppliers, sub-suppliers, subcontractors, vendors, the Owner/Owner's representative, as required on a EPC basis for the implementation, construction and putting into commercial operation of the whole project under the overall and sole responsibility of the EPC Contractor.

5. Complete civil engineering including, Soil and Geo-technical investigation and design and carrying out all necessary civil and construction works at site. To carry out soil resistivity test for designing of plant earthing system.

6. Supply of all information, documents, calculations, drawings, reports, etc. which are required for Owner/Owner's representative's approval and to obtain all necessary permits, clearances, from the Government authority, except those which are specifically stated to be obtained by Owner/Owner's representative.

7. All statutory clearances and approvals to be taken by the EPC contractor in relation to the performance of the works.However,the Owner/Owner's representative shall assist the contractor and /or sub-contractor upon receiving written request from the EPC contractor to acquire the necessary permit,approvals and /or licenses.

8 Supply of all consumable materials required for civil construction, erection, testing and commissioning, reliability run, performance guarantee test, taking over of the plant. However fuel (Natural gas) required for these trial/test of the plant will be provided by Owner/Owner's representative at specified terminal point.

9. Provision of all labour, necessary erection equipment, temporary site facilities, temporary connections to power supply, water supply etc. for erection and commissioning required for the fulfilment of the Contractor's duties in connection with the works and for completion of the entire project in time.

10. Provision of all accommodation, transport, canteen, social facilities, etc. for the Contractor's personnel employed at site.

11. Co-ordination with other agencies including with the Owner/Owner's representative at the plant interconnections (interfaces), if any.

12. Cleaning and application of corrosion protection during erection as required by the Owner/Owner's representative and apply final painting in accordance with the specification.

13. Carry out erection test / test run, mechanical completion, electrical / instrumentation checks / tests, pre-commissioning tests, commissioning tests, trial operation, reliability run, performance guarantee test run, taking over, of the systems / equipments / plant including civil, structural and architectural works specified and handing over of the plant to the Owner/Owner's representative's requirements and approval and in compliance with the requirements of this specification.

14. Installation and removal of temporary piping and equipment for carrying out oil flushing, Acid / Alkali boil out , Steam blowing operation or such cleaning facilites as required.

15. Relocation & refurbishing of existing temporary shed existing now at the CCCPP plot area to a location as identified by Owner/Owner's representative within the Complex..

16. Removal of surplus materials, scraps out of fabrication yard, temporary infrastructures, subsequent cleaning up and handing over of plant to the Owner/Owner's representative.

17. Provision of supply of all documents required and specified including AS BUILT drawings.

18. Training services for the Owner/Owner's representative's operation and maintenance personnel.

19. Any other supplies and services in connection with or related to the works so far as the necessity for providing the same is specified in or reasonably to be inferred from the contract and/or required for the completion of the power plant.

20. The Contractor shall accept full responsibility for the completeness and for the satisfactory working of equipment and the plant as a whole. These shall be executed on the basis of proven design principles and in accordance with the state of-the-art in such a manner that the purpose to be served by the plant is fulfilled in every respect. Standardization of equipment, materials as well as of buildings shall be attempted and evidenced in the design. Care shall be taken to ensure simplicity of assembling and dismantling of all parts of the plant.

21. Construction power and water (ON CHARGEABLE BASIS) : Owner/Owner's representative will provide 415 V supply at one point within the plant boundary, further distribution shall be part of the Contractor's scope. Demand and consumption charges shall be borne by the Contractor. Contractor shall provide month-wise power requirement for the Project duration immediately after Contract signing. The temporary metering for power & water usage shall be put up by the contractor and informed to ONGC Engineer of Hazira plant.

    Construction water shall be supplied by ONGC at one point and rest extension shall be part of EPC Contractor scope. No ground water tapping permitted.

22. Satisfactory conclusion of the contract

By accepting the Contract, the Contractor shall be deemed to accept the obligation of supplying everything necessary as per the Contract for the purpose mentioned above, regardless of any omission in the specification or on the drawings.

More detailed scope of supply and service is described under this section and the relevant chapter of the detailed technical specification.

### 3.1.0 Scope of Engineering Services

The engineering services of the Contract refer to the complete basic and detail engineering of all equipment and equipment systems, Providing engineering drawings, data, instruction manuals, as built drawings and other information for Owner's/Owner's representative's review, approval and records. 3D walkthrough model of the plant shall be included in the scope of Contractor and the same shall be furnished before the final approval of the drawings. Full fledged 3D modelling shall be developed for power house. Also all piping for which isometric will be developed will be generated from 3D modelling.

The Contractor shall be responsible for the plant design & construction related licensing/permitting applications, However Owner/Owner's representative will extend necessary support as required to the Contractor.

### 3.2.0 Common Equipment and Services

The following supplies and services are to be included in the Contractor's scope and corresponding section.

### 3.2.1 General

- Material and personnel costs (e.g. for testing authority staff) for tests and inspections which are mandated by legislation and also cost involved in quality assurance requirements as specified.
- Material costs for site inspections.
- Declaration of conformity with Indian requirements and markings for all machines
- Engineering design of complete supplied equipment including interface coordination
- Preparation of General Arrangement and all layout drawings.
- Estimation of Bill of Materials
- All as-built documents (on data carriers; data formats as requested by the Owner/Owner's representative)
- Quality control plan and safety plan
- Complete documentation as set out in the technical specification.
- Operating and maintenance manual containing the summary. Detailed operating and maintenance instructions .
- Technical library shall contain O&M Manuals and As-built drawings of various systems / equipments in the plant. Further the plant hand book shall also cover system description, site conditions, technical parameters of all the items of the power plant indicating equipment features viz., configuration, design parameters, operating parameters, MoC, drawings.
- Conducting HAZOP Study for the entire proposed plant supplied by the EPC Contractor with the involvement of the "Owner/Owner's representative" and furnishing the report. For MPP supplied systems participation (for conducting HAZOP study by Contractor) in design review and implementation from MPP shall be ensured by EPC Contractor.
- All necessary co-ordination with other contractors on site for erection, testing and commissioning of equipment and accessories.
- Making available of all testing and commissioning equipment.

### 3.2.2 Mechanical

- All necessary pipelines, warm up system, vents, drains, valves, actuators, required for commissioning, operation and preservation in standstill.
- All temporary installations required for tie-in measures including post weld heat treatment complete, inner cleaning.
- All temporary pipe work as required during connection measures.
- All support structures, hangers, supports.
- All base frames, mounting plates, grouted in parts, rag bolts, covers.
- All required steel parts embedded in concrete.
- All couplings and coupling guards for electric motors and other drives.
- All lifting equipment and hoists (for repair work where loads exceed 50 kg) (cranes, hoists, monorails installation arrangement.
- Required safety equipment, pressure relief valves.
- All thermal (Hot and Cold) and noise insulation including cladding as well as any other noise attenuation measures,
- Stairways, ladders, platforms, galleries and walkways to all plant components, including escape routes as necessary, pipe cross-overs in plant,
- All necessary steel structures, stairs, ladders and platforms including weather protection
- All required ventilation and / or air conditioning equipment as specified and as required for safe operation of mechanical and electrical equipment, to be supplied.
- All necessary corrosion protection measures for plant components and equipment stored or mounted on site up to the time of 'Handing Over'.
- Complete primer and top coatings conforming to colour code to be agreed with the Owner/Owner's representative
- Noise abatements measures to comply with noise pollution control requirement.
- All corrosion protection for outdoor installations.
- Complete labelling of all plant components according to the Owner/Owner's representative's system in English and also in local language for notices.
- All fire protection measures.
- All lubrication systems.
- Initial lubricant filling and sufficient lubricants for commissioning, minimization of lubricant types by screening and co-ordination with the Owner/Owner's representative.
- Provision of all connections and temporary pipe work for steam blowing of the steam pipelines to a safe height.
- Flushing of all other pipelines including disposal of the effluents; protection with wood and/or plastic at all instrumentation and appendages to be installed during construction
- Chemical cleaning and Steam blowing of piping. Chemical cleaning of the deaerator is not applicable if fully assembled deaerator is supplied to site.
- All standard accessories and auxiliary equipment which normally form part of the scope of supplies.
- All tests, inspections and works acceptances as well as all certificates and reports of these
- Cleaning of all GT Intake filter elements before 'Handing Over' of the relevant Unit.
- Valve trims for purging and subsequent exchange.
- Removal of any unused material from site.
- Scaffolding for all work above ground level.
- Proven and latest air quality monitoring system at the strategic locations in and around the plant/Property to monitor and to comply with norms of various statutory bodies.

### 3.2.3 Electrical and Instrumentation

In general the power plant shall be started, stopped and operated through proprietary control systems of the GT, ST and also through plant DCS. The electrical control & monitoring of 66kV, 11kV & 415V system will be through a SAS system. The electrical, instrumentation and control for the plant shall mainly consist of, but not limited to the following:

- All controls, measuring and monitoring equipment for the complete power plant.
- All primary sensors, local and remote field instruments, valves and actuators (temperature gauges, pressure gauges, pressure / flow / level transmitters, local regulating devices) as well as all instruments for reliability and performance test and checks.
- All local instrumentation racks, enclosures and local gauge boards.
- All necessary electrical drives
- Complete installation material, that is wiring, cabling and impulse piping / tubing and fittings, valves, all needed fastenings, conduits, brackets and other supports, including the cable trays & its supports.
- All required junction boxes and cubicles
- All field control boxes
- Street and other outdoor lighting
- Lightning protection
- Electrical and electronic/signal earthing of equipment.
- Logic interconnections for sequencing, interlocking, protection, safeguarding for coordinated operation / start-up / shut down of various plant equipment and processes.
- Necessary interface with control systems of BOP offsite utilities for monitoring and supervisory controls.
- All the electrical equipment in the in the Hazardous area and battery rooms (shall be flame proof type. Refer Hazardous area classification plan (Overall) drawing no. 3114-00-16-50-0005,Rev-0) & Hazardous Area Classificatin Diagram (Drg. No.1-38101-00213, Rev.0).
- It shall be the endeavour of the EPC contractor to make maximum use of natural light while designing the buildings / sheds / enclosures.

### 3.2.4 Civil

- Soil investigations
- Any necessary surveying works
- Preparation of site, demolition works, removal of underground obstacles, cutting of trees.
- Preparation of site with barricading the proposed power plant area upto 10 Metre height with installation of sufficient number of gas detectors.
- FGL of proposed CCCPP shall be EL (+) 101.200 M Corresponding to NGL EL(+) 99.700 M.
- Earthworks, drainage, excavation and refilling works
- Roads and pavement
- Concrete and reinforced concrete works, masonry and earthing.
- Water proofing works.
- Fire protection during construction
- Roofing (non asbestos)
- Plumbing
- Facade works/glazing works( non asbestos)
- Non-load bearing walls/installation partitions/dry construction works
- Metalwork and blacksmith work/raised flooring/doors and gates/sheet metalwork
- Flooring work
- Fire protection with plumbing;

- Corrosion protection for underground/ over ground RCC and steel structures
- Crane way works
- Service water and waste water, sewage water, storm water (permanent and during construction).
- Housekeeping during construction (at least once a week total)
- Staff facilities during construction
- Transport of all dumping material to dump locations (at least once a week ).
- Proper drainage arrangement has to be ensured, so that adjacent plant area should not get affected.

## 4.0.0 PROVISIONS BY THE OWNER/OWNER'S REPRESENTATIVE

Refer Volume-I (Commercial Specification)

## 5.0.0 SITE CONDITION

### 5.1.0 Meteorological Conditions and other Project information

**ONGC, Hazira Site conditions:**

| | | |
|---|---|---|
| 1.0 | Location | ONGC Limited, Hazira |
| 2.0 | Elevation above mean sea level | RL 6.0 above, MSL |
| 3.0 | Nearest Railway Station | Surat, 20 KM |
| 4.0 | Nearest Airport | Surat, 10 KM |
| 5.0 | Nearest Harbour | Magdalla, 20 KM |
| 6.0 | Access Road | NH-8 (30 KM) |
| 7.0 | Atmospheric pressure at MSL | 1.013 bar |
| 8.0 | Ambient Temperature | |
| a) | Max. average dry bulb temperature | 45.6 $^{o}$C |
| b) | Min. average dry bulb temperature | 4.4 $^{o}$C |
| c) | Design temperature for electrical equipment / device | 50 $^{o}$C |
| 9.0 | Relative Humidity | |
| a) | Max. | 70% |
| b) | Min. | 18% |
| c) | Average | 64% |
| 10.0 | Seismic Zone | III (IS 1893) |
| 11.0 | Rainfall | |
| a) | Max. intensity of rainfall in 24 hrs. | 459.2 mm |
| b) | Period – Monsoon showers | June to September |
| c) | Average rainfall per annum | 1203.5 mm |
| 12.0 | Wind data | |
| | Max. wind speed (as per IS:875)<br>20-61 kmph for 20 days in a year<br>< 20 kmph for remaining period | 62 kmph |
| | Most predominant wind direction | South - West |
| 13.0 | Land | |
| 14.0 | Tropicalisation | |
| | All equipment supplied against specification shall be given tropical and fungicidal treatment in view of the climatic conditions prevailing at site. | |
| | Tropical protection shall conform to BS: CP-1014-1965 "Protection of Electrical Power Equipment" against climatic conditions. | |

| | | |
|---|---|---|
| 15.0 | Electrical | |
| | Refer Volume-III, Section-3, Detailed Technical Specification – Electrical of this tender document. | |

**5.2.0 Design requirements related to site conditions**

The Plot Plan is shown in the enclosed Drawing No. 10-5111168-G-001, ( Rev C).

However Contractor shall optimise the layout based on configuration and his standard equipment layout.

**6.0.0 PLANT LAYOUT AND SITE PREPARATION WORKS**

**6.1.0 Plant Site**

**6.1.1 Site Plot Plan**

In developing the site layout, a system approach shall be adopted with a view to ensure that all the subsystems comprising the power plant are optimally laid out both from the view point of capital cost as well as running costs.

Plot Plan is enclosed as Drg. No: 10-5111168-G-001, (Rev C). However, the Contractor shall further develop layout and arrangement which shall be subject to approval of the Owner/Owner's representative.

The development work consists primarily of clearing the site, grading the site to appropriate levels keeping in view the planning for storm water drainage and green belt and barricading the proposed power plant from operation plant for the construction facility needs.

**6.1.2 Earthworks and Site Grading**

Earthwork in excavation including rock quarrying/blasting if required, identifying borrow pits, transportation of soil from borrow pits, backfilling, disposal of excavated soil is required.

Site is generally plain but necessary grading/levelling required for the construction shall be done by the Contractor. The area shall be suitably cut and filled to suit the layout requirement if required.

Additional soil for levelling for site grading shall be obtained.

**6.1.3 Roads, Fencing and Compound Wall**

Approach roads to the plant site shall be provided to access from existing road network. Roads as required for plant operation & maintenance inside the proposed plant boundary shall be provided. The layout concept of roads is shown in Plot plan. The main plant existing roads area of double lane and the peripheral roads along the proposed power plant shall be of single lane.

66kV GIS, Transformer area, Gas Conditioning and similar unsafe areas shall be fenced off using PVC sheathed GI chain link fencing supported on precast post.

### 6.2.0 Layout of power plant area

### 6.2.1 General

The following factors shall be considered in developing the plant layout.

a) The layout of this Station shall be compact so as to optimize use of land, materials and minimize system losses.

b) Adequate provision shall be made in regard to space and access in order to carry out the maintenance of equipment. Adequate maintenance facilities shall be provided as required, for assembly, disassembly and handling during maintenance of equipment.

c) Due consideration shall be given for the wind direction while deciding on the relative location of Cooling tower and 66kV GIS to minimize the moisture drift towards the GIS.

d) Adequate space shall be provided for unloading and maintenance purposes in Turbine - Generator (TG) area. Requisite lay down area shall be provided for proposed unit on TG floor GTG area and same shall be approachable with electric overhead travelling (EOT) crane.

e) Adequate fire escape staircases shall be provided in power house building with fire doors at each landing.

f) EPC Contractor shall provide the following:

1. For HRSG one emergency exit through chimney staircase in addition to normal staircase.
2. Two staircases for Switchgear room/control room 66 KV Indoor Gas insulated sub-station
3. Two exits for Central Control Room, the elevation (at 2.5 m above the FGL)
4. Cooling tower will have two staircases.

g) The safety requirements as per the Factories Act, Indian Electricity Rules and other applicable codes/standards shall be observed while developing the layout.

h) Adequate maintenance facilities shall be provided as required, for assembly, disassembly, handling during maintenance and alignment work of all important equipments and auxiliaries viz., Gas Turbine, steam turbine casing (inner and outer), diaphragm glands, steam valves, journal/thrust bearings, turbine rotors, generator rotor, end rings, shaft seals, generator bearings, condenser water box, vacuum pumps, CEPs and BFP parts, BFP drive motor, turbine oil coolers, pumps.

### 6.2.2 Power Block Area

The following building / structures and equipment shall be located within power Block.

- Gas Turbine Generator, Steam Turbine and Generator Hall
- HRSG area
- Deaerator and Boiler Feed water pump area
- Control and switchgear building
- Power Cycle pipe rack and cable gallery
- Transformer yard area

A suggested General Arrangement concept of Power Blocks is shown in Plot plan. Bidder shall develop an optimized Layout of the Power Blocks to suit the configuration and equipment offered.

Clear walk ways of minimum 1.5 m width at all the levels shall be provided in the main plant building. TG fire escape staircases shall be provided in main plant building with fire doors at each landing.

For EOT crane maintenance, through walkway shall be provided along both rails at crane girder level. Approach to the crane through rung ladders shall be provided at least at two places.

Gas turbine, Steam turbine, generator, Lube oil system, CEP, and other equipments located in the turbine hall shall be accessible by the EOT cranes for their handling during maintenance and overhauling. For all other equipment/ components located in the main plant building, suitable handling arrangement viz. cranes/ chain pulley blocks/monorail hoists as required shall be provided for the maintenance and overhauling. Wherever special handling procedures are to be followed, the same shall be described in a separate document.

Floor drains shall be provided at all floors and drain discharge pipes shall be properly sized taking into account the fire water sprinkler system wherever provided.

**Gas Turbine, Steam Turbine and Generator (TG) Hall.**

The GTG shall be accommodated in a common Gas Turbine and Steam Turbine Hall of adequate span based on the model and frame size.

GTG/STG building shall be of steel framed building . Adequate space for maintenance of Steam Turbine, Gas Turbine and Generator shall be provided in the layout. The Gas Turbine, Steam Turbine and Generator lay down area shall be provided. Rolling shutter(s) / extended platform shall be provided to facilitate withdrawal of Generator rotor.

EOT crane shall be provided for TG hall for maintenance of equipment / components.

The off base equipment of Gas Turbines shall be located adjacent to the main Gas Turbine on skids ensuring EOT Crane access for the same wherever it is necessary.

**HRSG area**

The HRSGs associated with GTGs shall be located on the side of Gas Turbine building.

Shelter with necessary ventilation shall be provided for BFPs. Shelter shall be also provided with wall cladding as necessary. For SWAS dry section suitable Air Conditioning shall be considered.

The lay down area shall be provided on any one side of HRSG, which would facilitate easy access for erection and maintenance. Electrical drive Equipment located outdoor shall be provided with covered roof /canopy.

In the HRSG area, facility of crane/ chain pulley block/ monorail hoist shall be provided along with provision of space for maintenance/ overhauling of equipment such as boiler circulation pumps, motors, and handling of coils of economizer.

**Control Room**

The control room will be physically divided into sections. Each section will be separated by glass wall and entry door. The system cabinets and all other non-indicating type panels will be housed in one section. Operator consoles, printers, and control desks, auxiliary control panels will be housed in one section. UPS cabinets will be housed in one section. Double door air curtain facilities will be provided at the entry to the control room and the control room will have minimum two entries and exits. Ample space will be provided around the instrument panel / desk, about a minimum of 1.0 m to 1.5 m. The door will be made of glass fixed in aluminium frames. The glass panels will be long preferably one sheet of each frame. The control room will be air-conditioned. The bidder shall do engineering accordingly.

- **Wall panels & windows**

  A soundproof glass panel shall be provided for CCR. The walls and panels shall provide good acoustic insulation, shall prevent the ingress of dust and shall ensure the efficient operation of the air-conditioning system within the Central Control Room (CCR).

- **Other equipment**

  A sufficient number of chairs shall be provided for the operating personnel. These chairs shall be capable of being adjusted for height and position of backrest. The chairs shall be mounted on five castors, shall swivel and shall have arm rests.

  The central control room shall also include sufficient number of file cupboards & printer tables which shall be matching in appearance and dimension with the other hardwares located in the control room.

**Transformer Yard area**

All power transformers (GTG/STG/Station) shall be located outdoor.

Generator transformers shall be located near to the generator to reduce the length of the bus duct from the generator. LT transformers shall be located adjacent to switchgear building in the transformer yard. If dry type LT transformers are provided, it shall be located indoor.

Layout of facilities and equipment shall allow removal of generator transformers, station transformers and without disturbing structure, equipment, piping, cabling, bus ducts routed in the area. Suitable rail track and associated facilities like jacking pads, anchor blocks shall be provided to facilitate the movement of generator transformers(GTG/STG), station transformers to the maintenance bay. The Heat generating electrical equipments including the transformers shall not be placed near to the GT inlet Air filter.

### 6.2.3 Balance of Plant Areas

The Balance of plant areas consists mainly of the following:

a) Water System area
b) CCW / ACW pump area
c) Air compressor / workshop area
d) Waste water forwarding to existing effluent treatment plant.
e) Cooling tower area
f) Fuel gas Handling system area
g) Black start, Emergency DG Area
h) 66kV Gas Insulated Substation (GIS) area

The Cooling Towers (CT) and CW/ACW pumps shall be suitably located considering buried (to a large extent) cooling water piping to and from the power blocks, except at condenser and CW pumphouse end, where it will be above ground and the CT make-up water piping from the water makeup pump area. The CW pumps shall be located in the CW pump area at CT weir end and cooling water from the CT will enter the CW sump through a closed forebay. ACW pump will be taking suction from the closed Cooling Water fore bay.

The air compressor shall be housed in a Structrual steel building. The building shall have space provision for future air compressor. The compressor house shall have a maintenance bay for the air compressor, In addition, workshop area also to be considered in the compressor house. The workshop shall house a radial drilling machine, pedestal grinder and table with vice.

The interconnection pipework between plant utilities and power block equipment shall be routed through pipe racks / sleepers, pipe trenches or buried. The CCW / ACW water piping shall be laid below ground and buried to the extent feasible. Cathodic protection shall be provided for all buried metallic pipelines (such as CCW system, and discharge system etc,) except for such pipes (such as fire protection system etc) running in RCC trenches. Trestles / Pipe Bridge to be provided for routing of cables, pipes shall have a clear height of 7.5m at road crossings for normal traffic & 11.0 m for crane movement A walkway with hand rails and toe guards of 750 mm (minimum) width shall be provided all along length of the trestle for maintenance of cables and pipes. Ladders for approach to these platforms shall be provided near roads, passage ways.

$CO_2$ cylinders banks for GT fire protection shall be stored under a sunshade (if outdoor) and not in an enclosure

Valves shall be located in accessible positions. All piping shall be routed at a clear height of minimum 2.2 m from the nearest access level for clear man movement. Best engineering practices shall be adopted for keeping the minimum clear working space around equipment and clear headroom within main structures and cable trays.

Fire water pipes in power block area may be routed in trenches covered with pre-cast RCC covers or buried with coating covered with sand with due consideration of lack of corrosion protection.

**6.2.4 Non-plant Buildings**

Any other non-plant buildings like Administration building, canteen building, O & M building, is not envisaged in Contractor's scope.

**6.3.0 Layout and other facilities**

**6.3.1 DM and CW make-up storage tank**

The DM and CW make-up water storage tank shall be above ground water storage tank with top roof closed .The DM water transfer pumps shall be located adjacent to the DM water storage tank.

**6.4.0 Hazardous areas, fire protection provisions**

**Hazardous areas (Refer Area Classification Plan (Overall) – Drawing No. 3114-00-16-50-0005, Rev.0 & Hazardous Area Classification Diagram (Drg.No. 1-38101-00213, Rev.0) enclosed under List of tender drawings (Vol-IV,Sec-6).**

The Bidder shall take full account of any special requirements concerning the nature, handling and storage of all oils, gases and chemicals and provide plant, equipment, buildings and other services accordingly, including all facilities to ensure the safety of the operating and maintenance personnel.

Areas where a potential flammable atmosphere may exist shall be classified in accordance with the provisions of latest version of relevant IS. Certified equipment shall be used in the designated hazardous areas. To the extent practicable, equipment requiring operator's attention and/or electrical equipment shall not be installed in hazardous areas.

The Bidder shall provide drawings to define all the hazardous zones taking account of all sources of hazards under normal and abnormal operating conditions, (regardless of whether or not these areas are specifically listed in the specification).The zoning philosophy shall be subject to the approval of the Owner/Owner's representative and shall follow OISD standards.

In particular, equipment directly concerned with plant which may give rise to a hazardous situation shall be designed to requirements with electrical connection safety barriers or intrinsically safe equipment. Where required by the Owner/Owner's representative , certification shall be provided to confirm the suitability of the equipment and devices.

The Contractor shall be responsible for ensuring that all electrical equipment installed in any hazardous zone is designed and tested to suit the relevant zone classification and shall be to the approval of the Owner/Owner's representative. Cables shall not be laid in trenches with fuel pipe work.

**Fire protection provisions**

Unless otherwise specified or agreed with the Owner/Owner's representative, the following design principles should be observed as minimum fire prevention requirements:

Pipeline insulation and the infills of cable and pipeline wall penetrations are to be of non-combustible material.

All pipelines or vessels with internal temperatures of more than 180 °C shall be so arranged as to avoid any contact with flammable liquids if fuel or lube oil lines should leak. Sufficient physical separation shall be ensured.

Particular care should be taken to eliminate any risk of hot pipeline-insulating material becoming impregnated with flammable liquids in the case of fuel or lube oil line leakage. The insulation is to be covered in its entirety, with an oil resistant sheet, over which the cladding is to be fitted.

Cable and pipeline ducts must be so arranged and sealed as to avoid any risk of flooding with, lube oil or any other flammable liquid. In addition to sealing the cable and pipeline ducts, the cable basements must be completely sealed against leakage from above as well, in order to preclude the ingress of lube oil or other flammable liquids.

Covered floor ducts must be easily accessible for inspection and cleaning.

All parts of plant and equipment are to be arranged so that no corners or pits that would be difficult to inspect and clean and in which flammable matter could collect are formed.

Fuel pre-heating temperatures shall be limited to a margin of atleast 10K below the fuel flash point.

Lubricating oil lines in the turbine-generator lube oil system are not to be connected with compression-type joints but rather with welded or screwed-type points.

Non-combustible materials which do not release noxious or toxic fumes must be used for wall and ceiling panelling, for floor covering, and for cubicles and cabinets.

## 7.0.0 GENERAL PLANT DESIGN REQUIREMENTS

### 7.1.0 General

The design of the combined cycle power plant consisting of GT, ST & Generator, HRSGs and associated auxiliaries shall generally conform to the following requirements and shall be new and unused.

The plant shall be constructed considering prudent engineering practices and optimal utilization of resources. These shall be complete and include all the equipment and systems necessary to ensure required level of reliability, availability, efficiency, and high level of safety and maintainability over their lifetime. It is also necessary to consider various precautions to safeguard the operating and maintenance personnel.

The Plant shall be suitable for full range of ambient and other environmental conditions as per specified site conditions in this contract. The design of the power plant shall ensure that the plant can, in the state of normal operation, adapt itself to load, frequency, power factor, ambient variations within the allowable range of design and the Grid Code requirements.

The auxiliary systems and plant facilities shall be designed for serving the whole power plant with adequate redundancy. The redundancies shall be provided as specified in this Contract. Secondary system component shall be designed with suitable redundancy (redundancies are as specified in this Contract) in order to achieve the required reliability and availability of the power plant.

The life span to be considered for the design of equipment and component selection shall be at least 25 years and components which are not meeting this requirement shall be identified and its life shall be guaranteed, specifically in the Contract. Due to operation requirement, the plant components or parts will have definite material life span requiring replacement on more frequent basis, which needs to be recognized. Certain components like electronic parts, DCS, bearings, components subjected to wear and tear etc. will have a definite life span which will be less than 25 years. These components have lower shelf life and the life of the equipment needs to be prolonged by replacement of these components.

The various parts and systems of the power plant shall be designed to achieve the object of providing integrated and coordinated power plant operations. For the design of the power plant, it is necessary not only to consider the requirements of operation, but also, by suitably planning the layout, the convenience for inspection, cleaning, maintenance and repair are ensured.

The various parts or components or assemblies of equipment and systems shall be of proven materials with well established physical and chemical properties appropriate to the service as intended.

All materials, components and equipment shall be tested at all stages of procurement, manufacturing, erection, commissioning as per comprehensive Quality Assurance Programme to be agreed mutually between the Owner/Owner's representative and the equipment supplier.

In the design of the power plant and selection of equipment, the specific requirements of this project and likely occurrences of abnormal operating conditions (The abnormal conditions are, 1. During fluctuations in grid frequency and voltage (within the specified limits as specified in the specifications) 2. During load swings (from minimum stable operating load to base load) without any restrictions in operation). have to be taken into consideration to ensure that the power plant can, under these circumstances, operate continuously, safely and without undue loss of efficiency. The selection of materials shall be suited to local operating and ambient conditions.

Equipment installed outdoors shall be capable to operate in all-weather conditions and withstand the work site environment.

The equipment must operate without undue vibrations that may affect its operation/life and that of other machinery or of civil works under every condition.

Corresponding parts throughout the plant shall be made to gauge and be interchangeable for all models of same duty. The supplier shall provide the necessary original part references for all kinds of parts of equipment.

All equipment performing similar duties shall be of the same type and manufacture in order to limit the stock of spare parts required and maintain uniformity of plant and equipment to be installed to the extent feasible. Exact requirement, if feasible, will be ascertained during detail engineering.

The design & construction of plant shall be such that it is suitable to comply with all applicable environmental stipulations of the Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCB) including in regards to flue gas emissions, liquid effluent discharges, solid waste disposal, noise levels.

The plant site is in the coastal area, hence the environment is likely to be corrosive and the materials of construction for all exposed metal/ concrete surfaces shall be so chosen as to withstand the corrosive environment. Also suitable weather protection shall be provided to all exposed surfaces. Undergournd piping shall be provided with suitable anti-corrosive measures.

All stand-by auxiliaries shall be designed for auto start up, on failure of running auxiliaries with minimum time delay and without runback on unit load.

All heavy parts of the plant must be provided with some convenient arrangement for aligning and for handling during erection and overhaul. Any item of plant required to be stripped or lifted during period of maintenance and weighing one tonne or more shall be marked with its approximate weight.

### 7.2.0 Standards and Codes of Practice

All equipment, systems and works covered under these specifications shall be in accordance with all the applicable statutes, regulations, codes and standard specified as well as all such standards, statutes, regulations and safety codes applicable in the locality where the equipment will be installed. Contractor may familiarize themselves with all such requirements. Complete design including pressure parts, piping, valves and fittings shall meet or exceed all the latest requirements of the Indian Boiler Regulations (IBR),latest Indian Standards /ASME codes, latest codes and standards as applicable . Any Indian/International standards shall be followed for any imported equipment. For plant layout aspects and area classification requirments OISD standards shall be followed.

The design, construction and testing of all equipment, facilities, components and systems shall be in accordance with relevant standards and codes issued by Bureau of Indian Standards (BIS) and/or reputed international standards and codes as on the date of Award of Contract. A non-exhaustive list of reputed international standards is given below:

a) American National Standards Institute (ANSI)

b) American Petroleum Institute (API)

c) American Society of Mechanical Engineers (ASME)

d) American Society of Testing and Materials (ASTM)

e) American Water Works Association (AWWA)

f) American Welding Society (AWS)

g) British Standards (BS)

h) Cooling Technology Institute (CTI)

i) Deutsches Institut fur Normung (DIN), Germany

j) Gosstandart of Russia (GOST) standards

k) Heat Exchange Institute (HEI), USA

l) Hydraulic Institute Standards (HIS), USA

m) International Electro-technical Commission (IEC)

n) Institute of Electrical and Electronics Engineers (IEEE)

o) International Organisation for Standardisation (ISO)

p) Japanese Industrial Standards (JIS)

q) National Electric Code (NEC), USA

r) National Electrical Manufacturers Association (NEMA), USA

s) Central Electricity Authority (Construction of Electrical Plants and Electric Lines) Regulations, Notification, 20th August 2010 and to those referred therein

t) National Fire Protection Association (NFPA), USA

u) Occupational Safety and Health Administration (OSHA)

v) Tubular Exchanger Manufacturers Association (TEMA), USA

w) VDE association for Electrical, Electronic and Information Technologies (VDE), Germany

x) OISD

Other international Standards, equivalent or superior to the above Standards can also be adopted. However, In the event of any conflict between the requirements of the international

standards or codes and the requirements of the BIS standards or codes, the latter shall govern unless specified elsewhere in the specifications. Any Indian/International standards shall be followed for imported equipments.

The Plants and Electric Lines (within the plant) shall also be designed to comply with the requirements stipulated in.

a) Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006.

b) Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2007.

c) Central Electricity Authority (Measures relating to Safety and Electricity Supply), Regulations as and when these are notified by the Authority.

d) Central Electricity Authority (Safety Requirements for Construction, Operation and Maintenance of Electrical Plants and Electric Lines) Regulations as and when these are notified by the Authority.

e) Central Electricity Authority (Grid Standards) Regulations as and when these are notified by the Authority.

f) Central Electricity Authority (Construction of Electrical Plants and Electric Lines) Regulations, Notification, 20th August 2010 and to those referred therein

g) Indian Electricity Grid Code issued by Central Electricity Regulatory Commission (CERC) and

h) Applicable State Grid Code issued by appropriate Regulatory Commission.

All material and equipment supplied and all work carried out as well as calculation sheets, drawings, quality and class of equipment, methods of inspection, constructional peculiarities of equipment and parts and acceptances of partial plants, as far as these are beyond the special requirements of the specifications, shall comply in every respect with the technical codes of the above listed codes and Standards.

It shall be the responsibility of the Contractor to take all approvals required and get the HRSG registered under the IBR. In all other cases where IBR does not govern, IS/ASME, Japanese, American, British, German or other international standards established to be equivalent or superior to IS/ASME shall be acceptable with the approval of the Owner/Owner's representative at the time of detailed engineering.

Where there are no standards or regulations, or the standard is not sufficient to meet the need of design and supply, for such items relating to the power plant, the Contractor shall carry out the design, manufacture, supply and installation on the basis of good engineering practice.

During the period of Contract execution, if any standards change, the Contractor shall be responsible to notify the Owner/Owner's representative and provide the basis for the prospect that it would not cause the lowering of quality, performance and service life of the power plant due to alteration of the standard and the latest standards shall be followed by the Contractor.

Further requirements about applicable standards and codes are specified in the detailed technical specifications.

### 7.3.0 Operating Capabilities

The power plant will be operated in parallel with the grid normally at base loads as required and as permissible by the Original Equipment designs, but meeting the requirement of the Grid Code in all cases considering the fuel specified.

Combined cycle module, comprising of Gas Turbine, Steam Turbine, Generator and HRSG , shall deliver its Guaranteed Gross Power Output of 51 MW (Minimum) at the specified Site Reference Conditions and with the specified fuels & utilities at the guaranteed Gross Heat Rate at the time it is tested as per the Contract and thereafter with normal and reasonable degradations (as provided by MPP), performance will be subject to degradation as per MPP supplied curves.) where applicable considering the planned inspection and maintenance as proposed by the Contractor in the Contract without any undeclared expiry of life expectancy.

All combined cycle plant equipment sizing shall be carried out considering the maximum unrestricted gross power output.

In all cases it is understood that the plant will be operated & maintained by qualified professionals utilizing the Operation instruction and the Routine & Preventive Maintenance instructions as specified by the MPP and Planned Maintenance will be conducted under the supervision of MPP utilizing the parts acceptable by the MPP. It is also understood that Operator actions in case of emergency situations will be as per prudent industrial practices in India.

The unit shall be designed for constant pressure and sliding pressure operation.

The gas turbine, steam turbine and all rotating auxiliaries shall be suitable (That is offered equipment and it's arrangement in relation with other connected equipment should have been already validated) for continuous operation within the frequency range of 47.5 Hz to 51.5 Hz.

All the auxiliary equipment and the drive motors shall be capable of delivering satisfactorily their actual output continuously for voltage variation, frequency variation and combined voltage and frequency variation as indicated elsewhere in the specification.

The design of the equipment and control system shall be suitable for operation of the CCGT module in automatic load frequency control.

The design shall cover adequate provision for quick start up and loading of the unit to full load at a fast rate. The ST loading or unloading shall be in line with the recommendations of MPP.

The unit shall be capable of automatically coming down to house load and operation at this load in the event of sudden external load throw off.

There shall be a HP and LP bypass system to facilitate quick starting and loading under hot restart conditions and to facilitate conserving condensate where too many start ups occur. Owing to certain conditions in the system, part load operation of the machine could occur for prolonged durations. Under such conditions there shall not be any undue deterioration in the parts and the elements. The turbine unit shall be capable of deriving economic benefits due to lower temperature of inlet air to GT as per ISO conditions, circulating water and environment in winter.

### 7.4.0 Vibration

Vibration shall be reduced to the minimum as far as possible where it cannot be completely eliminated. Amplitude and frequency limitation in the design and supporting structure shall be considered for vibration, The variation in grid frequency to be considered for vibration design

shall be 47.5 Hz to 51.5 Hz. Also verification of structures for their natural frequencies shall be carried out by Contractor.

Special care shall be taken to avoid operating equipment making resonance with foundations, packing, duct, platform, piping or other components.

Unless otherwise stated or agreed by the Owner/Owner's representative, each rotating machine has to comply with the requirements for designation as 'good' stipulated by ISO standard for the respective group of machinery.If the vibration is higher than stipulated as 'satisfactory' the Owner/Owner's representative has the right to reject the corresponding equipment, subject to the conditions specified elsewhere.

**7.5.0 Noise levels**

The plant shall be designed and constructed to reduce the operating noise level as much as possible and when the plant is operating at all loads, the noise pressure levels specified in Section 17-Environmental Requirements shall not be exceeded. Any noise emanating from any protective systems such as ST bypass, and safety valve is excluded. For background noise from the existing plant, noise levels will be measured before commencing the test for proposed plant,

a) Noise level at the Property boundary shall not exceed the Ambient Air Quality Standard in respect of noise as stipulated by CPCB and SPCB in this regard.

b) Noise level for the continuously operating equipment including GT, ST & Generator, BFP, and CWP shall not be more than 85 dB(A) at a distance of 1 metre and at a height of 1.5 metre from any equipment .For short term exposure, noise levels shall not exceed the limits as stipulated in the Occupational Safety and Health Administration (OSHA) Standard.

c) For control room and offices, noise level shall not exceed 60 dB (A) near to the duct and at other places in the control room/offices noise levels shall not exceed 50 dB (A).

d) Equipment/ machines shall be provided with acoustic enclosures, wherever required so as not to exceed the permissible noise limits.

**7.6.0 Units of Measurement**

For all the technical tables and diagrams, calculation results, drawings, test data and scales adopted in the design and provided for the power plant, the standard international unit system (SI) as per International Standardization Organization (ISO) shall be uniformly employed.

SI system shall be employed for all the plant layout and arrangement drawings of equipment made especially for the project.

**7.7.0 Safety**

For this Project, Contractor shall have a dedicated Safety and Health Section, within the Project Team. The dedicated Safety and Health Section shall monitor all safety and health related activities at the site.

The construction site shall have one qualified officer responsible for health and safety co-ordination. He will be assisted by requisite numbers of safety supervisors and firemen to ensure smooth progress of work at site. This person shall ensure that safe and healthy working practices are implemented and maintained. A pro-active health and safety programme shall be implemented that provides the following for all Contractors' workers:

a) Policy statement, philosophy, objectives and targets, procedures and training that are compiled to produce a Health and Safety Plan;

b) A minimum of one (1) health and safety awareness meeting per month for all personnel; and a minimum of two (2) health and safety preview meeting per month for construction supervisors and designated health and safety personnel to assess the programme's effectiveness and implement improvements as necessary;

c) Continuous health and safety performances monitoring and audits;

d) Weekly health and safety statistics reporting;

e) First aid facilities and personnel; and

f) Procedures for responding to emergency situations.

The Contractor shall furnish and issue approved safety helmets, safety boots, safety belts, protective goggles, protective clothing, breathing equipment, as applicable, to all workmen and authorised personnel during the course of hazardous construction of all types.

The Contractor shall provide and properly maintain warning signs and lights, barricades, railings, and other safeguards for the protection of personnel as required by the conditions and progress of the work.

Special importance shall be assigned to all aspects related with the safety of personnel operating, assembling and maintaining the equipment, including other persons who are likely to come in contact with same.

The possibilities of human failure must be foreseen. Provisions shall be taken to avoid damage caused by human error or to ensure that such damage both to persons as well as to the equipment is the least possible.

Rotating or any other moving part of the machinery, hot parts or any part that may cause accident to the staff must be adequately protected, in accordance with the safest method known.

All components with surface temperatures exceeding 60°C shall be fitted with insulation to protect personnel. The surface temperature shall not exceed 60°C if the condition of the ambient temperature is 40°C and wind velocity is 1 m/s.

However if there are any hot spots such as connection of expansion joint to duct, where the surface temperature may exceed 60 deg. [C], suitable personal protection for the hot spot on exhaust duct shall be provided.

Bright paints used will be agreed upon with the Owner/Owner's representative to protect personnel, so that anything representing a potential danger will stand out: such as elements in movement, suspended hot, with electric tension.

It should be possible to carry out routine maintenance operations required by the equipment without interrupting its operation and without danger to the personnel.

Access stairs to the equipment must be safe, with anti-skid rungs and handrail. Normal circulation areas of the equipment shall be protected to keep personnel from falling or shall be surrounded by strong guardrails, platforms should have kicking plates to keep loose objects placed on the floor from dropping off, entrances and large openings in the equipment

shall be provided with lids or doors affixed in such a way as to open them also from the inside.

Every equipment or parts of equipment that must operate under certain conditions of maximum pressure, temperature, speed, position, should have devices to keep such limits from being exceeded and, if necessary, to stop the operation of the machine (Safety valves, limit switches, thermal switches).

For protection against the possible failure of the above devices, additional safety elements shall be provided such as stroke limiting stops, diaphragms, bolts and/or links or other dimensioned rupture elements so that in case of failure, when exceeding extreme operating conditions, additional safety is provided to the equipment.

Inside air and gas ducts, ladders have to be installed for inspection of dampers, venturies.

In designing an area where combustible gases are likely to accumulate, due consideration shall be given to provide safety measures to allow the gas to continuously diffuse or leak off to prevent explosion. The electric equipment in those areas shall be of the fireproof and explosion proof type. Suitable grounding shall be provided on the casing of electrical apparatus which might be energized.

Draining of water and venting of gas shall be performed with respect to the safe mode of discharge, and is not allowed to be carried out at or near the places where people exit and at the exit of the plant.

### 7.8.0 Fire Protection and precautions

The Contractor shall adopt necessary methods to minimize fire hazards.

The fire protection system shall in general follow the recommendation of TAC / NFPA / OISD standards. However, GT $CO_2$ Fire detection and protection system will be designed and supplied based on NFPA 12 ,IS – 2189/ NFPA-72.

The design of power plant shall include a complete set of composite fire monitoring, protection, and fighting system to identify, isolate, and distinguish fires as well as minimizing potential fire hazards.

A warning alarm for the power plant and alarm for evacuation shall be provided. The alarm is to be audible in the normal working areas of personnel. The selection of the alarming device shall be such that it is audible about the normal background noise of the plant. Visual alarm shall be provided in addition to audio alarms in high noise areas.

During the construction phase of power plant, the Contractor adopts advanced and safe working practices and a set of guidelines to keep the site in a clean condition to reduce the possibility of fire. The basic guiding ideology is to adopt two methods: fire prevention and fire control shall adopt to improve conditions in designing the layout, to reduce potential fire danger, ensure the safety of personnel, ensure the safety of the important and main equipment of the power plant.

Use fire proof or fire resistant materials ensuring that isolating combustible material is not used or stored in possible fire source area of the power plant.

The end connection type of hydrant shall fit in with local fire brigade requirements to ensure the manual device in power plant to be compatible with the fire control device of local fire brigade.

### 7.9.0 Signs

Safety colours, safety symbols and safety signs must comply in construction, geometrical form, colour and meaning with the ISO Recommendation 507 of the ISO committee TC 8O 'Safety Colours'. All signs should give the identification number. All signs shall be in the English language.

The signs should be of a material which is weather-resistant and of sufficient durability for the conditions prevailing on site. Indian regulations and codes are to be considered.

The positions for the signs must be chosen so that they are within the field of vision of the persons to whom they apply. The signs should be permanently attached. Temporarily dangerous areas (e.g. construction sites, assembly areas) may also be marked by movable signs. The safety signs must be mounted or installed in such a manner that there is no possibility of misunderstanding.

All Necessary Traffic signs, Information sign, Emergency sign , Mandatory signs, Warning sign, Prohibition sign viz., No Smoking, No Entry, Do Not Start, shall be provided at appropriate area in the entire power plant area.

### 7.10.0 Package, Storage and Store House

The Contractor should provide all the specifications and instructions for the self purchased and fabricated equipment during the planning period of the Contract. These specifications should include the cleanliness and maintenance requirements of materials during fabrication and the protection measures for the equipment from damage during transportation. Loss of materials during storage should be avoided before installation. The instruction should be worked out especially to suit the particular work site program.

All materials and equipment should be packaged according to the typical environmental conditions during storage. In case of severe conditions, these materials and equipment should be packaged carefully by taking a full and appropriate preventive measure to protect from any damage or wear.

The Contractor and his appointed Subcontractor for installation should guarantee jointly that a good supplementary storage will be carried out within the equipment site controlled by them.

Three classes for storehouse are described as follows:

Storehouse class A items: Special measures are taken to protect the stored goods and the temperature, humidity are controlled within a specified range.

Storehouse class B items: Goods are stored with temperature uncontrolled.

Storehouse class C items: It is an outdoor storage with a drainage system on the ground.

For storehouses of class A and B they should be fireproof, heat resisting, waterproof and well ventilated. They should not be wet and should be provided with good drainage system and preferably with a brick laying or concrete ground. For storehouses of class C, they should not be wet and should be well drained, preferably with a brick laying or crushed stone ground, should be protected from rainfall, salt corrosion, ash and other adverse conditions with a temporary cover or tent if possible.

Component surfaces should not be contacted directly with the ground or ground laying material. There should be a layer of oilcloth or wax or other similar materials between the machine surface and ground surface.

All components shall be inspected for their painting, storing, sealing and any damage or wear should be repaired during acceptance and storage periodically. The inspection interval is determined by the component function, applied protection measure and storehouse class.

Many components are provided with a drying agent or sealed in a coverage (polyethylene or insulating cover) containing drying agent. The drying condition shall be inspected during storage in an interval of every 4 weeks.

**7.11.0 Painting, Insulation, Anti-dewing**

Anti corrosive coatings and painting shall be carried out as a pre-treatment to all equipment and parts. The paint system used should coordinate with the painted objects and surrounding conditions of project.

In multi-layer painting system, different painting layers should be selected to make the painting coordinate. If multi-layer painting system is used, various painting layers should have distinct colours so that the later layer can be distinguished from the former one.

After the equipment or apparatus finished preliminary or full painting, it can be supplied to field. After the installation is finished, ground coat must be painted.

Entire painting procedure should be supplied in order to repair the injures of painting coat after the equipment is delivered to field.

Colour strip indication system should be used for pipes. These strips should be painted on the joint of pipes, entrance, valves of pipe. This pipe without outside protection layer should be marked by some colour in whole length. ***Refer Annexure-3 (Vol-IV,Sec-8) for the color coding of piping and fire equipments.***

The principal colour of field equipment should be determined by Owner/Owner's representative and Contractor during execution stage. For Electrical equipment, paint shade shall be as mentioned in the equipment Specification.

Further requirements with regard to painting, insulation, and anti-dewing are specified in the relevant sections in the detailed technical specifications. The specified requirements shall be applied to the whole equipment and facilities of the Contract.

Insulation specification for MPP supplied equipment shall be as mentioned in detailed technical specification.

**7.12.0 Language to be used**

English shall be used as the general Contract language English translations shall be provided for any code and standards not in English language.

Name plates of equipment and instrument scale shall be marked in English.

Documents for training shall be provided in English.

Danger signs / Exit signs shall be in English, Hindi and Gujarati.

**7.13.0 General Mechanical Requirements**

This section covers the general mechanical requirements of all other sections of this specification and shall be complied with in every respect unless otherwise stated or agreed by

the Owner/Owner's representative. Further requirements to be applied are specified in the detailed technical specifications.

### 7.13.1 Castings and Forgings

The quality requirements of approved international other national standards shall be taken as the minimum requirements.

Cast iron is not to be used for any part of equipment which is in tension or which is subjected to impact, or to a working temperature exceeding 100°C unless specifically approved by the Owner/Owner's representative. Materials for iron castings shall comply with approved international or national standards.

All forgings are to be manufactured from basic electric steel or fully killed acid open-hearth steel. Consideration shall be given to the use of vacuum-degassed steels in appropriate cases.

Forgings shall be free of cracks externally or internally, extensive non-metallic inclusions and surface defects which cannot be removed by subsequent machining.

Each forging shall be suitably branded with an identification number which shall be transferred throughout all final machining stages. The identification number shall be marked on all documents and test certificates relative to the forging.

### 7.13.2 Pumps

The following represents general requirements for pumps Intended for various services and the same shall be read in conjunction with the requirement specified elsewhere in the detailed specifications.

**General**

All pumps shall be so designed that they are suitable for continuous operation unless otherwise specified.

Pumps installed for parallel operation or as standby sets are to be of the same design, i.e. interchangeable (Subject to application, fluid handled and identical model).

Standard-type pumps with suitable characteristics shall be used wherever practical. Only proven makes and models are to be supplied to the extent feasible. All accessories and the overall design of pump sets are to be such that they are suitable for automatic operation as specified for the relevant systems.

All pumps shall comply with the applicable recommendations of Hydraulic Institute Standards (U.S.A) or approved equivalents (Latest codes and latest standards as applicable). Special pumps which are designed only as per manufacturer standard shall be identified and stated in the bid. Deviations to the specified Standard if any shall be subjected to approval by the Owner/Owner's representative prior to ordering the same. Owner/Owner's representative understands that deviations to the standard are to be recognized, but the reputation of the OEM, past performance at similar application and fit for the purpose consideration are the only considerations in accepting the deviations.

**Pump types**

Centrifugal pumps shall be used wherever possible.

Rotary-type positive displacement pumps will be accepted for handling viscous liquids, and reciprocating/plunger pumps will be accepted for chemical dosing and metering purposes

All pumps shall have a continuously rising head (up to shut-off) characteristics with the minimum shut-off head of 115% but not exceeding 125% of the head at best efficiency point for the rated impeller.

The pump shall be designed to have best efficiency between the rated and normal point. However in no case the rated point should be beyond 115 % of the best efficiency point.

Contractor shall note that the pump characteristics as obtained during the performance testing of pump shall not deviate from the characteristic furnished during earlier stages of approval particularly with regard to the operating point and shut off head and steepness of the curve beyond the duty point. Pump characteristic curve can be furnished during detailed engineering stage after finalization of specific vendor.

All large capacity and continuously operating pumps shall have 5% flow and head margin each, and all other pumps shall have flow and head margins of 10% and 15% respectively unless specifically stated otherwise in the detailed specification

The pump shall be capable of meeting the actual requirement for continuous operation at 47.5 Hz.

The equipment shall be made suitable for outdoor installation (this shall be applicable for pumps intended to be located outdoors). Weather/environmental conditions under which the equipment must operate are specified in the 'Project Data'. However, for the Owner/Owner's representative's guidance, the contractor shall list any special protection that the Owner/Owner's representative is required to arrange.

Pump shall be capable of automatic start up from stand still condition with discharge valve fully open in general. Motor shall be selected according to the above requirement.

Difference in flows handled by the two pumps when operating in parallel shall not be more than 5% of the flow through any one pump.

The impeller shall be of non-overloading type, Overloading type of impellers are acceptable for BFPs and CEPs, however the motor shall be designed taking this into consideration and shall be suitable for run out flow.

A hardness difference of 50 BHN minimum shall be maintained between the impeller ring and wearing ring, inter-stage bushing and spacer sleeve and balancing and spacer sleeve and Balancing disc/piston and counter balancing disc.

Mechanical seal of shall be provided at both ends of the shaft of pump for DM water/ Feedwater/ Condensate.

The maximum temperature rise of bearings shall not exceed as per standard over ambient temperature.

All major rotating components shall be dynamically balanced. The assembled rotors shall be dynamically balanced.

The Contractor shall also demonstrate that the pump can operate at the quoted minimum continuous stable flow without exceeding the vibration limits as stipulated in HIS.

Pump-motor set shall run smooth without undue noise and vibration .The limits of vibrations shall be applicable with maximum wearing clearances.

Acceptance of the forced lubrication system shall be subjected to the approval by the Owner/Owner's representative. Forced oil lubrication system provided for HP/LP BFPs shall be supplied with separate AC driven lube oil pumps, lube oil plant with interconnecting piping and controls. Acceptable peak to peak vibration limits shall generally be guided by HIS.

The drive motor rating shall be selected such that a minimum margin of 25% up to 18.5KW, 15% for 22-55KW, 10% for above 75 KW is available over the pump input power required at the rated duty point. However, motor rating shall not be less than the maximum power required by the pump at any point on the curve including the run-off condition.

### 7.13.3 Piping and Appurtenances

All the skid mounted equipment piping wherever specified shall be in fully assembled condition. Piping shall be duly supported on the base plate and terminated with ANSI flange at the edge of the base plate towards suction. Piping shall be properly tagged with metallic strips.
In mechanical seal cooler, cooling water shall be used on shell side. Tube shall be made of SS304.Shell shall be of carbon steel. Tubes used for cooling bearing housing shall be of SS 304.

Forced oil lubrication when used shall have all supply lines in stainless steel (from downstream of strainers) and return lines in carbon steel.

MPP supplied piping and Appurtenances shall be as per MPP standards.

The technical and design features of each is elaborated in a separate section.

### 7.13.4 Suction Strainer

Strainer shall be provided on suction line of each pump except for DM water application. Generally Basket type strainer is preferred .The clear area of strainer shall be five times the inlet cross sectional area of the connecting piping. Strainers shall be constructed of 16 gauge perforated stainless steel plates (304grade) and shall be lined with stainless steel (316 grade) screen.

The design pressure for strainers shall corresponding to maximum system pressure envisaged during the worst operating condition

The pressure drop across the strainers at rated flow under 100% cleaned condition and 50% clogged condition shall not exceed 0.1 kg/cm² (max.) and 0.15 kg/cm² (max.) respectively.

The strainer shall be so designed that they all capable of sustaining the differential pressure at rated design flow and 50% clogged condition.

Suction Strainers supplied by MPP shall be as per MPP Standard.

### 7.13.5 Welding

All welding / cutting / rework on IBR piping shall be strictly done as per IBR code.

All welding process shall be of standard and internationally agreed type and designation free from all unproven innovative or development features

All costs for inspection and testing including any additional tests required by the Owner/Owner's representative shall be deemed to be included in the Contract Price. Any additional inspection and testing required by the Owner/Owner's representative shall be performed promptly and no claims for consequent delay or disruption of the work will be considered. All tests shall be conducted as per finally approved QAP. There is no additional test required other than mentioned in the QAP.

The procedure to be followed in production welding of all parts of the vessel including main seam, circumferential seams, and branches shall be provided in detail by the Contractor for the Owner's /Owner's representative's approval.

Welding, post weld heat treatment and other non-destructive testing shall be conducted by Contractor as required by the ASME and as instructed by the Owner/Owner's representative. Procedures of all welding, welder qualification and treatment of welding defects, pre/post welding heat treatment, NDT shall be performed after welding as per ASME and Testing requirement shall be approved by Owner/Owner's representative. Contractor shall arrange suitable stress relieving equipment with automatic recording device.

All necessary radiography as per applicable code shall be included in the scope of work of the Contractor.
Approval of the welding procedure shall not relieve the Contractor of his responsibility for correct welding, electrodes and for minimising distortion in the finished structure.

All welders and welding operators shall be qualified for the work and shall hold current welder's qualification certificates in accordance with the ASME Sec. IX and IBR.

For welding on site, the Contractor shall provide drying ovens in sufficient number to permit the correct storage of electrodes for 48 hours before use. Drying ovens shall preferably be heated by electric means and shall have automatic heat controls and visual temperature indication. The storage temperature for electrodes shall be as stated by the manufacturer but in the case of low hydrogen electrodes shall not be less than 100 °C. The re-baking of low hydrogen electrodes shall be strictly in accordance with the manufacturer's recommendations.

Welds of stainless or special steel with steel which is not stainless must be made in a manner which ensures that the stainless steel or special steels do not lose their corrosion-resistant or other special properties.

Welded seams shall not be painted before inspection; in case of necessity, only colourless coating may be used.

All controls, examinations and tests corresponding to these specifications, shall be performed by the supplier, without detriment to the Owner's/ Owner's representative's inspection right to verify and control them on their part or to repeat them if they deem it is necessary.

The supplier shall keep 'welding records' for all pressure pipes with a qualified welding method, as well as for condensers, deaerators, water pipes, pressure vessels and other important weldings. He shall record on them, after every working day, the number of weldings executed during the day, their location, identification of welders, measured preheating temperature (if any) and other information of interest.

The Inspector shall be notified at regular site meetings at least 2 days prior to the commencement of any assembly or fabrication work.

All control protocols, such as of the qualifications of welders and methods, of evaluation of x-rays, of magnaflux examinations, as well as the x-ray films, shall be submitted to the Owner / Owner's representative's inspection for their approval at appropriate time.

Qualification of welders

The standard to be applied for the qualification of welders shall be approved by the Owner/Owner's representative. Welders shall be qualified according to the section IX of the before mentioned ASME standard. The inspector of the Owner's / Owner's representative's has the right to attend during the qualification tests. Tests with unsatisfactory results made by a welder under qualification may be repeated by him doubling the number of tests (This will be reviewed case by case during detailed engineering). For the welders acceptance each of the repetition tests has to be satisfactory. The supplier shall keep a 'registry of welders' on which he shall record systematically: qualifications, part of the supply on which they intervene, major faults and comments.

Qualification of methods

The variables to be considered in defining the weldings subjected to special qualification of method shall be agreed upon with the Owner/Owner's representative. Stipulations in Q-11, section IX, of the mentioned ASME standard, shall govern for this purposes.

Control of executed weldings

Unless otherwise agreed or unless other contractual stipulations exist, the section VIII, point UW 51 of the ASME standards, shall apply for 100 % x-ray controls, and the point UW 52 for x-ray sampling examinations, excepting from the last the indications about porosity which shall be agreed upon separately.

The Contractor shall have at the works site all necessary equipments and facilities to perform control, like portable x-ray equipments, radioactive isotope equipments, x-ray laboratory, magnaflux equipment, dye check penetrants and developers, fluorescent power and ultraviolet lamp to verify the watertightness of expanded tubes. The Contractor's personnel shall include a specialist and the auxiliary workers necessary to execute the controls.

### 7.13.6 Lubrication

Lubricated elements shall have a safety reserve against occasional lubricating deficiencies or their retaining capacity should be such as to operate without damage even if delays occur during maintenance periods. As far as possible, lubrication of the given element in the machine should be done with the same lubricant under all climatic conditions (winter and summer) and furthermore, a limited number of different types of lubricants should be required for the different parts of the equipment. Lubrication oil and grease of any brand shall be easily obtained on the local market in India. This requirement will be ascertained during detailed engineering and outcome of this will be informed to Owner/Owner's representative.
Where centralised lubrication system is provided then it shall include purification of the main lubricant by centrifugal or static filter.

Lubricant deposits such as those on bearings, accumulation tanks, should be easily accessible, simple to clean and to control their level and it should be possible to empty their contents.

The required lubricant characteristics shall be stated, also indicating the trade name for the products.

### 7.13.7 Vessels, Tanks and heat exchanger

All pressure vessels shall be designed in accordance with ASME Boiler and Pressure Vessel, Section VIII Unfired Pressure Vessels. All butt welds shall be subject to radiography test as per ASME relevant code and all other welds shall be subject to 100% non destructive testing. Other standards the Contractor intends to use are to prior approval of the Owner/ Owner's representative. All flanged connections to pressure vessels shall conform to at least pressure class 150. Threaded connections shall conform to pressure class 300. MPP supplied vessels, tank and heat exchangers shall be as per MPP standards.

All connections shall match for pipe instrumentation, drains and relief valves. All bolt holes must straddle the centre line of nozzles. Access stairways and handrails necessary for safe operation and easy maintenance shall be provided. Corrosion allowance shall be considered for carbon steel material. However, in case of coating or rubber lining or SS material, corrosion allowance will not be applicable.

If any degree of vacuum may occur the pressure vessel or tank shall be designed for full vacuum even if vacuum breakers are installed.

The items listed below shall be provided as a minimum.

- One(1) manhole (minimum nominal bore 600 mm) for vessels of 1.0 meter diameter and above
- Two(2) handholes (minimum size 200 mm) for vessels below 1.0 meter diameter.
- Two(2) spare nozzles
- One(1) drain nozzle

Manhole covers shall be provided with davit arrangement.

The saddle and reinforcing plates welded to the vessel shall be of the same material as the vessel shell or head. Insulated vertical vessels and tanks shall be furnished with insulation supports or clips.

**Tanks**

Unless otherwise specified, tanks used for the storage, lubricating oil, make-up water, condensate, chemicals. and tanks used for mixing and agitation shall be of welded construction, manufactured from mild steel plates of accepted quality and thickness in accordance with the approved relevant standards.

All welds shall be continuous, including welds around internal stays, stiffeners and supports.

All large tanks shall have at least two manholes each of 600 mm inner diameter complete with covers of the bolted type, fitted with a davit for easy handling.

All tank nozzles shall be provided with flanges, if not otherwise specified.

Nozzles shall be provided where necessary for the fitting of instruments, and piping.

Internal and external protection coating/painting of the tanks shall be performed according to the requirements of this Contract.

Arrangements shall be made for the blanking-off or removal of all valves or pipe connections during shot-blasting and painting to prevent the ingress of blasting material or other matter.

The protective process shall be applied also to any ferrous or non-ferrous parts mounted inside the tanks.

**Heat exchanger**

Heat exchangers are to be designed, manufactured and erected in accordance with the applicable standards.

Only proven products shall be delivered. No cast iron components are permitted.

It must be possible to install and remove the heat exchangers without undue difficulty. Lifting lugs and eyes and other special tackle shall be provided to permit easy handling.

Only Tubular heat exchangers are acceptable. Where necessary the tubes are to be protected by impact shields. An adequate number of visual inspection ports is to be provided in critical areas to facilitate condition monitoring.

Unless otherwise specified, all heat exchanger tubes and casings must be designed to withstand 1.2 times the zero flow pressure of the relevant pump at cold conditions, or 1.2 times of the maximum positive operating pressure, as applicable. The minimum design pressure is 6 bar, and the design shall be proof against full vacuum. The test pressure must be 1.5 times the design pressure.

The heat exchangers shall be designed for the maximum temperature incurred plus 20 K except for MPP Supplied Heat exchangers. For MPP supplied heat exchangers the design temperature shall be as per MPP standard design philosophy.

Heat exchangers must be capable of continuous unrestricted operation with up to 10% of plugged tubes, and a corresponding factor of conservatism of at least this amount must be used in the design of the heat transfer areas. However, plug margin for Condenser shall be as per Detailed Technical Specification (DTS).

Considerable importance will be attached to the ease of cleaning the heat exchangers.

Where any heat exchanger part in contact with liquid can be isolated, and there is a possibility of being heated from the other side, safety valves are to be provided for pressure relief.

Pipes from drains, vents and safety valves are to be grouped together, and routed to easily observable points equipped with covered funnels or to the flash tanks.

The overall design and conception of the heat exchangers and accessories is to be such that they are suitable for the degree of automation envisaged for the individual system.

### 7.13.8 Cranes and Hoists

Cranes and hoists are to be designed in accordance with the applicable Indian and International Standards.

The crane installations must be supplied with all the ropes, chains, shackles. needed for operation.

The minimum scope of supply per hoist for each lifting tackle includes the following items:

- four (4) single ropes each with 2 eyes at the ends, each rope 1 m long
- four (4) single ropes each with 2 eyes at the ends, each rope 2 m long

- two (2) single ropes each with 2 eyes at the ends, each rope 4 m long
- two (2) endless ropes, extended length 4 m each
- eight (8) shackles.
- 2 Sets of soft/synthetic slings of suitable capacity for handling generator rotor of GTG and STG.

The load-bearing capacity of the ropes and shackles must be suitable for the relevant hoist.

The maximum tension in the rope must not exceed 1/8 of the calculated breaking capacity of the rope. The ropes must be of the stranded type, and galvanized wires must be used.

The eyes of the single ropes must be secured with compression fittings. The length of the eyes must be at least 15 times the nominal diameter of the rope.

In special cases, where safe lifting of the relevant component is not certain, specially-made devices must be provided. At least two (2) of these must be provided in each individual case.

For each installation a list must be submitted, showing the number, type, nominal load-carrying capacity and strength characteristics of the materials used. In addition, factory and acceptance certificates must be submitted for all ropes and materials.

The safe lifting capacity of lifts is to be clearly marked stating both the maximum load in kg and the number of persons the lift was designed for. For this purpose the weight of a standard person shall be taken to be 75 kg.

For Design data for lifting devices for MPP supplied equipment shall be as per MPP standard, refer the detailed technical specification.

7.13.9 **Elevator**

One (1) no. elevator with a carrying capacity of ten (10) passengers shall be provided for the Switchgear / control building.

**7.14.0 General Electrical Requirements**

All equipment supplied and all work done including system design and detailed engineering shall also comply with the statutory requirements of the State/Central government and with the Indian Electricity Rules.

Unless otherwise specified, at least 10 % margin shall be considered in equipment sizing over and above the calculated load current/fault current/power requirments.

If not specified otherwise the electrical operational equipment must be designed to meet protection classes stated below.

| | | |
|---|---|---|
| • HT Switchgear (Indoor) | - | IP 4X |
| • LT Switchgear (Indoor) | - | IP 52 |
| • Control panels (Indoor) | - | IP 42 |
| • Relay panel | - | IP 42 |
| • Motors (indoor) | - | IP 54 |
| • Motors and other equipment located outdoor | - | IP 55 |
| • Emergency DG (Indoor) | - | IP 23 |

Each individual enclosure accommodating electrical equipment which is liable to suffer from internal condensation due to atmospheric or load variations shall be fitted with heating

devices suitable for electrical operation at AC single phase. Heaters in switchgear / control cubicles, panels, desks shall be controlled automatically by thermostats.

Motors rated 0.2 kW and below, except otherwise required for reversible service, shall be rated for use on a 240 V, single phase, 50 Hz, solidly grounded system. Motors rated above 0.2 kW and up to 160 kW shall be rated for use on 415V, 3 phase, 50 Hz, solidly grounded system. Motors above 160 kW shall be rated for use on a 11 kV, 3 phase, 50 Hz resistance grounded system. All Motors shall be designed for direct on line starting at full voltage.

Electrical motor operated actuators shall have non- integral starters.

Guards shall be provided for protection of personnel from all exposed moving and/or rotating machine elements. Necessary supports and accessories shall be furnished with each guard to prevent vibration. Guards for outdoor installation shall be galvanized steel. Grease fittings shall be extended through the safety guards.

For all other requirements of electrical system, the respective electrical sectionals shall be referred.

**7.15.0 General Control and Instrumentation (C&I) Requirements**

The Instrumentation and control systems shall be provided for safe, reliable and efficient operation of the combined cycle power plant. In general a consistent control and instrumentation philosophy is to be applied throughout the power plant. Standardization concepts shall be applied wherever possible to rationalize operation, maintenance and reduce spare parts. Adequate redundancy are to be ensured, so that no single point failure of the I&C systems/ equipments in the power plant results in the overall reduction of the plant output.

For the turbine control package standard control/protection system shall provide no single failure of field sensor cause Unit to trip. Redundant sensors shall be provided for control / protection functions with the exception of functions used only during start-up and where redundancy cannot be provided due to limitation in installation space. Also final control elements (trip solenoids and fuel valves) themselves and related accessories shall not meet this requirement.

In general all I&C systems/ equipments should be of modern and compact design, incorporating proven technology and modern industrial practice.

**7.16.0 General Civil Requirements**

The design specification covered in Section 5 of Vol-III establish the minimum basic requirements for all Civil structural and Architectural works. However all structures shall be designed for the satisfactory performance of the function for which the same are to be constructed.

With regard to soil and other hydrographic data furnished, it shall be clearly understood that the same are given to the Contractor in good faith and as such no claim for extra payment shall be entertained by the Owner/Owner's representative, if the actual condition met with during execution are at variance with the data given in Contract. The Contractor shall fully satisfy himself about the site conditions,nature of soil,ground water,contour levels etc,prior to the submission of the bid.The contractor shall conduct his own investigations to ascertain the correctness of the data furnished and based on the actual data the Contractor shall finalise the most suitable civil and structural design basis, which will be submitted to Owner/Owner's representative for review & approval.

**7.17.0 List of Approved Sub-vendors**

Refer Volume IV/Annexure-1/ Section 8.

With full information substantiating the technical acceptability of the proposed change. The Owner/Owner's representative's decision shall be final. Concessions granted shall not absolve the Contractor from any of his responsibilities under the Contract.

**8.0.0 QUALITY ASSURANCE, SHOP INSPECTION AND TESTING**

**8.1.0 General**

This section contains general requirements for inspection of material, parts, equipment and workmanship of the plant during manufacture, assembling to demonstrate compliance with specification, codes and standards to ensure overall reliability of plant operation and performance.

The Owner/Owner's representative and/or authorised Representatives shall, at any time, be allowed free and ready access to the Contractor's premises and those of his suppliers as well as to the site installation and the Contractor has to make the plant items available for the purpose of inspecting the specified equipment components and obtaining information as to the progress of the work. Failure on the part of the Owner/Owner's representative, at this or any other time, to discover or reject materials or work which do not meet specified requirements shall not be deemed an acceptance thereof nor a waiver of defects therein.

The approval of the Owner/Owner's representative shall not prejudice the right to reject equipment if it does not give complete satisfaction in service.

**8.2.0 Scope**

All materials, components and equipments covered under this specification shall be tested at all stages of procurement, manufacturing, erection, commissioning as per a comprehensive quality assurance programme. The requirements of minimum quality plans to be followed by the Bidder in respect of various equipment are specified in detailed technical specification. The Bidder shall draw his own quality plans in line with these requirements and his standard practices and implement such programme after approval by the Owner/Owner's representative.The Owner/Owner's representative shall appoint a Third party inspection (TPI) agency for bought out items/outside inspection.The Owner/Owner's representative will carry out on-site supervision and inspection.

Manufacturing quality plan shall detail out, for all the components and equipments, 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 contractor's quality control organization, the relevant reference document and standards, acceptance norms and inspection documents raised. during all stages of material procurement, manufacture, assembly and final testing/performance testing.

The Contractor has primary responsibility for ensuring the quality of items of equipment supplied under the contract and remains accountable when manufacture or erection is subcontracted. It is therefore a requirement of the specification that work is only subcontracted to companies with effective quality control organization and that the Contractor monitors the performance of these by the attendance at tests of experienced inspectors employed by the Contractor. The Contractor shall, at the appropriate time, prove that his

material and / or equipment comply with all the requirements of this Section, such proof being the successful completion of tests and inspections. Routine test and type test certificates shall be submitted for each item of equipment, wherever applicable.

All materials, components and equipment supplied under the contract shall be subject to inspection by the Owner/Owner's representative, his representative, Inspectors of Boilers (India) or his authorized Agency or any other Inspector of the Government, should they so require during manufacture, erection and after completion. The necessary inspection charges of the authorized agency of Inspection of Boilers (India) shall be borne by the contractor. The inspection and tests shall include but shall not be limited to the requirements of this section of the specification. Further requirements to be applied are specified in the detailed specification.

The Bidder along with quality plan, shall also furnish copies of the reference documents/plant standards/acceptance norms/test and inspection procedure referred by him in quality plans. These quality plans and reference documents/standards will be subject to Owner/ Owner's representative's approval and will form a part of the contract. In these approved quality plans, Owner/Owner's representative shall identify customer hold points (CHP), indicating tests/checks which shall be carried out in presence of the Owner/Owner's representative's or authorized representative and beyond which work will not proceed without consent of Owner/Owner's representative's in writing.

No materials/equipment shall be dispatched from the manufacturer's works before the same is either accepted subsequent to pre-dispatch final inspection including verification of records of all previous tests/inspections by Owner/Owner's representative or such pre-dispatch final inspection is waived by the Owner/Owner's representative and dispatch is authorized after review of test reports.

All materials used or supplied shall be accompanied by valid and approved material certificates and test and inspection reports duly approved by the Owner/Owner's representative. These certificates and reports shall indicate the acceptable identification number of the material they proposed to certify. The material certified shall also have the identification details stamped on it.

All material used for equipment construction including castings and forgings shall be of tested quality as per relevant codes/standards. Details of results of the test conducted to determine the mechanical properties, chemical analysis and details of heat treatment procedures 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 as specified in detailed specification.

All welding shall be carried out as per welding procedure drawn and qualified in accordance with requirements of ASME Section IX. Welding procedures shall be submitted to the Owner/Owner's representative for approval prior to carrying out qualification test in the presence of I/Owner/Owner's representative

All welders/welding operators employed on any part of the contract either in the Supplier's works or at site or elsewhere shall be qualified as per ASME Section-IX.

Test results of qualification tests and specimen testing shall be furnished to the Owner /Owner's representative for approval. However, wherever required by the Owner/ Owner's representative, tests shall be conducted in presence of Owner/Owner's representative

All the heat treatment results shall be recorded on time temperature charts and verified with recommended regimes.

All the sub-vendors proposed by the Bidder for procurement of major bought out items including castings, forgings, pumps, heat exchangers, semi finished and finished components/equipment-(list of which shall be drawn up by the Bidder along with his offer and finalized with the Owner/Owner's representative) shall be subject to Owner/ Owner's representative's approval.

The type and extent of inspection of items shall be in accordance with the relevant International/Indian Standards/Indian Boiler Regulations and other standards approved by the Owner/Owner's representative, supplemented or amended by the requirements of this section of the specification or as specified elsewhere in the Specification.

**8.3.0 Inspection Program and Test Notifications**

Before manufacturing commences and not later than 45 days after award of contract, the Contractor shall submit an outline of his proposed inspection program, which shall include all major stages during manufacturing. The inspection and test program shall include for the various items the designation No., name of equipment, part of equipment, the kind of test, test standard, company which carries out the test, place, date and witnesses by the Contractor, third party or Owner/Owner's representative's .

The Owner/Owner's representative will return a copy of the Contractor's proposed inspection program indicating those inspection stages for which notification is required. Notification shall be by Fax or email in a format to be agreed and shall be sent at least 20 days prior to the intended test in accordance with 'Conditions of Contract'. If the Owner/Owner's representative intends to be represented at the test he will provide at least 24 hours' notice and if his representative does not attend on the notified date, the test may proceed unless an alternative date has been requested by the Owner/Owner's representative.

**8.4.0 Test Certificate Documentation**

The results of all tests shall be certified by the manufacturer, Contractor or independent agency as appropriate.

Document files containing material certificates, welding procedures, test report shall be compiled for each item of plant and shall be suitably identified (including equipment classification reference) and bound.

Three copies of each document file containing inspection reports and certificates of site erection testing activities of a particular item of plant or system shall be supplied to the Owner/Owner's representative prior to commissioning.

Copies of the performance and acceptance test reports shall be prepared and distributed as specified in Clause 'Performance and acceptance test data and reports' of this Section. All documentation as required by IBR shall also be prepared and submitted.

**8.5.0 Certification of Equipment by Owner/Owner's representative's**

The Personal and travelling costs in connection with the Owner/Owner's representative's inspection and witnessing of tests of equipment, components and material manufactured in India and abroad will be borne by the Owner/Owner's representative.

**8.6.0 Codes and Standards**

**8.6.1 General**

The type and extent of inspection shall generally be in accordance with that specified in the standard used for design and construction of the item of equipment supplemented or amended by the requirements of this section of the specification. The Contractor should provide the relevant codes and standard to the Owner/Owner's representative.

**8.6.2 Reference to Codes and Standards**

Reference to special codes and standards, where designated either directly or as "relevant", is intended to provide a measure of performance, safety, in-shop and on-site testing, and methods of construction and/or installation which must be equalled or exceeded in order to be considered acceptable for use under this specification. If more than a single degree of quality or accuracy is permitted within the scope of particular code or standard, the highest quality shall be applicable and the degree of accuracy commensurate with the intended function shall be selected, but with the understanding that the final decision will be made by the Owner/Owner's representative.

In all instances, the finally accepted applicable code or standard shall be the version last published.

**8.6.3 Alternative Standards**

Where no appropriate standard is available, tests shall be conducted in accordance with the manufacturer's standard practice, subject to the approval of the Owner/Owner's representative.

In such cases the Contractor shall submit to the Owner/Owner's representative, complete data and a suggested procedure for the testing to be performed. Commencement of manufacture before receipt of the Owner/Owner's representative's approval shall be at the Contractor's risk.

If the proposed procedures are accepted, the Contractor shall provide the Owner/Owner's representative with four additional copies in English before any test is performed.

**8.6.4 Derating Standards**

The Contractor's attention is drawn to the climatic conditions in the site area. Derating factors shall apply in accordance with the relevant and approved standards if not specified in the contract documents.

**8.7.0 Services prior to and During Inspection and Testing**

In accordance with and in addition to specified standards the Contractor shall submit procedures for material testing, manufacture, quality control and performance testing as they apply from the procurement phase of raw materials to the finished product. Manufacture commenced before receipt of the Owner/Owner's representative's approval of material specifications and testing procedures shall be at the Contractor's risk.

No inspection shall be valid unless the Contractor and manufacturer are in possession of relevant approved drawings and procedures for the item to be tested. The Contractor on

request shall supply the Owner/Owner's representative's with a copy of drawings and procedures at the time of the test.

All instruments and apparatus required for the inspection or used for the performance of tests shall be subject to the approval of the Owner/Owner's representative at his discretion and shall be calibrated to an agreed standard in approved laboratories. The cost of making such calibrations shall be borne by the Contractor in all cases.

If the Contractor wishes to apply for a concession in respect of a departure from an approved procedure or standard, this shall be made in writing with full information substantiating the technical acceptability of the proposed change. The Owner/Owner's representative's decision shall be final. Concessions granted shall not absolve the Contractor from any of his responsibilities under the Contract.

**8.8.0 Testing During Manufacturing**

The minimum testing requirements for mechanical, electrical and C&I equipment testing to be conducted at manufacturer's works are specified in the detailed specifications.

**9.0.0 EQUIPMENT ERECTION, SITE TESTING, COMMISSIONING AND PERFORMANCE TEST**

This Specification generally covers the standards, scope of works, documentation, scope of installation, testing and commissioning of various mechanical, electrical, control and instrumentation equipment & system and various requirements to be adhered to during the execution of the works.

Works shall be performed in accordance with this technical specification and various other drawings and schedules submitted and approved by the Owner/Owner's representative during the execution and the instructions from Engineer-in-charge or his authorized representatives during the progress of the work. Consumables required for the job shall be ensured by the Contractor. All necessary equipments and instruments required to carry out the works, recalibration of the instruments required during loop checking and commissioning shall be done by the contractor.

Field quality plans shall be submitted and shall detail out for all the equipments, the quality practices and procedure to be followed by the Contractor's site quality control organization during various stages of site activities including receipt of materials/equipments at site, preservation and storage, pre-assembly, erection, pre-commissioning and commissioning. The Contractor shall provide all necessary means for execution of inspection and testing, according to the requirements.

**9.1.0 Erection**

**9.1.1 General**

Erection work shall be carried out in the manner and sequence as may be directed by Contractors supervisory Engineers and the Owner/Owner's representative.

All existing structures, piping, conduits, equipment and facilities shall be protected by the Contractor against damage/degrade during erection. Any damage/degradation caused by Contractor shall be rectified at his cost to the satisfaction of the Owner/Owner's representative within short timelines.

As erection proceeds each assembled part before being boxed up with a view to erecting it finally, shall be inspected and approved by the concerned supervisor. Should any defect be found out during such inspection, the Contractor shall make it good as per directives from Owner/Owner's representative.

All materials such as electrodes, gaskets, bolts, nuts shall be of reputed make and conforming to relevant Indian Standards. Prior approval of Owner/Owner's representative will have to be obtained before commencement of work. Manufacturer's test certificate shall have to be provided when called for.

Contractor shall furnish all instruments, isotopes, films for conducting radiography and equip himself fully. Necessary operators of all testing equipment shall be provided by the Contractor. Dark room facilities with air conditioners for storing and processing radiography films and equipment, as necessary, shall have to be arranged by the Contractor. The radiography shall be done on any weld (including welds for repair) only after final heat treatment.

The equipment shall be placed on respective support, levelled and aligned with precision measuring instruments, checked for proper clearance between moving and stationary parts wherever applicable.

The installation of motors shall be carried out along with driven equipment in accordance with manufacturer's instructions and/or as directed by the Owner/Owner's representative.

Wherever the scope includes control panels, all connections in control panels shall be completed, checked and adjusted to ensure safety and satisfactory operation of the equipment.

Particular attention shall be given towards removal of buckles and other forms of distortion.

Holes in plate work to assist in erection should be avoided.

Misalignment in vertical joints shall not exceed 10% of plate thickness or 1.0 mm, whichever is larger.

Misalignment in horizontal joints shall not exceed 15% of upper plate thickness with a maximum of 2 mm for plate thickness above 8 mm and a maximum of 1.0 mm for plate thickness less than 8 mm.

Welding sequence shall be adopted in such a way so as to minimise distortion due to weld shrinkage and shall be got approved from the Owner/Owner's representative prior to commencement of work.

Welding shall not be carried out on wet surfaces and shall be protected from high winds.

### 9.1.2 Erection Program and notification

The Contractor shall furnish a detailed erection programme taking into consideration the constraints likely to be encountered during various phases of work including interfacing with the existing plant. This erection programme shall be strictly adhered. The Contractor shall take appropriate steps as directed by the Owner/Owner's representative to make up for any slippage from this erection programme and no additional compensation shall be allowed on this account.

Before erection commences and not later than three months before start of erection, the Contractor shall submit the proposed erection test program and the commissioning test program with all proposed erection and commissioning tests and checks. Together with the test programs the proposed test procedures have to be submitted.

The test programs should consider:

- that the sequence and duration of the proposed activities are logical, realistic and in accordance with safety and permit regulations in force
- that the commissioning of any item of plant would not interrupt the normal operation of the existing plant.
- that allowance for training the Owner/Owner's representative's operation personnel during this period has been made.

The Contractor has to take care that the test programs are maintained by the erection organization during erection and commissioning.

The Contractor has to mark all stages, which are subject to the Owner/Owner's representative's acceptance and has to notify at least two week's in advance when such inspection for acceptance becomes due.

### 9.1.3 Supervision during Erection

The Contractor shall provide at proper time the necessary supervisory Engineers, Supervisors and other supervisory personnel duly qualified and in sufficient number for transportation, handling, unloading, storage, erection, pre-commissioning and post commissioning, startup, testing and test operation of plants and equipment.

The Contractor shall keep a competent representative who will be resident Engineer-in-charge and shall remain as In-charge of Contractor's work site and also remain answerable to the Owner/Owner's representative for all activities of the Contractor at site. Before his placement at site, the Contractor shall submit his bio-data to the Owner/Owner's representative for his approval.

The Resident Engineer-in-charge shall supervise the work of all men of the Contractor working at site. He shall work in complete harmony and co-operation with Owner/Owner's representative. All statutory rules and labour laws prevailing in the area must be observed by the Contractor. All safety measures against occurrence of accidents must be taken effectively. Resident Engineer-in-charge shall not be withdrawn without written permission of the Owner/Owner's representative. If any of the Contractor's personnel was found unsuitable for the job, the Contractor shall remove him forthwith and a suitable replacement shall be posted to site within a reasonable time. No compensation for withdrawing of unsuitable or unqualified person(s) from site or for posting suitable person(s) to site at any stage of the project shall be allowed by the Owner/Owner's representative.

### 9.1.4 Sequence of Erection Work

All packing cases and packages shall be opened in presence of the Owner/Owner's representative or his authorised representative.

Nails and packing strips should be pulled out with suitable appliances and kept separately in container and not thrown away at random. All timber of packing cases shall have to be sorted out and stored properly at a suitable place as directed by the Owner/Owner's representative.

From time to time packing materials, timber, nails and strips shall be delivered back to the Owner/Owner's representative or otherwise disposed of as directed by the Owner/Owner's representative. All timber and packing materials shall remain the property of the Owner/Owner's representative.

Each material after stripping from boxes or received loose, shall be carefully inspected, checked with shipping list and identified with erection drawing if necessary. Any short supply and/or damaged part shall be reported forthwith to the Owner/Owner's representative in writing. The Contractor shall be completely responsible to make all necessary arrangements, application and follow procedure to process claim on underwriters, obtain replacement repair/rectify and modify as required on all such damaged/defective/lost equipment and material at no extra cost to the Owner/Owner's representative in order to execute the work to satisfaction of the Owner/Owner's representative within the stipulated contract time. Once the materials are inspected, the same shall be preserved properly and adequately protected from theft and deterioration or damage by rain, storm, dust, water, tampering by casual visitors or workers. The Contractor shall prepare and maintain stores, ledgers and bin cards for all materials in his custody.

Carrying out all repairs to damages/degradation that might have occurred during transit and in subsequent storage. Also modifications and rectification work as necessary and replacement of all lost parts, are under the Contractor's scope.

### 9.1.5 Safety Regulations

Contractor should follow all the safety regulations / norms as imposed by the Law/Authority/factory inspectorate /Owner/Owner's representative. When going to or from place of work in the plant only the prescribed walkways, paths or cross-overs shall be used and required protections, barricades shall be established for the plant area.

Crawling on, over or under movable equipment shall generally be prohibited.

For overhead work, proper signs shall be placed below and, when conditions justify, a watchman shall be stationed to warn employees in the vicinity.

Work on or about crane runways shall not be undertaken without the Owner/Owner's representative's permission. Whenever it is necessary to do any work on or above the crane runways, the Contractor shall furnish a flag man stationed on the floor.

Only scaffolds which meet the requirements of governing laws shall be used in the project.

Work in area of electric wires and cables shall generally be avoided.

All burning and welding equipment shall confirm to, and be used in accordance with, regulations governing such equipment. No burning or welding shall be done at any place on the site until location where such work is to be done is approved.

Adequate fire protection shall be available before work preceding the work.

All warning signs shall be observed.

Contractor shall require his employees to wear hard hats at all times when they are inside the plant area.

Goggles shall be worn whenever there is a possibility of flying particles or splashing of corrosive fluid.

While working at site all workmen shall wear necessary safety protective equipment.

When ladders are the means of access to a platform, they shall be firmly secured top and bottom and the ladder rails shall extend at least one meter above the top landing. When a ladder cannot be secured, a man shall be stationed at the base.

Safety belts shall be used by men working in high places when no hand rails or other guards are in place.

All accidents resulting in injury shall be reported to the Owner/Owner's representative promptly. Owner/Owner's representative's safety rules, regulations and directives shall be followed and reports thereon shall be submitted as and when required.

**9.1.6 Proper Treatment of Injured**

Contractor shall ensure that proper treatment of injuries is immediately available either as such or in the form of constantly available transportation to a source of such treatment.

Contractor shall ensure that stretchers are available near all areas in which their men are working and that the location of stretchers are well marked.

Contractor shall be solely responsible for the dissemination of all safety regulations including those written here, those promulgated by Owner/Owner's representative and those dictated by good practice, and shall ensure that all his employees and those of his Sub-Contractors are conversant with same

**9.2.0 Inspection**

After completion of erection and/or installations and before start-up the equipment and all its appurtenances shall be thoroughly cleaned and then, inspected in the presence of the Owner/Owner's representative for correctness, soundness and completeness of installation and acceptability for start-up.

All works to be carried out by the Contractor shall be subject to inspection by the / Owner/Owner's representative as applicable. The work shall be carried out as per applicable specifications, codes of practice, drawings and instructions of Owner/Owner's representative . The Contractor shall provide necessary facilities, instruments and personnel for carrying out the inspection as above and shall comply with the instructions given.

A check list in triplicate will be furnished for the approval of Owner/Owner's representative wherein all items to be checked and necessary instructions will be listed. Inspection and checking shall strictly follow this check list. On completion of the joint inspection and checking two (2) copies of the check list will have to be handed over to the Owner/Owner's representative. The check lists after checking will have to be jointly signed by the Contractor's supervisor and the Owner/Owner's representative to ensure that all inspection and checking have been properly carried out. However, such endorsement shall not relieve the Contractor from the responsibility in ensuring proper erection and cleaning.

During inspection all clearance, alignment and important measurements and adjustments as may be directed shall be noted by the Contractor for future reference and guidance. Two (2) copies of such notes shall be delivered to the Owner/Owner's representative.

All reports of radiographic examination in a format approved by the Owner/Owner's representative shall be submitted to the Owner/Owner's representative for his approval and records.

### 9.2.1 Cleaning

The Contractor shall observe strict cleanliness during execution of the work and shall be in possession of vacuum cleaner for cleaning the internals of machinery under installation. They shall check that all the finished surfaces are greased and covered.

Before boxing up, the Contractor shall examine carefully to ensure that no foreign material, such as welding rod ends, welding beads, metal chips, rope, working tools has been left inside any equipment.

In the case of motors, the following procedure shall be observed

a. Checking and cleaning of bearings and charging / filling of lubricants, wherever necessary.

b. Cleaning of core and winding, drying out and cornicing the winding and measurement of air gap for motor assembled at site.

Wherever the scope includes control panels, all withdrawable components shall be taken out and internals shall be cleaned with vacuum cleaner, if required.

### 9.3.0 Testing and Commissioning

### 9.3.1 Erection Test

Following the satisfactory completion of inspection, checking and cleaning of a unit, the plant will be placed in test run. During this period, all adjustments and repairs as required shall be made by the Contractor. Protocol shall be made and signature has to be obtained from Owner/Owner's representative. On completion of satisfactory test run, the plant will be placed under trial operation.

Prior to trial operation of any equipment the following shall be checked:

During erection all required erection tests as well as final erection checks of the mechanical completion of the systems and part thereof have to be performed.

After successful mechanical completion Mechanical Completion Certificates will be issued.

The activities necessary for mechanical completion shall include but not be limited to following testing:

- Visual inspection after unloading at site
- Checking of completion of relevant systems
- Proper installation of the drive and equipment on the foundation
- Proper alignment of drive and the driven equipment
- Proper connection of supports, hangers, piping, valves, instruments and other fittings.
- Freeness of the rotors of drive and equipment
- Healthiness of lube oil system, changing and filling as necessary.
- Safety audit
- Testing of site welds (non-destructive examinations)

- Pressure/leak/tightness test
- Pipe line and equipment flushing and cleaning
- Chemical protection of piping systems
- Checking of coating
- Testing of cranes and hoists
- Safety signs and warning signs
- Completion of buildings and civil works
- Test of ventilating and air-conditioning units

**Electrical/instrumentation equipment tests**

The following checks and tests measurements shall be made:

- Screwed connections for correct assembly
- Terminals and terminal connections for correct assembly
- Checking of earthing connections and testing of earthing resistances
- Measurement of insulation values
- Verification of neutralization conditions
- Fire-proof partitioning
- Marking, inscription, provision of designation plates
- Voltage checks
- Polarity checks in the case of DC voltages
- Fuses, over current trips, short-circuit trips, time settings, relay settings
- Transformer oil levels
- Setting indicators, revertive (check-back) signals to the central control room.
- Checks on wiring and cabling for conformity with the constructional circuit-drawings and plans
- checking and functionality testing of electrical systems according to IEC standards
- checking and testing of instruments

### 9.3.2 Pre-Commissioning Testing

After alignment of all equipment, alignment tests shall be carried out by the Contractor to check levelling, clearance, eccentricity.Measurements will be witnessed and acceptance will be certified by the Owner/Owner's representative.

Hydro-test / eddy current test, as applicable will be carried out on equipment as identified in the QAP to be finalized during detailed engineering. . All necessary blanking arrangements for hydro testing shall be furnished by the Contractor. All necessary test pump/temporary piping shall be supplied by the Contractor.

Preconditions for the commissioning are the issue of the Mechanical Completion Certificate and the availability of the accepted commissioning program and the Contractor's commissioning procedures. The Pre-commissioning Checks cover the functional tests of the individual items and their alarm and tripping systems. Following tests shall be included:

**Mechanical equipment**

- Individual pre-commissioning runs of all rotating equipment such as pumps, compressors, dosing equipment.
- functional tests of the mechanical equipment
- Testing and adjustment of safety devices.

**Chemical Cleaning of Piping Systems and Equipment**

Necessary procedure for chemical cleaning of piping and equipment shall be submitted to Owner/Owner's representative for their approval along with pre-commissioning document during detail engineering stage.

Before introducing chemicals, all the piping systems and equipment shall be water flushed. Water flushing will be followed by alkaline cleaning, acid cleaning and passivation or by EDTA (Ethylene Diamene Tetra Acid) and passivation.

However, the Contractor shall submit along with the offer his usual procedures and practices for chemical cleaning of the piping and equipment specified. The Contractor shall submit all schematics, write up, details of chemicals to be used. and detailed procedures he intends to follow. These schematics and procedures shall be subject to the approval of the Owner/Owner's representative.

Pre- cleaning procedure:

Prior to starting any phase of cleaning operation the following procedures shall be ensured:

Installation of all temporary piping, valves, pumps and equipments as required for the flushing and chemical cleaning operations. Temporary piping shall be routed at floor level as far as possible and secured in place to prevent movement/ vibration beyond acceptable limits.

Installation of the instruments as required to ensure satisfactory monitoring and control of the cleaning process. The Contractor shall also determine and arrange locations for sampling of the cleaning solution during cleaning.

By passing all regulation/control valves coming in the cleaning circuit or installation of temporary spool pieces.

Installation of special end covers and temporary suction strainers, for boiler feed pumps and condensate pumps. Pump internals shall not be installed.

Installation of plastic seal in the condenser neck to protect the turbine from alkaline fumes.

Blocking and securing of all spring hangers in the steam lines which may be flooded during the cleaning operation.

Hand cleaning of the interiors of all vessels which are included in the cleaning operation.

General cleaning procedures:

a) Seal water lines to pump shall be flushed by the permanent arrangement provided for the same.

b) Where pipeline terminate in spray headers, these headers shall be inspected after each phase of the cleaning operation and cleaned if necessary.

c) All strainers shall be observed closely during the cleaning operation by reading differential pressure gauges, and shall be cleaned when the differential pressure exceeds a predetermined value.

d) All high points, vents shall be opened periodically to ensure full system flow.

e) Upon completion of each stage of cleaning, the waste products shall be drained and transferred to the waste treatment basins. The Contractor shall then supply and add the necessary chemicals to the basin to neutralise all waste solutions and rinses generated by the cleaning process, and arrange for its disposal to an area to be indicated by the Owner/Owner's representative.

f) Strict safety precautions shall be exercised at all times during the chemical cleaning and during storage and handling of the chemicals. The Contractor shall ensure provision of all protective clothing, apparatus and equipment along with necessary first aid kits as required for handling the chemical and for carrying out the cleaning operation.

g) All Hazardous waste material generated during construction, erection and commissioning shall be disposed by Contractor using authorised waste disposal agency.

**Steam Blowing of Piping Systems**

i) Steam blowing shall include engineering, supply and installation of all temporary piping, valves, fittings including quick actuating valves (for puffing purposes), supports, blanking plates, spools, target plates, instruments, controls and all other accessories and services required to complete the cleaning process as specified herein

ii) The detailed schemes and procedure for steam blowing operations shall be prepared and furnished by the contractor and discussed and finalized during the detailed engineering stage.

iii) Steam blowing shall also include reinstatement of cleaned piping systems; and dismantling/removal of all temporary piping, equipment and materials from site. All temporary piping, valves, equipment and materials shall be taken back by the contractor upon satisfactory completion of cleaning, and shall be removed from the Owner/Owner's representative's premises.

iv) Engineering involved regarding temporary piping shall include the following:

a. Selection of temporary piping including disturbance factor calculation.
b. Preparation of layout of temporary piping and performing stress analysis as per ANSI B 31.1.
c. Selection of temporary hangers and supports as required.

v) The following piping systems shall be cleaned through steam blowing operation.

a) Main steam, , LP, HP and LP bypass and process steam piping system.
b) Auxiliary steam piping system.

vi) Steam blowing shall be carried out for removal of particles (rust, scales, weld splatter) from various piping systems to avoid damage to turbine bladings. Cleanliness of system shall be checked by means of test plates made of steel, which will be installed in the centre line of the piping system.

vii) Cleaning shall be achieved by steam purging i.e. by blowing of steam through the piping such that the momentum of flow is greater than that of steam flow during normal operation of unit (at TMCR). The disturbance factor during steam blowing (ratio of momentum of flow during purge to that during TMCR) shall be more than 1.4.

viii) The blow off shall be done with steam, which is exhausted through adequately sized, open-ended temporary piping. Temporary piping and motor operated valves shall be installed for steam blowing operation. Pressure shall be built up in the boiler and the

piping warmed before release of steam by quick opening of motor operated valve located on temporary piping. The cycle shall be repeated until steam from the blow out pipe is determined to be clean.

ix) If the flow nozzles and control valves have already been erected these shall be removed and replaced by spool pieces before steam blowing. The removed flow nozzle and control valves shall be put back after steam blowing.

x) The motor operated valves used for steam blowing shall have special characteristics like minimum loss of pressure, resistance to wear during severe working conditions (high velocity and carryover of water and solid particles), quick opening time, minimum effort on electric actuator.

xi) The steam blowing termination criteria shall be as under:

a) Acceptable target plate condition
b) Measured disturbance factor (DF) more than 1.4 ((to be reviewed and decided during detailed engineering stage depending upon type of cleaning adopted by Contractor Acid/alkali boil-out).

The required values to calculate actual DF will be measured at site. The criteria for acceptable target plate condition shall be finalised during detailed engineering.

**Electrical equipment**

As far as not already covered by the erection tests the pre-commissioning tests shall cover:

- High voltage tests
- trip tests
- Equipment Functional Test

**Tests on Motors** as per IS

- Insulation test of winding by megger, drying out and, if necessary, high potential test.
- Winding resistance measurement on all 3 phases for motors of bigger size.
- Testing the motor for proper direction of rotation and reconnection, if necessary.
- No load test run of the motor for a minimum of eight (8) hours to check out bearing or other associated parts.
- During test run, hourly record of currents on all the three phases shall be maintained and careful watch shall be maintained on the equipment for any abnormal sound, temperature of bearing, vibrations.
- After no load test run of the motor each rotary equipment shall be coupled and shall be subjected to a test run. The duration of this test run shall be mutually agreed.
- The objective of the test run shall be to ascertain that the following are within the permissible limits and the operation is satisfactory.
  - o Vibration and noise level
  - o Bearing vibration and temperature
  - o Performance of the lube oil systems

- o Motor winding temperature
- o Performance of various control, interlocks and protective elements, wherever applicable.
- o Performance of annunciation system and indication, wherever applicable.

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**Tests on transformers**

During installation : Checking of complete delivery, checking of core earthing and insulation of active part from tank, H.V. sample tests of transformer Oil in accordance with IEC or equivalent Standards.

During commissioning : Checking of satisfactory operation.

**Tests on earthing and lightning protection system**

Acceptance tests and measurements of the earthing installations in accordance with IEC or IS standards.

**Tests on lighting system**

Proof of the minimum new value of lighting densities, checking of correct operation both electrically and mechanically.

Contractor shall provide the list of site tests to be performed on electrical equipment as part of pre-commissioning activities for Owner/Owner's representative's review.

**Control Equipment**

- Calibration tests of all analog measuring loops including all remote indications and recorders and the input signals used for closed loop control.
- Testing of all plant mounted transmitters.
- Wiring test of all control cabling in the field, control rooms combined with the function tests.
- Testing of all control modules in the control room

Functional testing of remote control of drives, circuit breakers, solenoid valves, actuators etc.

- Testing of open loop devices especially all sequence logic equipment using simulated inputs.

Testing of all interlocks to ensure safe operation.

- Testing of the alarm annunciation and event recorder system in connection with all field and control room devices using simulated inputs.
- Testing of all closed loop controls.
- Testing of insulation between cable screen and ground.

### 9.3.3 Commissioning

Preconditions of the commissioning are the successful completion of the pre-commissioning checks of all items of the whole system.

Commissioning tests shall be performed in accordance with the procedure contained in the commissioning program approved by the Owner/Owner's representative for individual equipment/system and as a plant. Commissioning test shall also include Redundancy and automatic fall back by simulation of fault conditions

On completion of each commissioning activity to the satisfaction of the Owner/Owner's representative,the commissioning schedule shall be signed and dated by the Contractor and countersigned by the Owner/Owner's representative.

Commissioning test shall prove that the plant is prepared and adjusted to ensure the correct functioning of the individual components and of the complete plant.

After successful completion of the commissioning tests "Authorization to Performance Test " shall be signed.

The Commissioning test shall cover at least following tests:

- Protection tests
- operation of protection devices including the following as a minimum
    - fire protection
    - HRSG protection
    - Gas turbine protection
    - steam turbine protection
    - generator protection
    - transformer protection
    - 66kV GIS protection
    - Balance of plant protection
- Method of alarm/trip condition reset for subsequent starting Isolation procedures method of isolation of plant equipment for safe shut-down and maintenance procedures including as a minimum
    - HV station and unit supplies
    - LV supplies
- Protection systems/settings, in accordance with agreed design and the requirements of the transmission system
- Start-up tests
    - Normal automatic start to preset load
    - Staged automatic including start to synchronous speed, manual synchronizing (including synchro-check), automatic synchronizing, manual and automatic loading
    - Starting with stand-by auxiliaries
    - Operation of all auxiliaries
    - Verification of start-up times and loading rates of power units and steam generators at various conditions
    - Power unit(s), test partial and full load rejection to demonstrate.

- Full load rejection tests to measure transient maximum speed and steady state speed at normal governor droop setting
- Method of resynchronism to be demonstrated.

- Turbine bypass operation capability
- Demonstaration of start up of the plant utilising start up power only from black start DG and demonstration of safe shut down utilising DG for emergency purposes.
- Operating stability when operated in the full range of load conditions with load variations by increasing or decreasing the electric load/steam delivery.
- Demonstration of the capabilities of the Power Units to operate at rated voltage and frequency, at power factors and reactive conditions between 0.85 (lag) and 0.95 (lead)
- Start-up tests of the Plant equipment, facilities and
- Verification of vibration and noise emission
- Environmental monitoring equipment, water quality monitoring equipment, functioning tests and verification of guarantees
- Verification of active power response and voltage control response according to the requirements specified in the network connection conditions
- Demonstration of proper controlling, monitoring and recording according to the requirements of the grid code shall be as per MPP recommendations.
- Verification of completeness of scope of supply. This shall be carried out along with the punch list.
- Verification of 24 hours uninterrupted MCR operation
- Establish the capability to deliver the specified process steam even at minimum Gas turbine load, without any fresh air for atleast 8 hours on a continous basis.

**9.4.0 Trial Operations**

After successful completion of commissioning test and after relevant test protocols have been accepted by the Owner /Owner's representative, the Contractor shall be allowed to prepare the Plant Units for trial operation. The plant will be started up and loaded. During this loading operation all the controls and protections shall be finally set.

After the plant is loaded to the maximum capability rating and the contractor is fully satisfied with its performance he shall offer the unit for Trial Operation by communicating the same to the Owner/Owner's representative in writing. After receipt of such communication the plant will be on trial operation. The trial operation will be for a minimum period of fifteen (15) days continuously at rated full load/part load as made available by the Owner/Owner's representative or as mutually agreed between the contractor & / Owner/Owner's representative to demonstrate the following :-

- Sustained capability of the plant
- Reliability of the equipment and auxiliaries
- Adequacy of the various auxiliaries, ancillaries & systems and controls.
- Capability of each equipment of the plant to correctly perform the functions for which it is specified.
- Safety requirements

This trial operation shall be undertaken jointly with the Owner/Owner's representative. As a part of the trial operation reliability run and guarantee tests of the plant shall be conducted.

**9.5.0 Reliability Run**

Reliability run shall be undertaken jointly with the Owner/Owner's representative as a part of the trial operation and within the trial operation period. Reliability run shall be conducted for seven (7) days uninterrupted at a load as available at prevailing ambient conditions.

In the event of interruptions to the reliability test run, for which the Contractor is responsible, the length of the reliability test run can be extended by a period equal to the total duration of the interruptions. If such an interruption lasts more than 24 hours, the reliability test run shall be restarted, after repairing the defect. The reliability test run may be interrupted on a maximum of three occasions, provided that no interruption exceeds 8 hours and that the Owner/Owner's representative is notified of the interruption in good time.

After the successful completion of reliability run test the Contractor shall offer the Owner/Owner's representative to conduct the gurantee test on prior intimation to the Owner/Owner's representative. The Contractor shall conduct gurantee test as per approved procedures for such test to the satisfaction of the Owner/Owner's representative. Perfromace and gurante tests shall be a part of the trial operation and shall be conducted to the requirements of testing stated under the clause Guarantee test.

Essentially the perfromace tests shall consist of a simultaneous test to establish the capability of the plant when delivering the base load. The gross heat rate of the unit shall be also tested while demonstrating to the Owner/Owner's representative the Gross Power Output and Auxilliary Power Consumption.in order to demonstrate that the plant is able to perform within the parameter limits specified in clause 20 below.

A joint log would be maintained to note various performance data, the malfunctions, output deficiency and short comings and would be compiled and furnished at the end of the trail operation along with the perfromace test results.

**9.6.0 Guarantee Test**

This consists of performance and guarantee tests as a part of the trial operation and within the trial operation period.

**9.6.1 Objective of the test**

The parameters which have an impact on commercial viability of the station are Gross Power Output &Gross Heat rate of the plant and the Auxiliary Power Consumption for the entire plant.

Performance Guarantee shall be provided for operation at contract specific site reference conditions as specified and the guaranteed performance parameters of the plant shall be proved by the Contractor during the test. Should the results of these tests show any deficiency from the guaranteed value, the Contractor shall modify the equipment as required at no extra cost to enable it to meet the guaranteed parameters.

All heat rates shall be based on Lower Heating value for the fuel.

**9.6.2 Test Documents**

The procedure for carrying out the above tests shall be submitted to the Owner/Owner's representative for approval six (6) months in advance. The procedure shall highlight the anticipated date for the test, arrangement and form of the tests.

The procedure shall include the following for each test or group of tests:

1. The sequence of the tests to be conducted.

2. The time duration of each test

3. The number of test runs

4. A list of instruments that will be used for each test. The list shall define which instruments are (a) special test instruments, (b) certified, (c) to be calibrated before and after each test, (d) check instruments, (e) station supply instruments (f) Schematic diagram showing all test points and cross referenced to the instrument list and (g) method of data logging. Data logging thro' satellite communication is not permitted.

5. All formulae, calculations, conversion factors, curves, correction curves etc., to be used in the conducting of the tests and the calculations of the test results. All such items shall be to a accuracy level of four decimals.

6. Sample test reports to data sheets and all specific result sheet forms that will be used for the test.

7. Written procedure and description of conducting the test.

**9.6.3 Testing Method**

The testing shall be carried out as per PTC – 46. The test boundary shall include the entire unit with heat sink.

9.6.3.1 **Measurements**

The following measurement has to be taken during performance and guarantee test

**Output**

- Gross power out put of the GTG and STG
    - Auxiliary Power Consumption
- Noise level

All the plant, equipment and systems covered under this specification shall perform continuously without exceeding the noise level over the entire range of output and operating frequency.

Noise level measurement shall be carried out using applicable and internationally acceptable standards. The measurement shall be carried out with a calibrated integrated sound level meter meeting the requirement of IEC 651 or BS 5969 or IS 9779.

Sound pressure shall be measured all around the equipment at a distance of 1.0 m horizontally from the nearest surface of any equipment/machine and at a height of 1.5 m above the floor level in elevation.

A minimum of 6 points around each equipment shall be covered for measurement. Additional measurement points shall be considered based on the applicable standards and the size of the equipment. The measurement shall be done with slow response on

the A-weighing scale. The average of A-weighted sound pressure level measurements expressed in decibels to a reference of 0.0002 micro bar shall not exceed 85 dBA.

Corrections for background noise shall be considered in line with the applicable standards. All the necessary data for determining these corrections in line with the applicable standards shall be collected during the tests.

- Emission level

**Input**

- Natural Gas consumption

**Specific Site Conditions**

- Ambient pressure
- Ambient temperature
- Relative humidity
- Grid frequency
- Power factor
- Fuel analysis (Natural Gas)
- Cycle blow down

Correction curves shall be applied only on the above measured specific site conditions to arrive at the Plant Performance Parameters at the contract specified specific site reference conditions.

9.6.3.2 **Contract Specific Site Reference Conditions**

- Ambient pressure - 1013 mbar
- Ambient temperature- 35°C
- Relative humidity - 70 %
- Grid frequency - 50 Hz
- Power factor – 0.80
- Design NOX – As per GPCB norms
- Design fuel analysis - LHV of the Natural gas fuel as per contract
- Cycle blow down equal to 0 %
- Deterioration due to aging - factors that are to be applied for Gross power output as agreed and stated in the contract.
- Tolerances that are to be applied on corrected Gross Heat Rate and Gross power output parameters as specifically stated in the contract.

9.6.3.3 **Specific Conditions of Testing Method**

The correction method stated under cl.5.5.2 in PTC 46 shall be applied to correct the performance parameters measured and corrected as per the above stated method Tolerances are applied over these corrected performance parameters in such case.

9.6.3.4 **Test Uncertainties**

The test uncertainty (not tolerence) shall be calculated based on the accuracy and number of test instruments utilized. The same shall be done as per PTC 46 and the maximum expected uncertainty shall not exceed 3 % for corrected gross heat rate and 1.2% for corrected Gross

power output to validate the test. Accordingly the Tenderer shall state in the proposal the permitted deviations/fluctuations of design parameters that are permitted during the test for each operating mode testing.

9.6.3.5 **Correction Curves & Tolerance**

The correction curves shall be provided as mathematical equations in addition to the curves to an accuracy of four decimals. The equations supplied shall be utilized to perform the test result calculations.

**9.6.4 Measuring Equipment**

All test instrumentation and test equipment shall be provided by the Contractor. All the instruments shall be calibrated by a certified body before and after the tests. The calibration certificates shall be submitted to the Owner/Owner's representative prior to the tests. The calibration certificates shall be considered valid for a period of not more than six (6) months from the date of its calibration.

The anticipated points of measurement together with necessary isolation during the tests shall be indicated by the Contractor.

**10.0.0 CLEANING, PROTECTIVE COATING AND PAINTING**

Refer Vol III /Section 2/ Sub Section 2.15 Surface Preparation and Painting.

**11.0.0 SPARE PARTS**

The contractor shall also provide a list of recommended spares for two (2) years of normal operation of the plant over and above the mandatory spares.

**11.1.0 List of Mandatory Spares**

Refer Vol IV /Section 8/ Annexure 2

NOTE: All mandatory spares as per OEM declared critical items shall be included in the list.

**12.0.0 SPECIAL TOOLS, TACKLES AND EQUIPMENT**

One set of special tools and tackles required unit for the operation, maintenance, inspection and repair of the individual main equipment and auxiliary equipment shall be supplied by the Contractors in sufficient quantity to equip the shift personnel, maintenance personnel and workshop craftsman for commissioning, testing, calibration, modification and maintenance of the unit, List of such special tools, tackles and equipment shall be submitted in the EPC bid. Special tools and tackles excludes conventional ones and those locally available normally (not those requiring a drawing and considered as those made to order).

The special tools and equipment for maintenance and repair shall be delivered by the Contractor in lockable steel boxes and they shall be marked in an approved manner for identification purposes and a corresponding tool chart shall be supplied with the steel boxes.

The following tools and appliances shall be supplied under this Contract for use by the Owner/Owner's representative:

- two sets of special tools and gauges required for the maintenance of the Plant
- one set of special lifting and handling tackles / appliances required for the maintenance of the Plant.

The tools, tackles and appliances supplied in general, shall not be used for erection purposes by the Contractor and shall be handed over in brand new condition. Damaged tools, tackles, and appliances shall be replaced before handing over.

The exception to this is the special lifting gear which may be used provided that when it is handed over to the Owner/Owner's representative it has not been subjected to more than normal wear and is still fully suitable for its intended use.

Each set of tools, gauges and appliances under category (a) above shall be suitably arranged in fitted boxes of mild steel construction, the number of boxes being determined in relation to the layout of the plant and equipment in question.

If the weight of any box and its contents should be such that it cannot conveniently be carried, it shall be supported on steerable rubber-tyred wheels.

Each cabinet and box shall be painted, fitted with a lock and clearly marked in white letters with the name of the item of equipment for which the tools and appliances contained are intended.

Suitable storage racks shall be provided for all portable lifting tackle supplied under this contract.

Suitable lifting lugs, ears or ring bolts, or tapped holes for lifting rings shall be provided on all equipment items where the weight exceeds 15 kg.

All lifting tackle shall be stamped with a unique identification number and safe working load. A test certificate from an approved Authority shall be supplied for each item of lifting tackle.

The Contractor shall provide a schedule of all lifting tackle and tools and appliances being supplied, for the approval of the Owner/Owner's representative.

The Contractor shall provide all runway beams, trolleys, lifting blocks, special slings necessary for the safe and efficient handling and maintenance of the works. Particular attention shall be paid to handling of equipment located at higher elevations safety valves

The tools and appliances with the appropriate storage racks, cabinets and boxes shall be handed over to the Owner/Owner's representative at the time of Taking Over of the complete Plant.

Since the Contract includes site erection, any special tools or appliances required solely for erection shall be provided by the Contractor for his own use and shall remain the property of the Contractor.

Control and Instrumentation: Software with associated hardware required to access instruments or control systems to be provided.

## 13.0.0 CONSUMABLES

### 13.1.0 Lubricants and greases

All lubricants proposed for the Plant operation shall be suitable for all operating and environmental conditions that will be met on site.

All oils and greases shall where possible be readily available in India.

The number of oils and greases shall be kept to a minimum to the extent feasible. For each type and grade of lubricant recommended the contractor shall list at least three equivalent lubricants manufactured by alternative companies. This will be in line with that suggested by OEM and outcome will be informed to the Owner/Owner's representative.

In case of imported oils, lubricants and other consumables, the contractor shall indicate the indigenous equivalents to enable the Owner/Owner's representative to arrange subsequent fills. Preference should be given to indigenous oils and lubricants during first filling itself. Short shelf life items if any may be supplied in a phased manner keeping in view of their actual use.

The Contractor shall supply the first fill lubricants and greases, and also shall provide at the Completion Certificate sufficient lubricants and greases necessary for the efficient operation and maintenance of the Plant at full load 24 hours per day for a period as mentioned in the relevant portion of Commercial Specification.

**13.2.0 Chemicals and other consumables**

Contract includes the supply (by the Contractor) of all chemicals, reagents, resins, and other consumables required for testing, commissioning and setting to work of each section of the Works.

The Contractor shall provide all chemicals and other consumables required for the efficient operation and maintenance of the plant at full load 24 hours per day for a period as mentioned in the relevant portion of Commercial Specification.

The Contractor shall prepare a list of these consumables giving quantities necessary for each section of the works and the recommended suppliers.

The Contractor shall deliver to site sufficient quantities of consumables in his supply to allow for 6 months running of the Works prior to the issue of the Completion Certificate. The delivery of the remainder of the consumables shall be programmed to suit the operational requirements and space availability within the various stores.

**14.0.0 DOCUMENTATION**

**14.1.0 Format of Documentation**

All engineering documents and drawings shall be of international "A" series sizes, that is, A0, A1, A2, A3 and A4.

One set of CD containing all the drawings in Auto CAD (for final as built drawings) shall also be supplied in addition to hard copies.

Soft copy of all other documents shall be supplied in a CD in PDF or editable format. For review purpose pdf or editable version shall be considered.

Grouped documents shall be provided by size A4, with the inclusion of bigger size drawings which, however, have to be folded as Size A4.

For MPP package documentation shall be as per MPP standard.

**14.2.0 Numbering and Identification of Documents**

All the drawings shall be identified through a common way of numbering in accordance with the requirement of contracting. The numbering system of drawings and documents proposed by the Contractor shall be in compliance with the plant identification system and to be agreed

with the Owner/Owner's representative. Apart from this, some drawings may also be numbered in the way which the contractor or subcontractors are used to do. But, there shall be a common title Block on all published drawings which include the following contents:

- Owner
- Owner's Engineer
- Project
- Contractor
- System
- Drawing No.
- Sheet No
- Revision No.

The measuring units and dimensions marked on the project engineering drawings shall be of SI system conforming to ISO 1000.

English words shall be used as descriptions on drawings.

In case dimensions are not marked in conformity with the scale of drawings and any dimension on the drawing does not conform to those dimensions and sizes measured through certain scale, the actual marked dimensions shall be applicable.

For revision of drawings, the revised part shall be clearly and definitely shown on the drawing. For revision of documents which have been grouped together, a brief description shall be a perpendicular line with the margin of the revised copy closely following it.

### 14.3.0 Provision for Documents

Generally, copies of drawings or documents containing trade secret and drawings with patented nature need not be provided.

However, to know whether the Contractor has performed its obligations, the Owner/Owner's representative has the right to examine those drawings within the Contractor's working scope.

The Contractor shall meet the Owner/Owner's representative's reasonable demands to files and do the following to satisfy the Owner/Owner's representative:

- Contractor will work according to the requirements specified in the contract.
- Contractor's working has been arranged properly and developed according to the plan.
- The quality control system is reliable.
- After receiving all documents necessary for power plant operation and maintenance, Contractor shall supply equipment and systems.
- Having received all necessary documents for Contractor to perform its legal obligations or other relevant responsibilities.

### 14.4.0 Owner/Owner's representative's Responsibilities

The Owner/Owner's representative agrees that the Contract will be concluded in accordance with the EPC method of building the power plant. It is the Contractor's duty to ensure that design standards and conditions meet the requirements and that the power plant shall operate safely and reliably and with high efficiency, having the same performance as

stipulated and guaranteed. This is applicable until the plant performance is established in the last PG test. The plant performance beyond such last PG test will not be the same because of degradation as per equipment characteristics.

The Owner/Owner's representative will examine and check the drawings and documents with the aim of ensuring all these drawings and documents meet the demands and duties written in the documents. The Contractor shall have an active and cooperation working relationship with the Owner/Owner's representative.

If drawings and documents have been supplied to the Owner/Owner's representative, Contractor will await clearance / approval from Owner/Owner's representative at a pre-agreed time frame, before proceeding on design. In case, Owner/Owner's representative has comments / opinion, the same can be informed to the Contractor on priority basis so that corrections, if feasible could be incorporated in the drawings.

## 15.0.0 PLANT AND EQUIPMENT IDENTIFICATION, LABELLING

### 15.1.0 Plant and Equipment Identification

The contractor shall follow identification system for the whole plant equipment, instruments, facilities and systems as per the Annexure-4 Guide for Coding Equipment, Documents & Drawings

MPP generated drawings, identification system shall be based on MPP standard.

### 15.2.0 Labelling

Name plates which are to be firmly fixed on all the equipment, instruments, buildings and structures shall be provided. For equipment of small size, these are to be fixed on the piping or structure adjacent to the equipment. The contents of nameplate are to include the designation and principal parameters of the equipment.

The nameplate within the field shall be made of a high temperature - resistant metallic sheets, with designation permanently engraved on them. Indoor installed equipments (e.g., panels, cabinets, switchgear) shall also be labelled by appropriate name plate.

The form, size, base colour and colour of contents of the name plates and prompting plates will be agreed between the Contractor and the Owner/Owner's representative. It shall be possible for these to be readily seen by the operator. The designation of warning tags shall be different from that of other tags. All buried pipes and cables routes shall be identified with permanent marker.

## 16.0.0 CONTRACT DRAWINGS, DOCUMENTS FOR APPROVAL, LIAISON MEETINGS

### 16.1.0 General

The Owner/Owner's representative reserves the right to ask the Contractor to submit copies of drawings and other documents for approval to his Head Office or to the Office of his Representatives. If the Owner/Owner's representative or his Representatives are satisfied with the drawing, one copy will be returned to the Contractor marked with an 'Approved' stamp Within a pre-agreed time frame, If the Owner/Owner's representative or his Representatives are not satisfied with the drawing, one copy stamped 'Examined and Returned with Comments' will be returned to the Contractor with comments marked thereon and the drawing shall be revised and re-submitted for approval.

The purpose of having drawings checked and approved by the Owner/Owner's representative is to assist the Contractor in interpreting the Technical Specification so as to eliminate mistakes in the equipment or material actually shipped to the site of the work. The formal approval given to the Contractor is to be considered as in conformity with this purpose and in no manner shall be construed so as to release the Contractor from any liability or responsibility for proper design, fabrication or compliance with the Contract Documents.

Equipment drawings shall clearly indicate the general arrangement of the equipment to be furnished, give principal dimensions, and show sufficient details required for a complete power station.

While submitting drawings for approval, including any prepared by a Sub-Contractor, the Contractor shall certify that he has fully examined such drawings and that they comply with the requirements of the Contract.

If any item, equipment or work shown in the drawings does not completely comply with the requirements of the Specification or any other requirement of the Contract Document, the Contractor is obliged to clearly inform the Owner/Owner's representative and his Representatives of the differences giving full explanations and reasons for such changes.

For the purpose of this Clause, the term "drawing" shall include design calculations, equipment specifications, diagrams, schedules, performance curves.

Approval of a drawing by the Owner/Owner's representative will imply that:

a) Arrangement and layout drawings and key diagrams have been examined and appear to be in accordance with the basic design concept of the project and meet the requirements of the Specification.

b) Other drawings of components and equipment have only been examined in relation to compatibility of the items and equipment with the Specification and in respect of interconnection with other items and equipment.

c) Any approval given by the Owner/Owner's representative shall in no way relieve the Contractor of his responsibility under the Contract.

The Owner/Owner's representative will not normally require to receive copies of detailed manufacturing drawings but the Contractor shall make these available if requested to do so.

The Contractor shall ensure that drawings are submitted in due time to permit amendments to be made and the drawings re-submitted for approval without delaying the scheduled deliveries or the guaranteed competition dates according to the Contract. Execution of work shall be taken up after the drawings are cleared by the Owner/Owner's representative.

If, during the Contract period, the Contractor is required to modify the size of any buildings, foundation from that shown in Technical Specification drawings to accommodate the finally approved arrangement of the Work (with due allowance for access, laydown, maintenance), then such modification shall be deemed to be included in the scope of the EPC Contract.

Requirements about the format of drawings and documents, the provision for documents and the Owner/Owner's representative's responsibilities with regard to documentation are specified in relevant section of this volume.

The Contractor shall be responsible for any discrepancies, errors or omissions in the drawings and other particulars supplied by him, whether such drawings and particulars have been approved by the Owner/Owner's representative or not.

**16.2.0 Documentation by Contractor**

The drawings to be submitted by the Contractor for approval shall cover the complete Scope of Contract work as defined by the Contract Specification and shall generally include, but not be limited to, the following:

**16.2.1 Drawings and Documents to be submitted along with the proposal**

(**A) General (applicable for all discipline)**

- Heat and Mass balance diagram as specified in Vol IV /Section 7 (Technical Data sheets and Schedules to be filled in by the Bidder).
- Completely filled in technical schedules for all equipments as enclosed with the Tender specification.
- P&ID (Process and Instrumentation drawings) indicating Instruments and the destination / functionality of the signals.
- Plot Plan.
- List of spares
- List of Special tools and Tackles

(**B) Mechanical**

Start up curve for cold, warm and hot condition

Performance and correction curve for Gas Turbine, Steam Turbine and HRSG

**(C) Electrical**

- Key Single line diagram
- Metering and protection Single line diagram for Generators
- Metering & protection Single line diagram for 66kV GIS
- Single line diagram for Auxiliary power distribution
- Description of all Electrical equipment
- Generator capability curve, Voltage vs frequency curve, Overload capability curve , Open and short circuit characteristic and Excitation curves

**(D) Control and Instrumentation**

- Control system configuration / architecture drawing for Plant DCS, GT & Generator, ST, local PLC's.
- Control philosophy / operation philosophy / design philosophy / redundancy philosophy.
- Scope of supply and services for C&I.
- Brief process description / functional write – up for all open loop and closed loop controls.
- Details of C&I and PLC System offered for offsite plants.
- Brief write-up, scheme, technical details of Continuous Emission Monitoring (CEM), Steam and Water Analysis System (SWAS) .
- Codes and applicable standards followed for the project.
- List of vendors for instrument / equipment.

- Deviation schedule (if any)

### 16.2.2 Drawings and Documents to be submitted after Award of Contract

The documents required for design, construction, installation, operation and maintenance of the entire plant shall be submitted by the Contractor in good time so as to permit the plant as a whole to be constructed in compliance with the specified time table. The Contractor shall establish a online document and work flow management system to control the document flow and the approval process.

MPP supplied equipment will follow their standard documentation.

Only the most important documents are listed below. The list and approval category of the doc/drawings shall be agreed sufficiently in advance before award of relevant order, so that corrections and amendments desired by the Owner/Owner's representative as well as resubmission of the documents will not result in any delays with respect to the guaranteed time table. The Owner/Owner's representative reserves the right to request from the Contractor additional drawings, documents as may be required for proper understanding and definition of the design and engineering of the Plant.

**(A) General**

- Re-Submission of all the technical data furnished during pre award contract stage.
- Complete filled-in technical schedule.- For approval
- Plot plan - For approval
- General arrangement drawings /Equipment layout of all equipments along with sections indicating the unloading and maintenance area .- For approval
- Design basis for all the systems and major equipment sizing calculation - For approval
- P&ID (Process and Instrumentation drawings) indicating Instruments and the interlocks for all the systems - For approval
- Monthly progress report with photographs (Hard and soft copies)
- L2 network
- Quality plan for approval
- Equipment Testing procedure for approval
- Complete list of documents with proposed submission schedule
- Vendor Engineering document via Data sheets, General arrangement drawing , material of construction ,performance curves for approval for major items
- Painting and surface preparation procedure
- Technical specification
- General arrangement drawing with section for major building viz., GTG/STG hall, CW pump house, Deaerator & BFP area 66 KV switch yard,66 KV indoor GIS room and HRSG showing maintenance area
- Description of options and alternatives offered
- Safety Plan
- Training program and schedule for training of Owner/Owner's representative's personnel
- Space requirement for construction site and equipment
- Maintenance proposal (for GTG, STG and Fuel Gas system)
- Inspection intervals (major/minor)for six years along with the spares to be replaced during the above inspections .

- Bidder shall enter into a long term spare supply agreement with the OEM and agree to transfer the same faithfully to the Owner/Owner's representative upon COD. Bidder shall commit to facilitate further negotiations on the spares with the OEMs directly by the Owner/Owner's representative.

(**B) Mechanical**

- Major equipment sizing calculation viz Boiler Feed pump, Condensate extraction pump, Condenser cooling water pump, Aux cooling and closed cooling water pump, Air compressor, Bypass valve, Make-up pumps, for approval
- Start-up and shut down procedure along with the curve for approval
- Content (index) of the system description document for approval
- System description for all the systems for approval
- Pipe rack and composite piping layout for approval
- Thermal calculation for critical items for approval
- Fire protection system layout
- Heating and ventilation system layout
- Pipe sizing and determination of pressure and Temperature criteria. for approval
- Critical piping drg and calculation
- Acceptance and Performance test procedure and program
- Acid/Alkali/Boiling out procedures

**(C) Electrical**

- Key Single line diagram
- Single line diagram for Auxiliary power distribution for approval
- Single line diagram of Switchboards
- Single line diagram for switchgears
- Metering and protection Single Line diagram
- Logic diagram and schematic diagram
- Wiring diagrams of all equipment
- Performance / Characteristic curves of Generators, Motors, transformers.
- System Study such as Load flow, Short circuit, Motor starting calculations.(to be done in ETAP and ETAP file to be submitted for review)
- 66kV GIS metering & protection SLD, Schemes & General arrangement
- 66kV transmission conductor data sheet other details
- 66kV OHL sag tension calculation
- SAS architecture & system description
- SAS input & output list
- Electrical equipment layout.
- Lighting layout, earthing and lightning protection layout.
- Notes & details for lighting, cable tray, ligntning, earthing.
- Foundation details, fixing details and loading details of all equipments.
- Installation details
- Cable tray/routing layouts for the entire plant
- Cable block diagrams ,Cable schedule and interconnection schedule

- Relay setting calculations (to be done in ETAP and ETAP file to be submitted for review)
- CT and VT sizing calculations
- Electrical load list / equipment list
- Alarm schedule and list of Circuit breakers and control.
- GA drawing for all the major equipment such as Generators, transformers, Busducts, Description Excitation System and AVR.
- Type test certificates for Generator, Generator transformer.
- Catalogues of all electrical equipment.
- GA drawing for all the major equipment such as generators, gransformers, busducts, descriptin excitation system and AVR.
- Type test certifications for generator, generator transformer.

**(D) Control and Instrumentation**

- Detail dimensional drawings of various equipment, components / sub-assemblies.
- Control Room layouts
- Detailed DCS / PLC/ GT & Generator, ST control system architecture drawing (also indicating interconnection of different offsite C&I System) highlighting the applicable standards for control and information domain ; networking and security features; graphic capabilities data exchanger procedure, engineering tool, system capability such as graphic displays, trending, archiving, logs, reports.
- Outline general arrangement / Internal general arrangement drawing for all the I&C equipments drawing for all the I&C equipments.
- DCS / PLC / Local control system / Vibration monitoring system functional specification covering both the hardware and software details along with the data sheets and technical catalogues.
- DCS / PLC IO allocation details, System loading details, controller grouping details.
- Design philosophy of C&I systems.
- Process description / functional write – up for all open loop and closed loop controls
- Instrument loop schematics,
- Analog control schemes, Logic and protection diagrams for the entire I&C system along with the write-up/functional description.
- Performance calculations write up.
- Start-up and shutdown logics with procedures and write-ups
- Grouping philosophy of control loops in controllers.
- Marshalling / cabling philosophy
- Cable schedule, JB Scheudle ,Interconnection and wiring schematics for the I&C systems offered.
- Detail wiring diagrams of all panel desk, control consoles, system cabinets.
- Plant graphics, alarms, various displays, logs and reports with menu and format.
- Flow element sizing calculations and dimensional drawings.
- Control valve and Safety Relief Valve sizing calculations and dimensional drawings.
- Operation and maintenance manuals for all the I&C equipments and systems.
- Details of the PLC / C&I System in offsite plants.
- Interconnection Diagram of different PLCs and the DCS showing all hardware details.
- Analog and binary drive list for the entire system

- Complete Instrument Schedule, DCS I/O list, (Software and hardware) Annunciation list, SOE list, Hardware list for safe shut down, Flow element schedule, Control valve schedule, JB schedule, Rack schedule.
- Data sheets, Specifications, Technical manuals and catalogues for the offered make and model of field instruments, analyzers, lab instruments, SWAS system, SEMS, GPS, CCTV, erection hardware and associated accessories.
- Technical Particular Sheets of each hardware / instrument/control system/software offered with complete bill of materials and related detailed technical literature, coding procedure.
- Confirmation certificate for the latest version of software and hardware offered.
- Final BOQ for the I&C system with the bought item vendor list.
- Calibration test and quality assurance test procedure and test certificates.
- Pre-FAT, FAT(Factory Acceptance Test), SAT (Site Acceptance Test) reports
- Instrument installation and Hook-up diagrams showing all erection hardwares.
- Tapping point details.
- Instrumentation Layouts such as, CEM room layout, SWAS room layout, JB/ Rack/ Tray /Instrument location drawing.
- C&I power distribution scheme including UPS supply.
- Instrument air distribution scheme.
- Reference list with capacity of plant, year of commissioning and control system implemented along with minimum two users' certificate for the DCS system configuration offered.
- Evidence that the offered DCS system is upgradable and evolutionary in both hardware and software
- Letter confirming that any future compliance required for the system / applications software supplied and all up gradation would be implemented.
- Spare parts list, Laboratory Instrument list, test and calibration report, special tools and tackle list.
- Earthing schemes,
- All other lists and drawings as required
- DCS vendor drawings/documents.
- All the above drawings as applicable for the mechanical packages

**(E) Civil**

- General site plan of the entire site showing all buildings and installations, traffic routes and landscaping.
- Architectural arrangement drawings, design layouts and itemized drawings (plans, elevations and sections) to scale 1:100 of all buildings and plants
- Views of all sides of all buildings, scale 1:100
- Architectural drawings of each floor (plants, sections) including all necessary detail drawings, scale 1:50
- Arrangement drawings of the external plants of the site as a whole (existing, planned) with all supply and disposal facilities, roads and vehicle access and manoeuvring areas, sewers, channels and culverts.
- Detailed constructive description of the building with regard to the structural design (structural systems, foundations)

- Detailed specification of the buildings including information on interior decoration ,materials and qualities for execution
- Detailed construction drawings of all corresponding civil / structural / Architectural works including buildings, foundations, roads, trenches, cable ducts and services.
- Structural design calculations for all buildings and foundations including equipment foundation. For rotating and vibratory equipment, dynamic analysis calculations shall also be submitted. Relevant software files used for analysis and design shall also to be submitted.
- Sectional elevations and roof plan
- False floors/systems
- Underground services and ducts with equipment appertaining to the services
- Layout of roads
- Plant drains layout
- Design of Roads and Drains.
- Principal details and sections for traffic areas, especially for ramps and retaining walls
- Layouts for external works showing plants and fencing.
- Schematic details for plumbing
- Foundations and other underground concrete works for the transformer area.
- Finishing schedules for all the buildings.

**(F) Others**

- Testing report for approval.
- Declaration of conformance with statutory regulations.
- Operation and Maintenance manual.
- Training program.
- As-built-documentation including drawings of all equipment
- Complete bill of materials of the plant with expected life of major items along with break up price.
- Welding procedure (for workshop and site).
- Lubrication list and Schedule.
- Site Quality plan.
- Erection and Commissioning procedure.
- Overall project implementation with key dates and milestones for major plants design, construction, erection, test run, mechanical completion / pre-commissioning testing / commissioning, trial operation / Reliability run test / performance guarantee test run, and taking over of the complete power plant.
- Reference lists for delivery and installation of plants of similar type and size.
- Layout of temporary site facilities , buildings, structures , installations.

### 16.3.0 Liaison Meetings

The liaison meetings shall be organised by the contractor. Time period for the same shall be mutually discussed and agreed after contract finalization stage. Document distribution schedule shall be discussed and finalized after contract award stage.

Contractor shall supply all documents required in the appropriated number as requested by the Owner/Owner's representative.

### 16.4.0 Distribution of documents

The source, distribution, no. of copies shall be as per the following document distribution schedule.

### 16.4.1 Document Distribution Schedule - After Placement of Order

| Sl. No. | Document | Total Copies | Distribution | | |
|---|---|---|---|---|---|
| | | | Owner | | Owner's representative |
| | | | HQ | SITE | |
| 1. | PERT Network, work schedules, Bar charts, Layout drawings | 10 | - | 5 | 5 |
| 2. | Data, drawings, documents, write-ups, calculation | | | | |
| | - Preliminary | 10 | - | 5 | 5 |
| | - Revised | 10 | - | 5 | 5 |
| 3. | Approved drawings and documents. | 10 | - | 5 | 5 |
| 4. | Instruction manuals for erection and O&M | 10 | - | 8 | 2 |
| 5. | As built drawings including O &M manual | | | | |
| | - Hard Copy | 10 | - | 8 | 2 |
| | - Soft Copy | - | - | - | - |

## 16.5.0 Manuals

### General

The Contractor shall provide the manuals in a timely manner to enable the Owner/Owner's representative to review and comments and request changes as necessary.

Payments will be withheld for non-compliance or for late delivery of the drawings, procedures and manuals. In particular the Contractor shall be held responsible for consequential damage to the plant where such damage is due to late delivery of the O&M manual resulting in non-familiarity of the operating technique.

The Contractor shall also note that while all documents, procedures and manuals shall be in the English language including that of the Subcontractor of the Contractor, it is particularly important that the O&M manuals be in clear concise English.

All manuals shall be divided by systems or sections and cross-indexed as necessary.

### Certification Manual

This manual shall contain the approved works certification documentation for all plant equipment and services as specified in the relevant codes and standards and in this specification and the Contractors Quality Manual. This manual shall also include all material tests certificates. Certificates and test procedures shall be specific to the plant supplied.

### Design Manual

This manual shall contain all the design calculations (except for HRSG) and all equipment and system data sheets and design criteria required under the Contract. Contractor shall provide a design basis report and HRSG datasheet during detailed engineering stage after award of Contract

### Construction Manual

This shall include a comprehensive record of as built site construction tests and records. Again the manual(s) shall be compiled in separate parts to reflect the plant and services supplied.

### Commissioning Manual

This manual shall include all the records, certificates and test results arising from the agreed pre-commissioning and commissioning procedures carried out on site. The performance tests and guarantee test results shall also be included. There is a particular requirement that all commissioned plant/equipment values be recorded in this manual and subsequently incorporated into the O&M manuals.

### Operating and Maintenance (O&M) Manuals

The Contractor shall provide the O&M Manual properly bound, within the time specified, to enable the Owner/Owner's representative's staff to become fully acquainted with the operation, adjustment and maintenance of the entire plant. The manuals shall contain full and explicit instructions in respect of the operation of the plant under all operating conditions and the maintenance routines and requirements to be established to maintain the plant in optimum performance. These instructions shall be in the English language and be as comprehensive as possible and the form in which they are to be set out shall be agreed with the Owner/Owner's representative. The instructions may be divided as appropriate into in individual sections and sub-sections as necessary. All section and sub-sections shall be clearly indexed and cross-referenced as required for clarity.

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The instructions shall be tailored to suit the specific requirements of the Operations and Maintenance functions and personnel, taking into account the staffing philosophy for the combined cycle power plants.

The instructions for the related parts shall be accurate and easy to understand and shall contain the necessary sequence of individual activities. The diagram and drawings associated with the instruction shall be clear and unambiguous.

It is an essential requirement that all information and plant data contained in the manual must be project specific and derived from the design, manufacturers / suppliers and commissioning data of the as-built plant. Where the Contractor includes standard brochures the installed item of plant or equipment shall be clearly identified. All sections shall contain an introductory description of the particular item/system including its function and operating criteria and any special features. On the basis of the commissioning and running experience of the Plant, the instructions shall be amended to a final form within three months of the end of commissioning and, for this purpose; the Contractor shall supply the required number of printed copies of all approved amendments for insertion in the bound set of instructions.

The entire O&M manuals including that of the Subcontractor shall all adopt the same format paper size. The Contractor shall prepare manuals integrating all equipments supplied by the Subcontractors.

**Operating Instructions:**

The instructions shall include at least the following specific procedures/practices /items:

- starting-up
- shutting down
- operation / procedures during fault conditions
- surveillance and monitoring of plant .check lists
- standard readings
- operational parameters (especially limiting values in critical areas)
- isolating procedures
- Earthing /switching
- trouble-shooting
- fault reporting
- normal operational reporting
- compliance with requirements for interfacing with grid.
- safety/security/fire fighting/ first aid
- general plant standards and guidelines .
- test procedures
- maintenance and operating management systems
- drawings, schematics, logics and wiring diagrams, function diagram, P&IDs.
- protection

**Maintenance Instructions:**

The instructions should provide for the three maintenance functional groups – 1) Mechanical, 2) Electrical, and 3) Control and Instrumentation - and shall include at least the following:

Maintenance Management System

- a complete and accurate description of the main plant items and systems of the Power Station specific to each function
- detailed maintenance procedures and intervals for all plant items.

- assembly and disassembly procedures.
- spare parts
- use of special tools and equipment
- lifting procedures
- drawings, detailing tolerances
- schematics, logics and wiring diagrams, function diagrams P&ID's.
- isolating procedures,
- Safety and Codes of Safe Practice.
- Fire fighting/first aid
- set-up and calibrating procedures .
- optimisation of Control Loops
- diagnostics and trouble shooting
- specialist maintenance/repair procedures including welding procedures.
- materials test procedures

**Storage and Retrieval Facility**

For easy documentation storage and retrieval all the required software and hardware supply and commissioning shall be included in the scope of EPC Contractor.

**Owner/Owner's representative's Responsibilities**

The Owner/Owner's representative agrees that the Contract will be concluded in accordance with the EPC method of building the power plant. It is the Contractor's duty to ensure that design standards and conditions meet the requirements and that the power plant shall operate safely, reliably and with high efficiency, having the same performance as stipulated and guaranteed.

The Owner/Owner's representative may examine and check the drawings and documents at his discretion with the aim of ascertaining that all these drawings and documents meet the requirements specified in the contract documents. The Contractor shall have an active and cooperative working relationship with the Owner/Owner's representative. If there is a disagreement over any issue, Owner/Owner's representative and Contractor shall work together to reach some conclusion through mutual consultations.

The drawings and documents of the Contractor shall be returned with observations if any within ten working days by the Owner/Owner's representative. The Contractor shall clarify the observations raised by the Owner/Owner's representative and shall attempt to correct the drawing or document subsequently only.

## 17.0.0 ENVIRONMENTAL PROTECTION

### 17.1.0 Applicable Standards

The project must conform to the national standards of the Republic of India. The following standards and /or regulations are to be applied:

### 17.1.1 Environmental Quality Standards

The discharge of pollution in water and air as well as noise levels shall meet with the stipulations of State Pollution Control Board as well as other Acts of the Government under the Ministry of Environment and Forestry. It is a pre-condition that irrespective of what is stated in statutory regulations or any other act or norms, the Specification stipulated environmental qualities standards are the minimum requirements and shall be fulfilled in all aspects.

### 17.2.0 Fundamental Requirements of Environmental Protection for Power Plants

### 17.2.1 General Principals

To protect the environment, Power Plant should comply with state regulations, carry out composition and review system for Environmental Impact Assessment (EIA) report and execute the "Three Simultaneousness" system, namely, simultaneous design as per Technical Specifications, construction and operation of both pollution prevention facilities and the main plant. The preparation of EIA is not a part of EPC Contractor's Scope.

Environmental protection design for the power plant shall be based on the requirements of CPCB/ SPCB and relevant stipulations, and state of the art, proven technology shall be adopted. Latest CPCB/ SPCB guidelines as applicable.

### 17.2.2 Atmosphere Pollution Prevention and Control

HRSG main stack height shall satisfy the State Pollution Control Board requirement. The height of the HRSG stack shall be finalised during detail engineering (DDE). The exit velocity of flue gas at stack shall not be less than 22 m/s.

### 17.2.3 Water Pollution Prevention and Control

The plant should be designed to economize on water use and to set up a water management system featuring equilibrium between water feed and water discharge.

- Waste water from the plant shall be treated in distributed mode and will reach the standards before it is discharged to the final discharge point, i.e measurement shall be carried out before the return water reaches the existing seal pit
- The acid and alkali waste water from the chemical treatment station will be discharged after being treated in the neutralization pit and reaching the standards.
- The sanitary sewage will be permitted to discharge after the sewage has internally been treated and met the required criteria.
- The cooling tower blowdown shall be routed to the nearest OWS drain pit before being finally treated in the existing OWS treatment system. Also provision shall be kept for routing the cooling tower blowdown to the storm water drain with an isolation valve.
- Boiler blowdown along with the oily waste water (intermittent) shall be routed to the nearest PWS drain pit before being finally treated in the existing PWS treatment system.

### 17.2.4 Noise Pollution Prevention and Control

The Contractor shall take all necessary measures for noise attenuation in order to meet the specified noise levels.

General requirements of noise control :

- The minimum requirement shall be met as whatever has been specified in each of the Detailed Technical Specifications. However the station shall be acoustically designed so that an admissible noise level of 70 dB (A) during night time and 75 dB(A) during day time shall not exceed at nearest Property boundary during normal operating mode.

For Central Control room, near to the duct noise level shall not exceed 60 dB(A) and at other places noise levels shall not exceed 50 dB(A)

The noise level in the offices and the control room shall be not more than 50 dB (A)

The Contractor shall take measures for noise attenuation, if the above mentioned noise levels are not met.

### 17.2.5 Flue Gas Emission Levels

In order to meet the environmental quality requirements, the Contractor has to guarantee that at all loads and operating conditions of the plant the following flue gas emission levels, measured in the Main stack.

- Natural Gas – As per GPCB norms or better.

The above indicated emission levels shall be guaranteed by the Contractor for the entire load operation. Bidder to indicate how the Low NOx emission shall be ensured in the bid.

The Contractor shall provide on-line In-situ automatic continuous Stack Emission Monitoring System (SEMS) for monitoring the levels of SOx, NOx, SPM, CO, $O_2$, flue gas temperature and exit velocity. The Contractor shall also provide portable kit for measuring SOx, NOx and SPM in stack. Monitoring of required signals to Pollution control board shall be through an operator station . Required software shall be provided by contractor.

## 18.0.0 TRAINING REQUIREMENTS

### 18.1.0 General

The Contractor shall be responsible for the instruction and training of the Owner/Owner's representative's operation and maintenance personnel in all aspects of plant design, construction, erection, commissioning. and in such a way that operation, maintenance and if necessary repairs of all the power plant equipment and facilities specified can be handled competently by the said personnel.

Such training of the Owner/Owner's representative's personnel shall be performed

- DCS training shall be provided at manufacturers place. All other training provided for balance of plant systems shall be class room training at site.
- In Contractor's and/or sub-suppliers'/manufacturers' home office and/or workshops;
- In similar plants and such plants which are in operation or on simulator;

- On the job training at site by the Contractor's and/or his sub-suppliers, supervisors and/or instructors deputed to the site for supervision of erection, commissioning, testing and trial operation and/or by specialized training instructors.

- On the job training at site by the Contractor's and/or his sub-suppliers, supervisors and/or instructors deputed to the site for supervision of erection, commissioning, testing and trial operation and/or by specialized training instructors.

- At the Power Plant by the supervisors deputed to the Plant during the Warranty Period; in compliance with the provisions of the EPC Contract and the requirements of this specification.

The personnel required for the safe and efficient plant commercial operation and maintenance of the various types of equipment installed will be provided by the Owner/Owner's representative in accordance with the recommendation to be made by the Contractor.

The training shall be performed in English. Translators/interpreters if required shall be provided by the Contractor.

The Contractor's instructors shall use modern training techniques, procedures and aids and make available to the trainees all required notes, manuals, drawings to supplement the Operation and Maintenance Instruction Manuals.

The Contractor shall furnish during detail engineering detailed description on the recommended training services, including

- Number, category, seniority, experience required. of the personnel to be trained.
- Preliminary training program, showing
- Training facilities, training aids places of training
- Training schedule
- Specialty and details of lectures and training
- Duration of training courses

For each type of training such as classroom, manufacturer's / supplier/ sub-supplier works on the job site, at the proposed Plant.

The recommended training program should be based on the organizational and staff structures of similar plants already in operation in India, and should take into consideration not only the training for operation and maintenance staff, such as operators, skilled workers, foremen and technicians, but also for senior staff and key personnel employed for the management and organizational duties of the various power plant disciplines, such as for operation, maintenance, instrumentation and control, chemistry, administration, security, spare parts handling, scheduling and engineering.etc.

The bidder shall furnish in his bid quoted prices (all inclusive, taking into account the provisions specified in the following clause) for the training of the Owner/Owner's representative's personnel in the Contractor's country, in similar plants, at the Contractor's works and works of Contractor's sub-suppliers, on the job site and at the Plant site shall be given by the Bidder, based on his recommended training program to be indicated in the bid.

**18.2.0 Contractor's Obligations and Tasks**

The Contractor shall make every effort to train the Owner/Owner's representative's personnel so that they can be qualified for the management, operation and maintenance of the Plant.

The Contractor shall nominate their key person who will be in charge for organization and co-ordination of activities for training.

The training program shall be carried out according to the requirements of each speciality. It shall include but not limited to the following:

a) Systematic explanation in a classroom on specific subjects, such as the equipment performance, construction, main systems, auxiliary systems.

b) Visit to similar plants.

c) Practical training in similar power plants, which are under erection and commissioning.

d) Practical training on simulators and control rooms of similar plants.

b) Supply of all necessary training documentation (such as books, manuals, and drawings), equipment, tools and instruments. The Contractor will make best effort to achieve above item (c) and (d) with utility authority.

The Contractor will make available free of charge to the Owner/Owner's representative's personnel tools and tackles, safety helmets, shoes, stationary item as needed by the training program.

The Contractor shall allow the Owner/Owner's representative's personnel to carry back to India, all the technical documents supplied during the training. Transportation of Customer's personnel (air fare, car rental, train fare, etc.) to place of training will be to Owner/Owner's representative's account. Lodging and boarding and any other incidental expenses related to Training shall be to Owner/Owner's representative's account. Visa charges will be borne by Owner/Owner's representative. Local transportation from the place of staying to place of training shall be to Owner/Owner's representative's account.

The Contractor shall assist the Owner/Owner's representative's personnel in arranging entry visas and all the formalities for staying in foreign countries for training. Visa charges will be borne by Owner/Owner's representative .The Contractor shall also take all the necessary measures to ensure the safety of the Owner/Owner's representative's personnel during their stay in the foreign country.

Training shall be designed to offer instruction and training to both personnel with a reasonable level of experience in power plant operations and maintenance, and shall be of such quality so as to provide operation, maintenance personnel with a working understanding of all operational and maintenance aspects of the Plant. The purpose of the training services is to give to the Owner/Owner's representative's personnel a necessary knowledge of equipment and systems delivered by the Contractor.

In addition to classroom training, an essential part of the training will be the participation of the operation and maintenance personnel in the commissioning of the Plant.

Training shall be designed to offer instruction and training to personnel with a reasonable level of experience in power plant operations and maintenance, and shall be of such quality so as to provide operation, maintenance personnel with a working understanding of all operational and maintenance aspects of the Plant.

**18.3.0 Owner/Owner's representative's Responsibilities**

The Owner/Owner's representative shall appoint a person as official representative of the Owner/Owner's representative's trainees.

The trainees shall understand the English language and shall follow the training courses with due diligence. During their stay abroad, the Owner/Owner's representative's personnel shall

observe the Laws of that country and the rules/regulations of the factories/plants where the training will be conducted. The official holidays or national holidays, and weekly holidays as per the plant/ project site shall be followed by the Owner/Owner's representative's personnel.

For the successful completion of the training program, unless mutually agreed by the parties, the program cannot be interrupted for vacation leave.

To and fro rail/road/airfare of trainees between the place of posting of the trainees and place of training shall be borne by the Owner/Owner's representative.

**18.4.0 Training schedule and program**

The program for the Owner/Owner's representative's personnel will be defined during the liaison meeting.

Two (2) months before the arrival of the first group of the Owner/Owner's representative's personnel in training site, the Owner/Owner's representative shall inform the Contractor of the date when the Owner/Owner's representative's personnel are expected to be sent to training site

Within 2 (two) weeks after receipt of the Owner/Owner's representative's information mentioned above, the Contractor shall confirm their agreement or indicate difficulties, if any, for the staying of the personnel. Thirty (30) days before the arrival of the Owner/Owner's representative's personnel in the training site, the Owner/Owner's representative shall inform the Contractor of the brief career profile of the personnel including names, date of birth, nationality, specialisation, experience, qualification, position and knowledge of foreign languages for their reference / information.

The Contractor shall not charge the Owner/Owner's representative the costs for the training activities in the respective training sites.

**19.0.0 PROGRESS REPORTS**

**19.1.0 Reports during design and procurement**

The Contractor will submit a progress report each month, within the first 7 days of each month, which indicates the following aspects as a minimum:

- Executive summary
- Work completed last month
- Status of design and its approval
- Status of procurement, manufacturing, works test, shippings
- Status of permission from authorities
- Time schedule, indicating progress achieved
- Preview, indicating major activities, design meetings.
- Areas of concern

**19.2.0 Report during Site Erection, Start-up, Testing**

The intervals for report submission shall be decided jointly between Owner/Owner's representative and Contractor in addition to the aspects mentioned above, the following information should be added:

- Site safety report
- Photos showing erection progress
- employed personnel / equipments / cranes

- Preview on tests to be performed, start-up requirements.

**20.0.0 PLANT PERFORMANCE GUARANTEES**

**20.1.0 Reference Condition**

The plant performance guarantees to be provided during Performance Test shall be based on the following at .Site refernce conndtions as per clause 9.6.3.2 above

a) The "Gross power output" of the plant shall be the measured output at the outgoing terminals of the Generator and shall exclude excitation power.

b) The heat rate shall be referred to the gross power output at site reference conditions.

c) The plant shall be capable of operating at any ambient conditions prevailing at site as per specification without imposing any limitation on the specification requirements. However, the maximum power the plant can generate may be limited by the capacity to which the gas turbine is normally designed but shall at least be equal to its unrestricted capability at ISO conditions.

**20.2.0 Auxiliary Power Consumption of the plant**

The Contractor shall guarantee the power consumption of all continuously operating auxiliaries, which are required for the operation of the power plant at base load and transformer losses. The Bidder shall list the auxiliary power consumption separately for each equipment/system. Bidder shall provide correction procedure for variation in auxiliary power consumption for variation in ambient conditions and other reference conditions indicated above, as applicable.

**20.2.1 Equipment / system to be considered for guaranteed auxiliary power consumption**

20.2.1.1 **Definition of guaranteed auxiliary power consumption**

Guaranteed auxiliary power consumption shall mean the total electrical power consumed by the plant during normal operation, the plant generating guaranteed gross power output in combined cycle mode.

Equipment / systems need not be considered for guaranteed auxiliary power consumption

Lighting loads in areas other than specified below.

The performance test shall be conducted during daytime. However, all lighting in the following areas shall be switched "ON" while carrying out the Performance Guarantee Tests but not limited to :-

- GTG/STG Building
- Switchgear room
- Cable spreader room
- GTG/STG Control room
- GIS building
- GIS control room
- SWAS Room
- Air compressor/Workshop

Following equipment / systems also to be considered for guaranteed auxiliary power consumption

- CCW pumps
- ACW pumps
- Side Stream Filter (SSF) pumps
- DM water transfer pump
- BFP pumps
- CEP pumps
- Lube oil Pumps & Jacking Oil pumps.
- Compressed air system (CAS)

20.2.1.2 **Measurement of auxiliary power consumption**

To arrive at the Gross Power output of the plant, the Gross Power output of each generator shall be measured. The power to be measured/recorded at following locations to arrive at the auxiliary power consumption of the power plant-

a. 11 KV CCCPP auxiliary switchgear incomer,

b. Outgoing auxiliary trasformer feeders

c. Outgoing motor feeders for the power Plant

d. Outgoing feeders to the complex

**Auxiliary power consumption of CCCPP will be measured at individual 11 kV auxiliary feeers of 11 kV CCCPP auxiliary switchgear (11 kV CCCPP motor feeders and auxiliary transformer feeders). Individaul auxiliary consumption of 11 kV auxiliary feedes shall be summated and to be displayed at 11 kV switchgear as well as at Sub-station Automation System (SAS).**

All equipment / systems including transformer losses, busduct losses, switchyard losses etc., in the power plant shall be considered for guaranteed auxiliary power consumption.

**20.3.0 Heat Balance Data**

The Bidder shall furnish the heat balance diagrams as specified in Vol-IV / Section 7 (Technical Data sheets and Schedules to be filled in by the Bidder).

**21.0.0 PENALTY FOR SHORTFALL IN PERFORMANCE**

The Contractor shall provide guaranteed performance for the complete works and the values guaranteed shall be binding on him. The Contractor shall conduct performance test as described in contract document and prove the guarantees.

The terms under Guarantee fall under two categories:

A. Items for which penalty will be leviable for shortfall in Performance.

B. Items for which shortfall in performance is not acceptable and which must be corrected at no extra cost to the Owner/Owner's representative.

**21.1.0 Items for which penalty will be leviable for Shortfall In Performance**

**21.1.1 Simple Cycle Mode – Not applicable**

**Gross Power Output**

If the measured gross power output of the generator terminals falls short of the guaranteed gross power output under simple cycle mode, the penalty levied shall be as below:

Per kW shortfall : Rs. **-**

**Auxiliary Power Consumption**

If the measured auxiliary power consumption is in excess of the guaranteed auxiliary power consumption under simple cycle mode, the penalty levied shall be as below:

Per kW increase in Auxiliary power Consumption : Rs. **-**

**21.1.2 Combined Cycle Mode**

**Gross Power Output**

If the measured gross power output of the generator falls short of the guaranteed gross power output, the penalty levied shall be as below:

Per kW shortfall in Combined Cycle : Rs. **56192**

**21.1.3 Auxiliary Power Consumption**

If the measured auxiliary power consumption is an excess of the guaranteed auxiliary power consumption, the penalty levied shall be as below:

Per kW increase in Auxiliary power consumption in Combined Cycle : Rs. **67010**

Penalties for not meeting performance guarantees during the Performance guarantee tests shall be assessed and recovered by the Owner/Owner's representative from the Contractor as detailed above. Such penalties which are in addition to any other damages provided for in these General Conditions of Contract shall be assessed at the rates and subject to the other conditions set forth in the General / Technical Specifications.

**21.1.4 Gross Heat Rate**

If the gross heat exceeds the guaranteed heat release rate during performance & guarantee tests , the penalty levied will be as follows

For every excess in kcal/kwhr Rs. **20,00,000**

If the total penalty for shortfall and/or in excess of guaranteed performance figures is upto 5 % of contract price, the plant / system will be accepted after levying the penalty as specified. If the total penalty exceeds 5 % of the contract price, contractor shall carry out necessary modification to make the system comply with guaranteed requirement. However, if the contractor is not able to demonstrate the guaranteed values even after the modification within 90 days of notification by the Owner/Owner's representative, the Owner/Owner's representative

may at his discretion reject the plant and recover the payment already made for the entire contract or accept the equipment after levying the penalty at actuals.

**21.2.0 Items with no permissible deviation on Guarantee**

For the items indicated below under guarantee shortfall in performance is not acceptable and shall be guaranteed by the Contractor as under compulsory correction. The performance shall be proved under worst grid conditions and/or at variation in fuel composition as specified.

1. Vibration limits for the gas turbine, steam turbine and auxiliaries
2. Noise levels for the gas turbine, steam turbine and auxiliaries
3. Emission level as specified.
4. HRSG steam purity.
5. Capacity of condenser air evacuation plant.
6. Oxygen Content at condenser and deaerator outlets at all specified loads of operation.

For the items indicated above the Contractor shall carry out modifications to obtain the guaranteed performance in case they exceed the permissible limit. As these are primary parameters, they must be corrected even before reliability run is started. And further, these parameters must remain stable throughout the period of reliability run. All works related to correction and subsequent reliability run to prove the stability/reliability shall be completed within the guarantee period with no extra cost to the Owner/Owner's representative.

If finally, in spite of all practicable effort on the part of the Contractor, the stipulated guarantees on these parameters are not established, the Owner/Owner's representative retains the option to reject the equipment. In case the option to reject is exercised by the Owner/Owner's representative which will be binding on the Contractor, the Contractor shall replace the rejected equipment within a reasonable period of time as will be indicated by the Owner/Owner's representative and achieve the performance as guaranteed in the contract.

**22.0.0 BID EVALUATION CRITERIA**

Refer relevant portion in Volume I – Commercial Specifications.

**23.0.0 INTERFACE / HOOK-UP POINTS**

**23.1.0 Mechanical:**

Refer Plot Plan Drg. no 00-5111168-G-001 Rev B , P & ID for HP/MP/LP Process Steam System Drg. No. 20-5111168-M-022 Rev B & Hook-up Details Dwg. No 20-5111168-M-023 Rev B, enclosed with the specification for location & other details.

**23.2.0 Electrical:**

1. Approximately 10 Nos. (minimum) plant feeders presently connected to existing 11kV switchgear located in the MRSS (Main receiving substation) shall be disconnected and shall be reconnected to new 11kV switchgear of CCCPP. Feeders to be shifted will be identified by the Owner/Owner's representative. Also additional 15 Nos. breaker panel feeders on each bus (Total 30 no. feeders) shall be provided in the new 11kV switchgear for future use.

2. All Power & control cabling shall be disconnected from existing switchgear and reconnected to new 11kV CCCPP switchgear. Cable joints to be considered for power cables and new control cables to be provided. Necessary cable trench, cable racks, cable trays & necessary supporting arrangements to be included in EPC contractor's scope.

3. Existing 66kV transmission line conductor (DOG) for two nos. incoming feeders from GETCO, Ichhapore substation is around 4 kM route length. These conductors shall be replaced with a

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new 66kV conductor suitable for power evacuation of minimum 50MVA at 50 deg.C ambient temperature for each feeder. Any replacement of insulators, clamps, connectors or any other ancillary items (at GEB end & ONGC end) required shall be considered in EPC contractor's scope. No modification or replacement of existing tower due to conductor replacement work is envisaged.

4. 2 nos. 66kV transmission line feeders will be terminated in the new 66kV GIS as grid incomer feeders. 2 nos. outgoing feeders from 66kV GIS will be connected to the primary side of the existing 25/31.5MVA, 66/11kV transformers. Any modifications in protection & metering and any control cabling requirement due to the above work shall be considered in EPC contractor's scope.

5. The proposed power plant shall be provided with new 66 kV GIS which will be installed in a new building adjacent to the existing 66kV switchyard as shown in the plot plan.

6. Existing 66kV switchyard equipment shall be demolished with their structures except necessary gantry structures. Existing 66kV line isolators, LAs with their associated structures shall be relocated in front of new GIS room. This arrangement is required so that physical isolation of GETCO lines is possible for maintenance purpose.

7. Existing ABT metering outdoor kiosk shall also be relocated as per GETCO guidelines. Separate metering CT & PT to be considered in 66kV GIS line bays for existing ABT metering which can be used for the tariff metering.Additional ABT check meter to be provided.The CTs/PTs for metering shall be as per the specifications of GEB/GETCO and the EPC contractor shall take the approval of the CTs/PTs from GEB/GETCO.

8. Exiting GTG-3 ( 25 MW) connected to the existing 11kV switchgear located in MRSS will be disconnected and shall be reconnected to the new 66kV GIS through a new 11/66kV generator transformer.

**23.3.0 Control & Instrumentation**:

- Provision of remote Operating station of proposed DCS system at existing control room for monitoring of CCCPP operations. Cable, connecting ports, console required for the same shall be provided by supplier.
- Implementation of control and monitoring according to the mechanical hook up/interface.
- Provision for interface/ hook up of existing Fire alarm panel with proposed fire alarm panel shall be made. One common repeater panel shall be provided for existing & new unit at main fire control station, 2 km away from proposed power plant.

**NOTE :- General:**

**1)** ***EPC contractor to visit the site and assess all the interface requirements listed above and include the same in their scope before submitting their offer.***

***2) Any necessary modifications/additions in fulfilling the interface requirements shall be considered in Bidder's scope.***

***3) During the execution of the contract, any additional claims for either cost or time overrun from the successful EPC Contractor on this count will not be entertained/considered.***

***4) EPC contractor to consider 12 hrs/day working because of operational restrictions.***

# VOLUME – III

# TECHNICAL SPECIFICATION

## SECTION - 2

## DETAILED TECHNICAL SPECIFICATION - MECHANICAL

**VOLUME - III**

**SECTION - 2**

**DETAILED TECHNICAL SPECIFICATION - MECHANICAL**

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# VOLUME – III

# SECTION - 2

# DETAILED TECHNICAL SPECIFICATION - MECHANICAL

# SUB-SECTION - 2.1

# GAS TURBINE GENERATOR AND AUXILIARIES

**VOLUME - III**

**SUB-SECTION - 2.1**

**GAS TURBINE GENERATOR AND AUXILIARIES**

## 1.0.0 GENERAL

This section is intended to provide the scope, design, constructional and functional requirements for Gas Turbine and Auxiliaries.

## 2.0.0 SCOPE OF SUPPLY

The scope of work includes gas turbine and auxiliaries, comprising of one GT and auxiliaries (GT # 4) for proposed power plant expansion.

The scope of supply for each GT and auxiliaries (unless otherwise stated specifically) shall include but not limited to the following:

Base mounted gas turbine unit with compressor section complete with modulating inlet guide vanes. The gas turbine shall be suitable for firing specified natural gas.

Air intake system with intake louver, bird screen, automatic three stage static air filters, plenum chamber, silencer, expansion joints, ducts, elbow, transition piece, outlet trash screen (if necessary), supports, guide vanes, vibration isolators, flanges and any other items necessary to complete the system. There shall be nylon filters with a self cleaning arrangement.

Complete fuel combustion system.

Exhaust Gas ducting with bypass stack from GT exhaust to HRSG inlet complete with diffuser / transition duct, expansion joint, exhaust shell, stiffeners, steel internal lagging necessary insulation and liner material, vibration isolators, cooled legs / support guide vanes, inspection doors, silencing equipment insulation and cladding, flanges for interconnection to the Heat Recovery Steam Generator and equipment and fittings required to complete the system. The bypass stack shall have diverter damper and guillotine damper which should be motor driven.

Fuel gas system complete with SS gas piping, Duplex gas strainer, Gas fuel valves on accessory base and interconnecting piping between GT base and module.

Lube oil system in accordance with manufacturer's standard specification / design complete with oil storage and settling tank complete with vents, vapour extraction fans and mist eliminator, One Main Lube Oil Pump of shaft driven or motor driven, One Auxiliary Oil Pump of A.C motor driven, One emergency oil D.C driven pump, 2 x 100 % duty lube oil coolers (shell & tube type), 2 x 100% lubrication oil filter, lube oil heater as per package requirement.

Hydraulic / Control oil system consists of two full duty hydraulic oil pumps, 2 x 100% control oil cooler (shell & tube type), 2 x 100% hydraulic oil cartridge type filter, Accumulators for control oil system,

Two full duty jacking oil pumps - One A.C motor driven and other D.C motor driven.

Barring facilities as per Manufacturers own design comprising of either Turning Gear system with an A.C. drive and D.C driven pump, or an Auxiliary Hydraulic Ratchet System. Provision of manually turning the turbine generator also be considered.

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Integral automatic Fire Detection and Protection System for the generator and turbine enclosures includes cylinders, cylinder racks, piping, valves nozzles, detectors, fire alarm actuating system and all other equipment necessary for the safe and efficient operation of the units.

Compressor online and off line water wash system comprising of detergent and DM water tank, motor driven wash pump, motor driven detergent pump, interconnecting SS piping. The water wash system shall be skid mounted with an enclosure.

Starting means (black start provision through Static Frequency Converter, SFC or starting motor or diesel engine) with auxiliaries and shut down system.

Boroscope and instruments for inspection.

Machinery equipment unit enclosures with insulation and ventilation, interior lighting.

Drain system with associated pipe work and transfer pump.

Bolt tightening system either hydraulic or electric heating element type.

Turbine shell and exhaust frame cooling system.

Acoustic enclosure to ensure the allowable near field and far field noise levels indicated elsewhere in this specification.

Mounting System.

On base GTG and Auxiliary cooling water systems along with flow element, flow meter and flow regulating valves.

All necessary access ladders with safety hoops, platforms and guard rails shall be provided to allow easy and safe access to the test ports, inlet filter cleaning / inspection.

All accessories, Electricals, Control and Instrumentation, cables, piping, protection and safety equipment and auxiliaries normally belonging to a package unit required for safe and continuous operation, even if not specifically mentioned shall be included.

## 3.0.0 DESIGN REQUIREMENTS

The gas turbine unit shall be of high efficiency, well proven, state-of art industrial heavy-duty type, advanced class of multi shaft design i.e. separate Generator for Gas Turbine and Steam Turbine . The gas turbine shall be designed to fire Natural Gas up to its base load capability. The GT model shall be selected based on efficient utilization of available fuel gas.

The gas turbine, electrical generator and all electrical accessories shall be designed for continuous operation over the entire ambient temperature range as specified in general technical specification.

The gas turbine shall be of heavy duty, industrial type, suitable for indoor installation with a sound attenuation, and shall be coupled to Generator through load gear. Generator shall be capable of delivering continuously the power output at rated power factor voltage variations within ± 5% of the rated value and frequency variation within 47.5 Hz to 51.5 Hz.

NOx emission reduction down as per GPCB requirement. In order to limit the NOx level in the gas turbine exhaust, latest combustor design shall be considered.

The gas turbine, generator and all directly coupled auxiliaries shall be installed on one common foundation.

It should be possible to undertake inspection, maintenance, major overhaul and repair/replacement at the plant itself with the use of conventional tools/moderately special tools and under uncontrolled environment/atmosphere.

The type and model of Heavy duty industrial Gas Turbine being offered for this project should have achieved an availability factor of at least 94% during any one year of operation within the last five years. This should be supported by an end user certificate indicating the date of commissioning, fuel used and number of hours of operation and any other such data to substantiate 94% availability as stipulated above.

This is a qualifying criterion, which should be met, and the bids received without any such end user certificate or bids which are based on Gas turbine which do not meet the above requirement is liable for rejection.

## 4.0.0 CONSTRUCTION REQUIREMENTS

### 4.1.0 Air compressor

The gas turbine air compressor shall be of industrial heavy duty, axial flow type, and capable of operating in combined cycle mode. In order to enhance the high efficiency at part load, variable geometry inlet guide vane shall be installed as part of the gas turbine main component.

The gas turbine air compressor shall be sufficiently flexible aerodynamically to permit normal operation of the turbine generator unit without any tendency to surge such that it is unconditionally stable at all loads including during load changes, during run-up shut-down, and over speed conditions.

If any device provided for control of compressor surge and/or exhaust temperature control by virtue of air flow control, they shall be of proven design and independent of external supplies. Full details of the system shall be stated in the Bid. Performance details of the compressor shall be given to indicate the margin provided against surge under all operating conditions.

Tap-offs shall be provided to supply air required for sealing of gas turbine glands, bearings, cooling of the turbine rotor and blades, and cleaning of air filters.

The materials and coating of the compressor stationary and rotating blades shall be chosen to be suitable for continuous operation in the site climatic conditions. The air path of the compressor including rotor, blades, and housing shall be provided with suitable and adequate coating to protect against corrosion and erosion effect due to site atmospheric condition. The materials and coating used shall be as per manufacturer proven practice to prevent corrosion.

Provision shall be made for accurately measuring the mean compressor delivery temperature and static delivery pressure with test instruments and remote indication for the same shall be provided. Provision shall also be made for indication of position of inlet guide vanes and the bleed valves in the control panel.

Boroscopic inspection arrangement shall be provided at appropriate locations in the compressor section to facilitate usual inspection.

The compressor shall be provided with suitable nozzles for washing of the blades and vane under off load and on load conditions. Visual inspection glass at compressor inlet shall be provided.

The Bidder shall furnish the recommendation for the intervals between successive cleaning operations of the compressor blades and vane based on the number of operating hours or in terms

of deterioration of measurable parameters. Remote instruments for annunciation of deterioration of measurement parameters shall be provided in the DCS.

**4.2.0 Combustion System**

The combustion system shall be of robust long life design, suitable for continuous operation at base load on the fuel specified.

The burners shall be capable of stable combustion at all loads and to meet current allowable emission limits.

Combustion efficiency shall be sufficiently high to ensure the exhaust emissions complied with the requirements of Performance and Design data.

The Bidder shall not elevate the firing temperature solely for the purpose of obtaining higher efficiency, without due consideration of exhaust emission limitation and long operating life of 'hot gas path' components.

A reliable flame supervisory system shall be provided to detect the presence of a flame in the combustion chamber based upon two out of three redundancy system. This system in principle shall employ three sensing elements through three separate channels, with at least two channels detecting the absence of the flame to trigger the trip. Any one channel shall detect absence of the flame and shall initiate an alarm for immediate action. The flame monitor shall be Ultraviolet or Infra red type.

If the gas turbine is having more than one combustion chamber without any inter-connection, the redundancy system shall be fitted to each chamber. Where multi-chambers are cross connected the three supervisory elements shall be fitted to different combustion chambers. Inspection windows, or the facility for inspection equipment shall be provided and the method shall be stated in the Bid.

The combustion system shall be of suitable material and designed to withstand the internal pressures and temperatures. Thermal barrier coatings shall be applied to the inner walls of the combustion liners in order to obtain longer inspection intervals. For turbines with multi chambers, transition pieces (which conduct the combustion gases to the hot stage turbine nozzle) shall be cooled by air from compressor discharge. The materials of construction of the combustion system shall be stated in the Bid.

The ignition system shall preferably utilize high-energy igniters and for combustion systems with cross tube connections at least two igniters shall be provided diametrically opposed. For combustion chambers with no cross connections at least one igniter per chamber shall be provided.

Provision shall be made for reliable purging of the burner system to prevent combustion explosion as well as choking of the nozzles. Attention shall also be given to the need for fuel leakage detection system. Fuel and air distribution system materials shall be made of appropriate grade stainless steel.

The enclosure in which combustion chambers are located must adequately be ventilated so as to avoid the accumulation of fuel gas and risk of explosion in case of fuel leakage. The Bidder shall describe this feature in detail in his proposal.

Teflon seated ball valves suitable for the fuel temperatures shall be provided for isolating valves in the fuel system. The ball valves shall be designed and manufactured to meet the requirements of API 607 for fire safe valves.

Boroscope along with accessories shall be provided to facilitate inspection. The Boroscope kit shall be complete with fibroscope, light source, digital camera, video recorder, colour CRT and computer.

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### 4.3.0 Turbine

The gas turbine shall be of proven design using manufacturer's standard equipment where applicable to ensure maximum plant reliability, standardization of components, and early delivery in the planned time scale.

The gas turbine shall be suitable for operation under severe tropical conditions with extremely high air temperature and humidity and to meet the turbine components life / maintenance guarantees with the operating regime identified with the gas turbine fired on the fuel indicated.

The gas turbine shall preferably be of horizontally split casing construction for convenience in maintenance and shall permit easy access to blading inspection and fittings without undue difficulties. Suitable guides shall be provided where necessary, to prevent damage to the blading while raising or lowering the upper portion of the casings.

The turbine rotor shall be multi-stage, axial flow type design and constructed from proven material. The Bidder shall describe the constructional details, heat treatment subjected and the inspected procedure followed for the rotors to ensure quality and homogeneity of the material.

The rotor design shall allow changing of blading without the need of re-balancing the rotor. The method of attaching and replacing the blades (including special tools and skill required) to the rotors shall be stated in the Bid.

The turbine blading offered shall have been fully proven for expected guaranteed running hours at the turbine inlet temperature specified. The manner of blade cooling for stationary and moving blades shall be stated together with a description of the cooling system arrangement. If any external cooling pipes are used adequate drainage arrangements shall be installed where necessary.

The turbine casings, moving and stationary blading shall be designed to withstand the maximum temperature scatter which may occur in service under adverse combustion conditions with the machine running at the design maximum mean turbine inlet temperature.

The casings and blading shall withstand, without premature failure, the thermal shock associated with repeated starting, loading and rapid load changes. Any limitations on plant offered shall be stated in the Bid.

The factor of safety for the turbine disc and blades based on the disc and blade stresses applicable to an over speed of 10% in the fully heat soaked condition at the design full load shall be stated in the Bid.

The stationary and rotating blades shall be coated with appropriate high temperature protective layer, which shall reduce the attack of corrosive gases and products of combustion. The Bidder shall indicate the number of stages which are coated and shall describe the type of protective layer (coat) or other protective means.

Bidder provide maintenance philosophy of GT hot gas path parts, basis of computing maintenance cycle, degradation, Equivalent Operating Hours (EOH) etc.

Inspection equipment and facilities including suitable plugged openings shall be provided to examine the compressor-turbine stationary and rotating blading with minimum disassembly and without the need to open the casing or lifting the rotor. The internal inspection facilities and tools/equipment shall be stated in the Bid.

The materials of construction for the rotors & stationary & moving blades shall be stated in the Bid.

All instrumentation required to measure the gas turbine exhaust temperatures should be provided to be capable of identifying any imbalance in temperature distribution. Thermocouples including the junction box shall be suitably located where they shall not malfunction and to permit easy accessibility by the maintenance personnel.

### 4.4.0 Compressor / Turbine Blade

Suitable and proven washing system shall be provided to facilitate both on load and off load wet cleaning of compressor blades and off load cleaning shall be envisaged for turbine blading in order to dislodge the deposits such as dirt, oil mist and atmospheric contaminants. Suitable equipment shall be provided without the necessity for opening up or dismantling any part of the machine. The water wash system shall be skid mounted and suitable for automatic / manual operation.

Sufficient storage tanks to hold the cleaning medium to achieve one complete cleaning cycle shall be provided. Storage tanks or bins shall be located to be easily accessible for topping up the cleaning medium. The storage tanks, heater (if required), piping shall be of stainless steel construction.

The Bidder shall supply top-ups of cleaning medium stored in well-packed drums to allow proper storage. The Bidder shall state if the cleaning medium is locally available.

The margin of performance deterioration that the machine shall accept before a cleaning cycle is deemed necessary shall be stated in the Bid. The method used to ascertain this margin shall be stated in the Bid (e.g. compressor delivery pressure, power output with respect to turbine exhaust temperature).

The effluent formed during cleaning shall be piped to the nearby sump from where it shall be suitably disposed.

### 4.5.0 Load Gearbox

If a main reduction gear box is necessary between the turbine and generator, it shall be of a proven design. It shall be capable of transmitting the maximum rating of the set and be able to withstand 20% over-speed for a minimum period of 5 minutes. All bearings shall be readily renewable and it shall be possible to inspect the bearings and gear teeth readily without disturbing shaft alignment.

The offered gearbox models shall be of proven design and shall be from the gearbox manufacturer's existing regular production range. The offered Gear box must have completed 8000 hours of satisfactory operation on a continuous duty basis without any major overhaul.

### 4.6.0 Accessory Gear (Wherever Applicable)

If any accessory gear drive is provided to transmit power from the main turbine rotor to essential auxiliary equipment, the gear box design shall comply with requirements of API 613 or equivalent recognised National / International Standard and to the highest short-circuit loading.

Removable guards and shields shall be provided to protect personnel from the accessory gear and rotating shafts and warming signs installed.

### 4.7.0 Mounting System

The mounting system of the gas turbine casing onto the foundation shall take full account of vibration and thermal expansion of the unit and dynamic loading.

Details of the method used to locate the fixed point of the turbine casing in relation to the rotor thrust bearing and the provision for accommodating thermal expansion of the casing and maintaining rotor alignment without producing detrimental stresses shall be stated in the Bid.

If lubrication or gasket or cooling system is required between moving surfaces, the materials of the contacting surfaces and the method of lubrication, the gasket type, and the cooling system shall be stated in the Bid.

If any of the turbine generator supports require cooling, the equipment and the cooling arrangement and means of monitoring shall be described in the Bid.

Care shall be taken to ensure that radiant heat from the turbine exhaust casing does not adversely affect the mechanical integrity of the concrete foundation structure. The turbine shell and exhaust frame shall be cooled using two nos. 100% capacity blowers.

**4.8.0 Piping**

The gas turbine generator unit shall be provided with a complete system of high quality, non-corroding and heat resistant piping integral to or between, components furnished by the Bidder.

Piping shall include all high point vents, low point drains, instrument piping, insulation, hangers, and other piping accessories required for a complete system. All piping shall be factory mounted on the unit to the extent possible.

All piping shall be routed so as to be within the confines of the gas turbine generator enclosure whenever possible. A minimum of 2,200 mm head room clearance is desired over walkways and access areas. All flanges shall be easily accessible and pipes divided into manageable portions for handling.

All piping shall be neatly arranged to be as inconspicuous as possible and shall offer minimal obstruction while being easily supported and drained.

**4.9.0 Bearings and Glands**

The bearing design shall suppress hydrodynamic instabilities and also provide sufficient damping to limit shaft vibrations. Vibration sensors shall be provided for each bearing.

Hydrodynamic horizontally split radial bearings of the precision bore sleeve or multi-pad type with steel backed white metal replaceable sleeves or pads shall be provided for each main shaft bearing. The bearings shall be arranged so that they are adjustable and readily accessible and the lower halves can be removed and replaced without lifting the rotor more than the minimum allowable internal vertical clearance.

Each bearing shall be provided with a reliable shaft and pedestal vibration measurement system for monitoring and supervising the operation of the gas turbine generator and predictive maintenance of gas turbine generator.

Displacement probe / Bridge gauges and thermocouple shall be provided for each bearing so that wear on the bearings can be readily ascertained. These gauges shall be finally fitted and stamped on site after the alignment of the rotors has been proved.

The design and material specification of the probe/bridge gauges shall prevent alterations in the gauge reading with variations in temperature.

### 4.10.0 Thrust Bearing

The rotors shall be provided with a thrust bearing of tilting multi-pad type which shall have identified main and reverse thrust faces sized to withstand all normal and abnormal thrust in either direction that can be experienced in service under the most adverse conditions. The thrust collar may be integral with the shaft or separate and replaceable.

Vibration sensors shall be provided for the thrust bearing. Means shall be provided to indicate excessive axial movement due to a failure of a thrust bearing, preferably combined with facilities to measure thrust movement on load. This is to be in accordance with manufacturer's standard design.

### 4.11.0 Shaft Currents-Earthing

Provision shall be made for the prevention of damage to bearings; oil pump drives by any shaft currents which may be produced. Bearings and any associated pipes shall be insulated from ground and earthing brushes provided and care shall be taken so that no extraneous earth paths, e.g. through metallic cable sheaths shall short circuit the insulation.

### 4.12.0 Temperature Supervision

The Bidder shall install triplex thermocouple in the white metal of each bearing of the gas turbine and generator and also within each pad of the thrust bearing. This thermocouple shall be positioned to ensure a quick response in detecting abnormal changes in metal temperature. Any limitations on operating conditions, such as motoring the compressor and turbine generator, and the duration of transients shall be stated in the Bid. Compressor and turbine upper and lower casing temperature monitoring shall be incorporated in the turbine start-up control logic.

Each of the above radial bearing and thrust bearings shall be provided with a resistance temperature device to monitor oil drain temperatures which shall actuate both an alarm and trip on high oil temperature. Thermocouple is acceptable in place of resistance temperature devices.

### 4.13.0 Glands

Arrangements shall be made to preclude any leakage of fuels blowing from the glands into the turbine enclosure or turbine hall. Renewable, metallic sealing rings shall be provided at all internal close clearance points between the rotor and stationary parts to minimize leakage of air, fuel combustion products and oil from the casings or housings.

### 4.14.0 Condensation and Corrosion

The Bidder shall state the precautions and necessary procedures to protect the compressor and turbine components from corrosion and fouling when the plant is required to be off-service for long periods of standstill. Any necessary equipment such as heaters, hot air blower or other devices to maintain the plant especially, the internal parts under warm and dry condition shall be provided.

### 4.15.0 Noise Limits

The noise emanating from each gas turbine generator shall not exceed a limit of 85 dB (A) at a distance of 1.0 m away from the equipment.

If the noise level requirements applicable to gas turbine generator cannot be achieved, then suitable acoustic hoods / enclosures or treatment shall be provided & installed for gas turbine generator unit.

The use of earmuffs or earplugs is not considered a noise mitigative device.

### 4.16.0 Vibration, Balancing and Critical Speeds

Vibration monitoring equipment of the velocity type shall be provided for each main shaft bearing which shall indicate the severity of vibration expressed as velocity in mm/s. Bidder shall ensure that the vibration from the gas turbine shall not be allowed to transmit to HRSG through ducts.

However for critical bearings vibration measurement along X –Y axis with accelerometer pickup, key phasor shall also be considered as per manufacturer recommendations.

Individual shafts, discs and couplings shall be dynamically balanced before assembly so that the severity of vibration of the complete unit during operation at any load is within the range of class “Good” as per VDI 2056 or ISO 10816.

Any lateral or torsional critical speed of the total combined shaft system including the generator and exciters (if any) should be at least 20% above or below the normal range of operating speeds However, if the critical speed(s) as calculated or revealed on test does not meet the specified separation margin, the response of the rotating assembly to the critical speed(s) in question shall be demonstrated and certified in accordance with API Standards.

In-situ balancing provision in the turbine, balancing kit and computer aided balancing system shall be provided.

Care shall be taken in the design of the stationary parts of the plant to ensure that no static part is excited or touched/rubbed by vibration transmitted from the rotating parts.

### 4.17.0 Lube Oil and Control System

A complete lube oil system shall be provided for the turbine generator unit and shall be fully integrated into a common lubrication oil system. Preferably a separate reservoir for the control oil system shall be provided. Design with common reservoir for both lube oil and control oil system shall also be acceptable if it is standard practice of the manufacturer.

Oil shall be of the appropriate grade specific to heavy-duty industrial type gas turbine application. The Bidder shall state in the Bid the equivalent type of oil from all leading brands. The specification of the oils shall be such that they can be procured from local sources.

The system shall include sufficient full standby equipment to allow any item of equipment within the oil system to be taken out of service for maintenance without having to shut-down the unit and also without restricting in any way the normal full output operation of the gas turbine unit.

The lube oil system shall be preferably be independent of turbine base and shall meet API requirements. Capacity of oil reservoir and its capacity with respect to number of hours of GT operation shall be indicated in the offer.

The oil temperature rise through each bearing shall not exceed 30°C. The maximum bearing oil drain temperature from each bearing shall not exceed 90°C and the maximum bearing metal temperature shall not exceed 115 °C.

The oil system shall be designed to prevent the possibility of fire due to the leakage of vapours or fluids from the systems onto high temperature parts as a result of physical damage or piping failure.

Filters of 5 microns or smaller shall be provided for lube oil, whereas filters of 0.5 micron shall be provided for the control oil systems.

All pipe works shall be seamless stainless steel unless otherwise approved. All welded joints shall be subjected to 100% radiographic examination and shall have root runs of weld carried out by the Gas Tungsten Arc Welding Method. Oil piping shall be pickled and on commissioning, oil flushing with alternate cold and heated oil shall be carried out.

One dirty oil drains collection tank to collect oil by gravity drainage from oil leakage, venting and draining points such as pump glands, control valves, oil strainers, drip trays, lubricating oil filter, vent, drain dishes.

The lube / control cooler plate material shall be constructed for SS 316 with SS clad guide rails. Adequate margin in surface area shall be considered.

**Lube Oil Purifiers**

One (1) no. portable motor driven centrifugal or vacuum pump type oil purifier for water and sludge removal from the lubricating oil shall be provided with an hourly capacity of not less than 20% of the total oil quantity in the lubricating oil system.

The purifier shall be fully self-contained on an oil-tight base plate with automatic lubrication as necessary.

It shall be complete with all necessary reinforced flexible hoses and convenient connections to suit each location in which it shall be required to operate when the turbine generator is either running or shut - down. Hose and fittings shall be of an approved type allowing connection and disconnection to the readily made without oil spillage.

Those parts of the purifier that are liable to corrosion, in particular the bowls, shall be manufactured from appropriate grade stainless steel.

The purifier shall be provided with an indirect electrical heating system with thermostatic control arranged to heat the incoming oil as necessary for optimum purifier performance. It is preferred that this heating system should also provide for increased heating capacity to be utilized in conjunction with elevated oil temperatures for oil flushing purposes, both during initial commissioning and subsequently after each unit overhaul.

The purifier shall be provided with all necessary tools and equipment to effect its connections, operation and maintenance.

**4.18.0 Turning Gear System / Auxiliary Hydraulic Ratchet System**

AC and DC motor driven turning device shall rotate the gas turbine rotor after the gas turbine plant has been switched-off, so long and with sufficient speed until the cooling of the rotor has progressed to the point that a remaining deformation at shut down is excluded.

The turning device must automatically come out of engagement as soon as the turbine speed exceeds the turning speed. The turning speed shall ensure a safe lubrication film formation. The

turning device shall also ensure a complete safe shut-down of the turbine even during the condition complete failure of A.C. power.

Facilities shall also be provided for manually turning the gas turbine generators rotor during maintenance outage. The manual facilities shall be based on portable hydraulic system.

The period of barring before start up and after run down under hot and cold conditions and also the turning speed(s) shall be stated in the Bid and the reasons given for such a period.

**4.19.0 Starting System**

Starting equipment shall be of robust design and construction, proven in service and be of such a rating that the torque available up to the self-sustaining speed of the gas turbine generator is in excess of requirements by a margin of at least 10%. Curves showing the relationship between starting torque required by the gas turbine and torque available against speed, together with speed against time shall be given in the Bid.

The starting system shall be by black start provision for Static frequency convertor (SFC) or Starting motor or diesel engine based on manufacturer's standard.

The starting system should be rated without limitation on the number of starts attempted in succession and without restricting the rate of starting.

If the system offered has limitations on the number of consecutive start attempts in a time period, this limitation with reasons shall be fully explained and justified in the Bid.

The minimum starting times, under normal hot and cold start conditions from initiation of start sequence to synchronization and from synchronization to full load shall be stated in the Bid.

Interlocks shall be provided to prevent starting of the turbine generator unit in the absence of lubricating oil pressure.

Details of the starting system shall be stated in the Bid together with statistics on reliability and availability.

**4.20.0 Purging**

Each gas turbine shall have automatic purging system. The combustion chamber and exhaust plenum shall be automatically purged with air prior to ignition and upon shutdown to remove traces of fuel that could cause explosions.

**4.21.0 Shaft Drive Coupling and Alignment**

The coupling shall be designed for the worst anticipated condition of a short circuit reaction from the generator or an attempted out-of-phase synchronization. Details of the design basis on which the couplings have been designed shall be stated in the Bid.

The tolerance on misalignment of the coupling and the load that can be transmitted in that condition shall be stated in the Bid.

**4.22.0 Bolt Tightening Equipment**

Two complete sets of equipment for tightening compressor casing, turbine casing and shaft coupling complete with accessories shall be provided. This equipment may be either hydraulic or electric heating element type.

The Bidder shall state the time required for bolting and unbolting operations using the equipment offered and the detailed description of the equipment proposed. The design and rating of the equipment shall be such that the bolting or unbolting times are reduced to a practicable minimum.

Provision shall be made for direct measurement of imposed tightening strain on high temperature bolts, whether mechanically or thermally extended, by means of suitable bore holes and the use of depth gauges.

If hydraulic bolt stretching equipment is offered, the Bidder shall briefly describe the procedure for tightening the bolts. In this case all necessary items shall be provided including four full sets of spares for all wearing parts.

For tightening using heating elements it shall include all necessary apparatus, including transformer together with six full sets of spares for the heating elements and insulators.

### 4.23.0 Air Intake System and Filtration

### 4.23.1 General

The primary function of the air intake system shall be to provide the gas turbine with sufficient clean ambient air for combustion and for internal cooling of gas turbine rotor and blades.

The filtration system shall be designed to operate under the environmental condition specified in General Technical specification.

The number of access points and penetrations into the air inlet system for maintenance and inspection shall be minimized. Any door or hatch shall be capable of being securely air-tight locked and interlocks and shall be provided to prevent any attempted start with any door or hatch not properly closed.

### 4.23.2 Air Intake

The air intake must be atleast 2.5 m above ground level to ensure that no ground dust is drawn in. It shall be protected by stainless steel weather hood. The air intake shall also be positioned to avoid the ingress of exhaust gases from the gas turbine. The design of the hood shall not hinder access by men or crane facilities to the air filtration plant.

Bypass doors shall be provided in the ductwork to allow the air filters to be bypassed in the event of excess filter differential pressure. An alarm in the control room shall be initiated on high filter differential pressure. On further increase in differential pressure a further alarm shall be initiated together with automatic opening of the bypass doors. In addition, DP transmitter to be provided for continuous monitoring of the pressure drop across air intake in the DCS.

### 4.23.3 Air Filtration Plant

The air intake filtration shall be accomplished by a three stage dry system comprising:-

i) First stage, inertial type separator.

ii) Second stage, coalescer type pads (disposable elements).

iii) Third stage, nylon filters (self-cleaning type).

The overall efficiency of the filters shall not fall below 99.5% after extended service, such that particles remaining in the filtered air shall not exceed 0.5 microns diameter. Assured life of static filter shall not be less than 18 months.

The air intake shall be equipped with a silencer downstream of the filtration system and the whole of the ducting shall be sealed to avoid unfiltered tramp air ingress.

The air filters chosen shall be suitable to reduce the sand, dust (*cement dust also as cement plant is nearby ONGC, Hazira plant*) and salt content of the atmospheric air to a level which is not detrimental to the life of the gas turbine unit and under the most adverse atmospheric conditions at site when the plant is operating continuously a maximum output with the necessity for blade cleaning reduced to a minimum.

Access ladders, platforms and stairways shall be provided so that the filter units can be easily inspected, cleaned or replaced. The design of the filter unit arrangement should be such that while a fouled unit is being replaced, debris collected on this element is not drawing into the air stream. The area around the intake filter shall be provided with layer of gravels so that the settled dust is not sucked by the intake system.

A manually operated hoist with swivelling facility shall be provided at an approved position and the roof of the electrical annexe for the purpose of lifting and lowering filter elements between the ground floor level and the electrical annexe roof. The hoist shall be supplied with attachments suitable for use with the filter elements.

The design data on which the filter plant is based shall be stated in the Tender. The details shall give the anticipated particle size distribution upstream and downstream of the filter unit and include curves of separation efficiency.

The proposed filter plant shall be fully described in the Tender, together with anticipated time between renewal of the filter elements, the cost of the elements, and the time taken to renew all the elements of the filtration plant.

The design shall minimise the inlet system pressure drop. The instrumentation and control equipment shall also be kept to a minimum but must include a differential pressure monitor at the filter with provision for fitting of additional instrumentation to determine the guaranteed filtration plant test pressure drop. The differential pressure monitor will initiate an alarm in the Local and Central Control Rooms for high pressure drop.

### 4.23.4 Control System

A Control system shall be provided for automatic and manual operation of filtration system. The control system hardware shall be suitable for outdoor installation.

Imported signals from the inlet air filtration system shall be hardwired to the DCS / gas turbine control system.

### 4.24.0 Air Inlet Ducting

Ducting expansion shall be accommodated by means of proven expansion joints such that no loads or forces are transmitted to the air compressor inlet flange.

Sliding joints shall not be used in the duct work. All expansion joints shall be flanged for removal without disturbing the main sections of the ducting.

The duct work shall be of appropriate corrosion and wear-resistant grade steel, not less than 5 mm thick. The material of the duct guide vanes, expansion joints, outlet trash screen and other parts shall be suitable for the full load flow and temperature conditions.

All duct work surfaces shall be shot blasted to remove mill scale before and after assembly. Adequate precaution shall be taken such that no entrapped nuts, bolts or rivets shall present inside the duct work downstream of the filter.

Air tight access doors of proven type shall be provided to give access to ducts for inspection and maintenance at the location before and after the silencer. They shall be of the flange type and not less than 600 x 800 mm size. The ducts shall be adequately stiffened to support the doors. Any door or hatch shall be capable of being securely locked and interlocks shall be provided to prevent any attempted start with the doors open.

Attention shall be paid to the provision of landing platforms local to any access doors for the air ducting. To ensure safety and convenience of access, landing platforms shall be provided inside and outside the ducts where there is no obvious landing within 1 meter of the door itself. Such platforms are to be bolted or resting type for easy removal. The platform shall be provided complete with a safety rail and access ladder with safety hoops.

The duct work shall be sloped 1 in 7 and contain drainage points which shall be piped to the station drainage system, including all pipes, valves and fittings.

The silencer shall be capable of being removed from the duct work without dismantling or removing any other duct work other than that portion containing the silencer. The infill and panels shall be fully resistant to the worst atmospheric conditions anticipated on site. Precautions shall be taken to prevent settling or packing of the infill material and also the small components or parts of the silencer cannot become detached and obstruct air passages. The infill material shall be vermin proof. The materials of construction of the intake silencer and ducting shall be stated in the Bid. The Bidder shall provide all necessary weather proofing and elastic sealing where the ducts pass through walls/roofs of the turbine hall building.

A series of test ports shall be arranged in the ducts at suitable positions according to performance test standard such that the distribution and temperature of the air can be determined and the filtered air can be sampled. The test points shall be fitted with covers so arranged that their removal does not entail damage to the insulation if any. The covers shall be completely gas tight and retained against loss by chaining or other approved means.

Filtered air sampling instrument including all necessary accessories shall be provided.

All necessary access ladders with platforms and guard rails shall be provided to allow easy and safe access to the test ports.

**4.25.0 Exhaust Flue Gas Ducting**

Gas turbine shall be provided with a proven design exhaust ducting system.

The exhaust system shall comprise of pre-fabricated corrosion resistance steel duct section horizontally connecting the gas turbine exhaust to the HRSG with a bypass stack for operation of the gas turbine in simple cycle.

Ducting shall be designed to give the required distribution of gas flow at entry to the installed heat recovery steam generator.

The exhaust duct system shall be free of drumming, vibration and any resonance with the exhaust gas pulsations under all operating conditions.

The Bidder shall provide all necessary weather proofing and elastic sealing where ducts pass through the wall or roof of the building.

For further design requirement, Refer HRSG Section for Exhaust Flue Gas Ducting.

The exhaust gas system shall be designed to reduce the overall pressure drop to a minimum possible value and to provide uniform distribution of gas flow in terms of velocity and temperature at the inlet to HRSG.

Bidder to ensure adequate heat insulation for the gas turbine, compressor casing, exhaust duct, HRSG to minimise heat loss. Application and removal are to be easy and performed without disturbance to the turbine casing or damage to the insulation media. The Contractor shall include in the tender the type of insulation and description of the removal. Duct and piping insulation shall be of pad type. Thermograph test shall be conducted for measuring the temperatures – Gas turbine, GT exhaust, HSRG, Steam Turbine.

### 4.26.0 Expansion Joints

Expansion joints shall be provided at inlet to HRSG to accommodate the expansions associated with the high exhaust temperatures and thermal loading from the gas turbine. Expansion joints shall be specifically designed for use in the heavy duty industrial type gas turbine application.

Sliding joints shall not be used in the duct work.

Expansion joints shall be a proven design and sized by the manufacturer of the joints to meet the conditions specified and the arrangement of the Contractor's duct work with respect to expansion, contraction and offsets in all directions. Expansion joints shall be capable of withstanding temperature excursions and vibration. Internal design pressure for expansion joints shall be the same as duct work.

The maximum possible longitudinal and angular misalignments shall be stated in the Bid.

A detailed description and calculations of the allowance for free thermal expansion and insulation/sealing shall be stated in the Bid.

The expansion joint materials shall consist of corrosion-resistant steel bellows or reinforced heat resisting fabrics. Metal bellows type expansion joints shall be of appropriate grade stainless steel. Expansion joint flanges and bolting shall be of appropriate grade corrosion-resistant materials. The exterior surfaces of expansion joints shall be restriction free insulated.

All expansion joints shall be flanged for removal without disturbing the main sections of the ducting. The lagging shall be sectionalised for removal local to the expansion joints.

The expansion joints when operating under the conditions described shall be capable of the equivalent of at least 50,000 running hours of operational life running on specified fuels at design base mean turbine exhaust temperature.

### 4.27.0 Fire Detection and Protection system

The entire gas turbine generator installation including all auxiliary enclosures shall be protected from fire with a complete automatic fire protection system. The extinguishing agent shall be Carbon Dioxide ($CO_2$) dedicated for GT area. LED detectors wherever required including ventilation ducts are to be provided.

All fire suppression gas cylinders or tanks to be provided with online weigh system so that any loss of gas causes an audible alarm & visual indication.

The fire protection system shall be fully automatic and shall be designed and installed in accordance with applicable codes of the National Fire Protection Association.

All devices for shutting down supplementary equipment shall be considered integral parts of the system and shall function with system operation.

The system shall be designed for total flooding for closed-up enclosures and local application for hazards in open spaces. The installation shall be interlocked with the GTG Enclosure ventilation system and enclosure ventilating fans shall be stopped and openings closed automatically by dampers in any enclosure in which the fire protection system comes into operation.

The quantity of extinguishing agent shall be sufficient to ensure rapid extinction of any fire and have adequate spare capacity. The extinguishing agent used for initial supply and replenishment shall be good commercial grade, free from contaminants that might cause container corrosion or interfere with the free discharge through the nozzle orifice.

A minimum of two (2) gas masks with suitable activated filters shall be provided at the main entrance to each protected enclosure. They shall be kept in a glass-fronted cabinet.

A fuel leak addressable detection, measurement and indicating instrument alarm system shall be furnished to monitor and initiate alarms of any hazardous levels of flammable gases within the gas turbine enclosure. Each section of the enclosure shall be provided with a detector head. The control module shall monitor and alarm each detector head. Failure of the detection elements or their associated wiring shall be detected and displayed by a fault detection system.

The extinguishing agent containers supplied shall of a type for which facilities are available for refilling by local Bidders. Each cylinder shall be supported in an upright position by a steel cylinder support frame suitable for wall and floor mounting. The frame shall include facilities for convenient individual servicing or content weighing. A reliable means of indication other than weighing shall be provided to determine the pressure in refillable containers. The means of indication shall account for variation of container pressure with temperature.

A cylinder supplying the same manifold outlet shall be interchangeable and of one selected size and charge.

Full reserve cylinders of the fire-extinguishing agent shall be supplied for each enclosure/ compartment to be covered.

A separate detector system and alarm shall be provided for each enclosure. A minimum of two detectors shall be located in each area particularly susceptible to fire and/or areas which would sustain catastrophic fire damage.

In order to discharge the extinguishing agent automatically, at least two detectors must be activated. This mode of operation obviates the possibility of erroneous discharge due to one detector responding to conditions which are regarded as normal.

The detector's circuit wiring shall be supervised continuously for line fault. A disconnection to this circuit would be indicated as a fault at the control panel both visually and audibly by a fault lamp and buzzer respectively. Remote indication of alarm and fault conditions shall be provided at the Master Alarm and Indicator Desk.

Provision shall be made to trip the gas turbine simultaneously with release of extinguishing agent.

Each compartment or enclosure shall be protected as a separate risk and the discharge of the extinguishing agent into one compartment or enclosure shall not affect the other compartments or enclosures.

An independent facility for emergency operation, by manually discharging the extinguishing agent via a "break glass" handle type manual switch/pull box shall be provided and mounted outside the exit door of the protected space.

A control panel shall be suitably located near the gas turbine.

**4.28.0 Machinery Equipment Unit Enclosures:**

Except as otherwise specified, all equipment shall be enclosed in a minimum number of prefabricated appearance enclosures. The enclosures shall be constructed in a neat and workman like manner.

Where fitted, the enclosures shall be of pleasing appearance, suitably stiffened and secured to avoid thermal distortion. They shall be resistant to corrosion and mechanical damage.

For the purpose of reducing maintenance outage periods to a practicable minimum, the enclosures shall be designed to be readily removable. The enclosures shall be strengthened to facilitate removal and replacement without damage and arranged so that when enclosures are removed, instruments, instruments panels, gauge boards and connections need not be disturbed.

Enclosures shall be designed to absorb and limit noise emitted by the gas turbine generator units. Enclosures shall be constructed of reinforced sheet metal lagging.

Enclosures shall be designed to permit easy accessibility to the equipment and to provide necessary protection for maintenance personnel. Enclosures shall be provided with pedestrian and equipment doors of the locking type.

Enclosure insulation and ventilation shall be provided to maintain temperatures suitable for personnel and for all systems whether on standby or operating. Enclosures shall be ventilated using motor driven fans mounted on top of the enclosure. Each enclosure shall be provided with 2 x 100% capacity fans.

Special care shall be taken to vent out any hazardous materials, which may accumulate inside compartments. All vents shall be ducted and discharged at a safe height.

Adequate explosion proof interior lighting shall be provided for operational and simple maintenance. Emergency DC lighting shall be provided and shall be energized by an emergency changeover contactor. Emergency lighting power supply shall be supplied.

Enclosure lighting shall be provided to maintain illuminance level as 150 lux for Emergency access areas and 50 lux for all other areas.

Two general service air points shall be provided at a suitable position for each enclosures including all necessary pipe works, isolation valves, quick connecting hose couplings, supporting steelwork and other equipment required to complete the system for the purpose of cleaning and routine maintenance of the equipment.

The electrical fittings shall be flame proof and cables shall have fire retardant property. Lights are to be operated by three way switch at access way on each side of enclosures.

Each enclosures compartment shall be provided with 100% redundant fan driven induced ventilation or forced ventilation and purge air system designed to provide adequate ventilation and purging during the most severe climatic/load condition.

If cool down ventilation is required to prevent damage to the gas turbine, auxiliary system and/or instrumentation with enclosure, a separate DC back up fan system shall be provided. The Bidder shall provide fire proof glass window for each compartment.

Each enclosure compartment shall be provided with necessary fire protection system. The fire detection and protection system shall be automatic type and shall be remote / manually operable from the fire alarm panel. The system shall be provided with suitable redundant source of power supply.

The layout of equipment shall recognize human needs and limitations and ease of movement during maintenance.

If the area beneath the inlet air filter ducting extending to the ground level is utilized for locating auxiliary equipment requiring an indoor environment, then this area shall be enclosed.

**4.29.0** Emission Control

NOx emission reduction down as per GPCB requirement is essential. Suitable combustor of latest design shall be considered for controlling the NOx emission limit in the exhaust gas of the gas turbine.

**4.30.0** Maintenance / Inspection Requirements of GTG and It's Auxiliaries

Bidder to clearly state in his bid, the list of parts which need maintenance/replacement periodically. Bidder to furnish such a list along with replacement period. Also Bidder to indicate a regular inspection schedule (i.e.) inspection required for every "X" running hours throughout the life of the plant. Bidder provide maintenance philosophy of GT hot gas path parts , basis of computing maintenance cycle, degradation, Equivalent Operating Hours (EOH) etc.

## 5.0.0 SPECIFIED DESIGN DATA SHEET

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| 1.0.0 | **General** | | |
| 1.1.1 | Type | | Heavy Duty Industrial Grade |
| 1.1.2 | Location | | Indoor |
| 1.1.3 | Fuel | | Natural gas |
| 1.1.4 | Operation | | Combined Cycle Mode |
| 2.0.0 | **Design Requirements** | | |
| 2.1.0 | **Compressor** | | |
| 2.1.1 | Type | | Axial flow, heavy duty |
| 2.1.2 | Casing type | | Split |
| 2.2.0 | **Combustion Chamber** | | |
| 2.2.1 | Type | | Annular/Can annular / Silo type Combustor with low NOx emission. |
| 2.2.2 | Ignitor type / Numbers | | As per manufacturer's std. |
| 2.3.0 | **Gas Turbine** | | |
| 2.3.1 | Application | | To drive electric generator |
| 2.3.2 | Duty | | Heavy duty base load |
| 2.3.3 | Installation | | Indoor |
| 2.3.4 | Operational Class | | Class D as per ISO : 3977 |
| 2.3.5 | Range | | III as per ISO : 3977 |
| 2.3.6 | Design maximum speed of rotor | | Greater than 1.10 times the rated speed |
| 2.3.7 | Method of cooling turbine casing | | By external fans |
| 2.4.0 | **Bearings** | | |
| 2.4.1 | Gas turbine shaft glands type | | Labyrinth |
| 2.4.2 | Method of sealing labyrinth | | By compressor air |
| 2.4.3 | Gas turbine shafts thrust indicator | | Required |
| 2.4.4 | Mechanical bolt over speed trip provision | | Required |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| 2.5.0 | **Air intake System** | | |
| 2.5.1 | Intake air silencer | | |
| | a) Location | | Inlet air duct |
| | b) Material | | Stainless steel / HDG perforated steel sheet |
| 2.5.2 | Acoustic insulation | | Required |
| | Expansion joint | | |
| | a) Type | | Elastic |
| | b) Material | | Reinforced rubber |
| 2.6.0 | **Exhaust Gas Ducting** | | |
| 2.6.1 | Duct material | | Carbon steel |
| 2.6.2 | Insulation material (Internal) | | Ceramic Wool |
| 2.6.3 | Liner material (Internal) | | ASTM A 176 TYPE SS 409 |
| 2.6.4 | Outside surface temp. to be maintained | °C | 60 at maximum ambient temp. |

**NOTE:**

EPC Contractor shall submit GTG Package Equipment description, data sheet, list of drawings, mechanical interface table, performance characteristic curves, testing commissioning & Start-up procedure, performance guarantee, Auxiliary power consumption continuous & Intermittent / standby (electrical load list), special tools & tackles, specialised testing equipment, mandatory spares, Inspection & Test procedures, Quality Assurance plan, Operation & Maintenance (O& M) manual, etc.

# VOLUME – III

# SECTION – 2

# DETAILED TECHNICAL SPECIFICATION- MECHANICAL

## SUB-SECTION - 2.2

## HEAT RECOVERY STEAM GENERATOR AND AUXILIARIES

## SUB-SECTION – 2.2

## HEAT RECOVERY STEAM GENERATOR AND AUXILIARIES

### 1.0.0 GENERAL

This section is intended to provide the scope, design, constructional and functional requirements for HRSG and its auxiliaries.

### 2.0.0 SCOPE OF SUPPLY

The scope of supply for each HRSG shall include but not limited to, the following:

#### 2.1.0 Heat Recovery Steam Generator

- Condensate/ Feed water Pre heater
- HP and LP Economizers.
- Evaporator sections including drum, headers, evaporators, risers, down comers for HP & LP pressure levels.
- Circulation pumps, if HRSG design is envisaged with forced circulation.
- Super heaters, and any apparatus used for steam temperature control, including any automatic apparatus used in conjunction therewith for sections as applicable.
- Safety valves (including silencers as well as vent and drain pipes) as per applicable design code and the system requirement.
- Electromatic relief valve for super heaters.
- Steam stop valves for HP & LP.
- Feed control station for HP & LP with inlet & outlet isolation valve for each control valve.
- Process steam piping shall be at three operating pressure, viz. HP-30 kg/cm$^2$(g), MP-18.5 kg/cm$^2$ (g) and LP-9 kg/cm$^2$ (g). With necessary PRDS system arrangement including valves.
- HRSG Purge air fan having sufficient capacity as per applicable code.
- All start-up and normal drains & vent valves.
- HRSG initial fill arrangement.
- All necessary instruments & controls required for proper functioning with necessary redundancy.
- Duct burner system (supplementary firing) considering natural gas, consisting of burner flame assembly, fuel control skid, flame safety system, seal air fans, scanner air cooling and observation ports. The duct burner /supplementary firing to be designed so that steam at rated condition is generated even at partial gas turbine load with no addition of fresh air.

#### 2.1.1 Drain and Blow-down System

- Continuous and intermittent blow-down flash tanks with internal wearing plate, baffles, valves and integral piping.

2.1.2 **Steel Structure, Wall cladding, insulation, Outer casing**

- Necessary expansion joints at HRSG inlet & outlet.
- Complete structural steel works for boiler and auxiliary equipment.
- All necessary access galleries, stairways, ladders and platforms.
- Cover for expansion bellows.
- Roof and side cladding for drum **with stair upto** operating floors.
- All necessary lagging, metallic cladding and insulation.
- Doors and ports necessary for access, inspection and supervision including service air nozzles and connecting piping to inspect all tubes and permit easy removal/replacement of tubes.
- Adequate access and inspection doors of approved type and size shall be provided to allow free access for maintenance and cleaning of the HRSG gas path (including top and bottom dead space), headers, tubing and other pressure parts. Suitable platforms shall be provided for all the manholes. The elements shall be arranged in banks sufficiently shallow to enable the gas passages to be easily cleaned and with ample space for access between banks. All doors shall be perfectly airtight when closed.

2.1.3 **Stack (Main Stack)**

- Flue gas exhaust duct from HRSG to exhaust stack with necessary expansion joint.
- Exhaust stack of straight cylindrical, thermally insulated along with intermediate platforms for sampling ports, maintenance platform at exit, cage ladders up to top platform, aviation warning lamps, lightning arrestors.
- Inter connection between stack and HRSG for easy access.

2.1.4 **HRSG Accessories**

- Utility stations for air, steam and water from connection branch of main distribution supply up to the consumer, including hoses, hose couplings and isolating valves.
- System equipment required along with temporary piping for boil out and acid cleaning.
- Fire fighting equipment for heat recovery steam generator, complete with all integral pipes, valves, nozzles, hoses.
- Equipment and provisions for stand-still conservation (storage) of the heat recovery steam generator.
- Portable hydro- test pump complete with accessories.

2.2.0 **Deaerator**

- Integral or stand alone deaerator complete with deaerator level control station, with inlet & outlet isolation valve for each control valve, integral piping and insulation with necessary control & instruments.

2.3.0 **Boiler Feed Pumps**

- Three (3) nos. (2w+ 1s) BFPs for HP / LP feed water pump system with inter-stage tap-off for LP feed water system with all accessories and auxiliaries.

- A heavy duty suction strainer of stainless steel construction.
- Vibration monitoring system.
- Lubrication system of sufficient capacity complete with oil reservoir, 2 x 100% lube oil pumps, 2 x 100% lube oil coolers, duplex filters, all interconnected piping, valves and fittings.
- Variable frequency drive with electrical bypass so as to run the boiler feed pump at constant speed in case of failure of VFD.
- BFP discharge valves shall be motor operated.

2.4.0 **Chemical dosing system**

HP & LP dosing system complete with dosing tank with agitators, dosing pumps, valves, fittings & piping with necessary control & instruments.

2.5.0 **Sampling**

Condensate water, feed water, boiler water and superheated steam sampling equipment inclusive of coolers, for on-line continuous monitoring.

2.6.0 **Pipes and Valves**

Complete high pressure steam system, feed water, condensate and spray water pipe work and accessories required for use including valves, funnels, headers, silencers, measurement devices, mountings and fittings for the auxiliary systems of the boiler such as venting, drainage, fire fighting water, cooling water, cooling air, sealing air, service air, instrument air and inert gas system.

3.0.0 **DESIGN REQUIREMENTS**

3.1.0 **HRSG**

The design, manufacture, safety aspects and inspection of the pressure parts shall be in exact conformity with ASME and IBR.

The design of HRSG shall be suitable for Natural Gas firing in the upstream gas turbine. HRSG shall be designed with an optimum pressure drop. The tube arrangement and fin pitch of the HRSG shall be selected to achieve the optimum performance for the type of fuel fired.

HRSG shall be of fired, natural / forced circulation type, with double pressure level steam generation as per the optimum heat cycle design and the operating modes of the plant.

HRSG shall be designed to accept the maximum gas flow and exhaust temperature of the connected gas turbine. The heat transfer modules shall be arranged in such a way to recover maximum available heat from the flue gas.

In arranging the layout of tubes and tube banks of the HRSG, adequate care shall be taken to ensure that flow induced vibrations are minimized and necessary baffle plates for this purpose shall be provided.

HRSG design shall offer minimum resistance to the exhaust gas flow while GTG is running at site rated full output and steam conditions are maintained. The emphasis for the HRSG design shall be on maximizing waste heat recovery from exhaust gas.

Gas side of the HRSG shall be designed to withstand maximum exhaust gas temperatures, pressures, mass flows anticipated under all operating conditions of the Gas Turbine and HRSG supporting supplementary gas firing condition.

Pinch and approach points should be selected at optimum ambient conditions so that the heat transfer area available is sufficient to operate under all specified ambient conditions.

Pinch and approach points shall be selected in such a way that temperature cross situation do not take place and steaming should not occur in economiser at any operating conditions including part load operation.

HRSG response rate shall be suitable to achieve the guaranteed cold start-up, warm start-up and hot start-up time for combined cycle operation and shall be compatible with turbine acceptable limits. Stack damper shall be provided to conserve heat in HRSG to achieve faster warm and hot start-up times.

HRSG water volume shall be furnished by the vendor.

HRSG shall be designed for direct on-line starting with gas turbine.

Purge air fans, 2 x 100% shall be provided for purging of the HRSG as per NFPA requirements.

The HRSG shall be capable of following the instant start-up and shut-down of the gas turbine without thermal stresses.

HRSG shall have long life and high availability consistent with the gas turbine.

To enable reliable operation of HRSG throughout the design life, special attention shall be paid to the low cycle thermal fatigue in pressure parts and the other thermal and mechanical design issues such as casing and expansion joints.

The HRSG and accessories shall be suitable for outdoor installation of saline weather conditions and shall confirm to the specified design and duty conditions. Necessary protection from wind and rain shall be provided. Rain water collection and drainage system shall be provided. No water ingress into the HRSG chamber is to be allowed.

The HRSG shall be completely insulated for minimum heat loss and personnel protection. It shall be so designed as to give a temperature differential of 20°C or less between the skin temperature and the ambient temperature or 60°C (max.) whichever is more conservative, and considering 0.5 m/s wind velocity. The duct shall be lined with SS material internally.

HRSG casing shall be made gas tight to reduce leakage of gases to the atmosphere. Openings for peepholes, access doors shall be provided with service air.

HRSG shall be designed for constant and sliding pressure modes of operation.

For HP and LP feed control station, 1 x 100% motorized on/off valve shall be provided which will be operational when the boiler feed pump is operating with VFD.

In addition to this, 1 x 100% pneumatically operated feed control valves shall be provided which will be used when the feed pump shall be running at constant speed( in case of failure of VFD) . An inlet and outlet isolation valve shall be provided for each control valve. The upstream isolation valve shall be motor driven type.

All headers shall have adequate draining facilities with welded inspection nipples. Air vents shall be provided on drum, headers and high points of piping.

Only seamless steel tubes shall be employed in HRSG construction.

Finned tube construction may be employed for all pressure parts including convection zones, economiser, Superheater. The fin density shall not be higher than 200 fins/m.

The selection of fin density shall take care of fin tip temperature criteria for the type of fuels fired in Gas turbine.

System shall design as per ASME TDP 1 – Recommended Practice for the prevention of water damages to ST.

The gas temperature at HRSG exit, the temperature of condensate entering condensate pre-heater and temperature of feed water entering economiser shall be such as to avoid acid dew point corrosion.

Prior to fabrication, the Contractor shall conduct a flow model test of the HRSG system. The purpose of the flow model test is to determine proper placement of the perforated plate / flow vanes, if required in the ductwork to ensure uniform gas flow distribution through the HRSG systems.

### 3.2.0 Deaerator

The deaerator capacity shall be adequate to maintain the HRSG in continuous operation at MCR conditions.

The deaerator shall be designed as per HEI standard, ASME section VIII Div-I, and also for full vacuum.

The deaerator shall be designed to heat and deaerator the condensate. The oxygen content of the deaerator water shall not exceed 0.007 ppm under all conditions of operation. Deaerator shall be include pegging steam arrangement for initial start-up purpose from HP steam circuit.

Deaerator (cum LP Drum, if applicable) shall have a capacity between normal water level and low-low level equal to 10 minutes of water requirement of HRSG working at its MCR conditions with a filling factor not more than 0.66. Minimum 3.2 mm corrosion allowance shall be provided.

### 3.3.0 Boiler Feed Pumps

The Feed pumps shall be designed, manufactured, tested and supplied in accordance with HIS / ASME or equivalent.

Design capacity shall be suitable for catering to the HRSG when GTG is operating at 100% base load at minimum ambient temperature along with the make up requirement for blowdown, spray water requirement for PRDS and attemperators.

The sizing parameter shall also take care of abnormal & transient conditions of operation of the Power Cycle.

In the event of failure of the working pump, the standby pump shall automatically start-up. The standby pump shall be kept continuously warm for this purpose, and the motor shall be sized for open discharge valve condition. Rapid, start-up of the pump set shall be possible from any operational condition (i.e.) cold or partially warmed-up.

The system design shall be such that the standby pump is well established, before the level in the steam drum drops to low level, thus avoiding the HRSG trip.

Pump shall be provided with Automatic minimum flow recirculation cum check valve to be mounted near pump discharge flange. Recirculation outlet of the valve shall be connected to deaerator with appropriate pressure breakdown arrangement.

The oil temperature rise through bearing shall not exceed 28°C and maximum bearing metal temperature shall not exceed 90°C.

### 3.4.0 Chemical Dosing System

To control the boiler water quality within the prescribed limits, HRSG shall be provided with HP dosing system. Tri - sodium Phosphate dosing shall be dosed into the HP and LP drums of the HRSG and Elimin-ox (or other non carcinogenic chemical) shall be dosed at suction of BFP for treating the boiler feed water.

Cyclohexylamine & oxygen scavenger shall be dosed for pH & dissolved oxygen control as mentioned in latter part.

### 3.5.0 Pressure Reducing and Desuperheating Station

Desuperheater specification shall be as per standard specification and other specifications as specified elsewhere in this package. Wherever pressure reduction is also required along with Desuperheater, a combined PRDS (Pressure Reducing and Desuperheating Station) shall be preferred. However PRDS design with separate pressure reduction valve shall also be acceptable provided the valve is specially designed for high differential pressure, high temperature and high pressure steam application. In case combined PRDS design is selected, bidder must ensure that PRDS body has been designed considering stresses generated because of steam quenching. This should also be ensured in case of Desuperheater design.

Desuperheater design should ensure that the temperature at the outlet shall be maintained with ± 5 °C of the desired outlet temperature, unless otherwise specified by the process licensor.

Separate liquid injection valve and steam valves, if provided, must be installed along with block and bypass valve. The body and trim material of construction shall be suitable for the service. In general trim including spray nozzles shall be stellited.

The PRDS / DS in steam application shall be IBR certified including valve in Boiler Feed Water line.

## 4.0.0 CONSTRUCTION REQUIREMENTS

### 4.1.0 HRSG

#### 4.1.1 Pressure Parts

The HRSG shall be arranged with the total pressure parts comprising steam drums, superheaters, evaporators, economisers, headers, down comers and integral pipe work in the form of a self contained unit supported by its own steel structure. This structure shall be independent of other structures, buildings except for normal interconnection points like access galleries and platforms.

Circulation system shall ensure adequate circulation ratio during rapid startups and load changes to prevent overheating of the evaporator tubes with minimum possible heat flux there in the exhaust gases. This shall be ensured by suitably sizing the steam drum, down comers and evaporation sections.

If HRSG is designed for forced circulation, the circulation ratio shall be selected in such a way that minimum ratio is assured even for the tube at the most unfavourable location. Preferably 2 x 100% circulation pumps shall be considered for forced circulation configuration. Also automatic taking-over device shall be installed to keep the cycle in operation even when one circulating pump fails.

Forced circulation design shall protect the tubes of the evaporator from dry-out during rapid start-up and load variation.

Space between two tube bundles shall be at least 1 m for accessibility with manholes.

4.1.2 **Drum**

Steam water separators of high efficiency cyclone type backed up adequately by scrubber / demister or a combined baffle and wire mesh type water separator shall be provided.

The drum internals and its size shall be so designed that the steam leaving the drum does not contain more than the specified ppm of total dissolved solids that is called for by the steam turbine.

Water level indicators shall be Bi-colour port type and Water level in the steam drum shall be observed from the lower floor / operating level by periscope arrangement / Hydrastep.

Chemical dosing and continuous blow down connection shall be located on opposite ends of the drum to prevent short circuiting.

Steam drums shall be provided with safety valves in accordance with ASME / IBR requirements.

If LP drum is provided with integral deaerator, it shall be designed with deaerating capability.

4.1.3 **Superheater**

Superheater surface area shall be sized, distributed and located to maintain the specified steam temperature at superheater outlet over the entire steam temperature control range under the following conditions.

1. With minimum possible use of de-superheating spray.

2. With HRSG heat absorption surface condition varying from clean up to permissible fouling limits.

The superheater section shall have provision for draining. The design shall be as per applicable codes.

In order to effectively control the superheated steam temperature, attemperator shall be provided. The attemperator shall be of spray type fitted with a removable lining, which can be removed easily without recourse to extensive cutting of the construction welds.

The design of Superheater shall be compatible with the requirements of constant and variable pressure operations and the variable characteristics of the gas turbine exhaust gas flow.

Bidder shall provide start up motorized control valve with silencer on the HP & LP superheater.

Super heater shall be provided with safety valves in accordance with ASME / IBR requirements. In addition, power operated impulse safety valves of 20% MCR capacity at super heater outlet flow at MCR are to be provided.

4.1.4 **Desuperheater**

Desuperheater shall be designed to ensure that the steam temperature at the steam turbine stop valve does not exceed the rated condition under all modes of operation. The design shall be such that the spray water requirement shall be zero at 100% MCR condition.

The Desuperheater shall be located in between the superheater stages to avoid carryover of moisture into the steam turbine.

2 x 100% Control valve shall be provided. Quick acting block / trip valves shall be provided on the upstream side of the super heater spray control station.

4.1.5 **Evaporator Section**

The Evaporator section shall be of finned tube arrangement. Evaporator section shall be designed to achieve maximum steam generation rate with an optimal pinch point. The evaporator shall be designed for operation over the full load range of the HRSG without undue vibration and shall ensure even distribution of water through the tubes.

The evaporator sections shall be of natural/forced circulation type with adequate circulation ratio for even distribution of water through evaporator tubes under all operating conditions of HRSG and shall be adequate to minimize circulation disturbances that may occur during rapid start up and load swing.

Finned tube Evaporator section shall be designed to prevent hot spots and fouling.

Tube arrangement shall permit easy access for cleaning and maintenance. Material of construction for tubes shall suitable considering flow accelerated corrosion particularly in the LP evaporator section.

Down comer zone shall be kept at the cooler side of flue gas stream to increase the effectiveness of boiler circulation.

4.1.6 **Economiser**

Economiser shall be Staggered/in-line, non steaming type of finned tube type. Uniform flow and heat distribution shall be ensured throughout. Provision for recirculation of water during low loads as protection against overheating of tubes shall be considered.

The flue gas temperature at the exit of economizer will be low, hence corrosion resistance tube, fin and header material shall be provided.

The design of the economiser shall allow easy access, inspection and replacement of tube elements when necessary.

Vibration isolator shall be provided to take care of tube bundle vibration, particularly where pumps directly connected.

4.1.7 **Condensate Preheater / Feed water pre heater**

The condensate preheater / feed water preheater shall be designed to absorb the available heat energy of the exhaust gases of gas turbine to the maximum extent.

The flue gas temperature at the exit of condensate pre heater will be low, hence corrosion resistance tube, fin and header material shall be provided.

Condensate pre heater / feed water preheater flue gas inlet temperature shall be designed considering the fuels specified and to maintain the HRSG exit flue gas temperature at least 10 $^{0}$C above the dew point temperature.

4.1.8 **Integral Piping, Valves, Fittings**

All drain, vent and blow down connections should be double valve, for HP steam and feed water systems.

All start-up and shut-down vent/ drain valves shall be of motor operated type with provision for manual opening & closing to enable remote and automatic start-up of HRSG from the control room.

The steam stop valves for HP and LP steam lines shall be Motor operated with integral motor operated bypass valve for pressure equalization. Swing check type non return valves shall also be provided.

Pneumatic regulating type Deaerator level control station shall be provided with inlet and outlet isolation valve for the control valves. The upstream isolation valve shall be motor driven.

Steam and water stop valves shall be complete with actuators and hand wheels and all necessary fittings and mountings.

The blow down valves shall have arrangement for locking at various positions and protection against tampering. All drains from the HRSG shall be led to CBD tank. Drains from the same pressure level shall be grouped into a header and then led from the header to the CBD tank. All high pressure drains shall have two valves in series.

Safety valve escape piping shall be provided to discharge steam at a safe height above the highest operating point/floor. Safety valve outlets shall be designed to reduce noise by providing suitable silencers.

All control valves and the feed water regulator in particular shall be designed with proper trim to contain the noise level to acceptable limits as per PCB.

The HP / LP steam vent line shall also be provided with silencers to limit noise as above.

4.1.9 **HRSG Structures, Platforms, Galleries and Ladders**

All parts of the structure shall be designed for the appropriate wind loading as specified elsewhere in the specification.

Design loads for platform, stairways shall be as follow unless otherwise specified in structural specifications.

- Access platform, walkways and staircases etc. a live load of 400 Kg/m$^2$.
- Operating floors and platforms where maintenance work shall be carried out, live load of 300 Kg/m$^2$ plus point load 500 kg.
- Platform attached to vessels, live load of 125 Kg/m$^2$.

Use of cage ladders shall be totally avoided except for the stack.

At drum level, there shall be adequate space for removal / repair of drum internals.

There should be two exits with hand railing from each platform level from safety point of view. The landings shall be covered with galvanized steel gratings. Hand railing shall be made of 40 NB GI pipe.

The clear width of the platforms and walkways shall be 900 mm minimum. Angle of staircase shall not be more than 45 degrees. Auxiliary platforms shall be 750 mm wide minimum.

Drain channels and pits shall be covered by hot-dip galvanized gratings or chequered plate of adequate thickness.

The walkways, galleries, platforms shall be safe guarded with proper hand railing and toe plates.

Steel structures in contact with hot gas from any point of HRSG shall be suitably provided with thermal insulation.

HRSG drum floor, feed control stations and sample cooler racks shall be provided with suitable canopy and side cladding for protection against rain and other climatic conditions.

### 4.1.10 Insulation and cladding

Thermal insulation and insulation for personnel protection shall be carried out in accordance with the general provisions of the specification.

The insulation material shall be suitable for continuous service at maximum operating temperature of HRSG. The material used shall be suitable for the climatic conditions prevailing at site.

All high noise producing equipment (e.g. fans, pressure reducing stations, control valves, safety valves) shall be provided with acoustic insulation.

All pipes, ducts and other equipment on which condensation on the outer surface is liable to occur, shall be provided with a water proofing insulation.

### 4.1.11 Flue Gas Ducting

HRSG shall be provided with a proven design ducting system to direct the exhaust gas to the main stack.

The material of the duct work, guide vanes, expansion joints and all other parts of the exhaust system shall be suitable in every respect for thermal cycling and continuous operation at the high temperature conditions pertaining to the maximum load on the gas turbine at the highest ambient temperature. Stress levels shall be kept to levels which ensure a creep life at the maximum temperature of at least 100,000 operating hours.

Adequate number of expansion joints shall be installed to accommodate duct expansion and prevent undue thermal stresses in the duct work under all operating conditions whilst maintaining gas turbine exhaust flange anchored and free of onward transmission of all forces and moments by the ducts.

Test air ports shall be arranged in the ducts at performance test standard positions such that the distribution and temperature of the exhaust gas can be determined and the exhaust gas sampled. The test points shall be fitted with covers so arranged that their removal does not entail damage to the insulation. The covers shall be completely gas tight and retained against loss by chaining or other approved means.

Exhaust gas-sampling instrument including all the necessary accessories shall be provided.

Gas tight access doors of proven standard type shall be provided to give access to ducts for inspection and maintenance. They shall be of the flange type and not less than 600 x 800 mm size. The ducts shall be adequately stiffened to support the doors. Any door or hatch shall be capable of being securely locked and interlocks shall be provided to prevent any attempted start with the doors open.

Attention shall be paid to the provision of landing platforms local to any access doors for all gas ducting. To ensure safety and convenience of access, landing platforms shall be provided inside and outside the ducts where there is no obvious landing within 1 meter of the door itself. Such platforms are to be easily lifted / removed. The platform shall be provided complete with a safety rail and access ladder with safety hoops.

Any exposed surfaces shall be sufficiently lagged and clad for personnel protection and to maintain metal temperatures above the dew point of the exhaust gas. Preformed lagging shall be secured to the duct work and clad with suitable sheeting to reduce the heat radiation to a minimum and to protect against the entry of rain water. Lagging shall conform to the specifications as stated in the General Technical Requirements.

The Bidder shall provide all necessary weather proofing and elastic sealing where ducts pass through the wall or roof of the building.

The ducts shall be of all welded appropriate grade corrosion resistance steel plate construction suitably stiffened where necessary by means of angles, tees or flats secured to the outside of the ducts.

Ducting downstream shall be carbon steel with internal insulation and shall be internally lined with SS 410 material including studs, bolts of SS material. The temperature of the duct casing shall not exceed 60 °C and be safe for human touch. Bends shall be provided with guide vanes to ensure a smooth flow of gases.

The duct wall and roof shall not be less than 8 mm thick and the duct floor not less than 10mm thick including corrosion allowance of 3 mm and strongly supported.

Appropriate length sections of the ducts shall be bolted together and the joints shall be sealed by welding after erection at site. Sections of ducts which require to be dismantled for the regular maintenance of any part of the gas turbine shall be of convenient manageable size.

All joints between sections of ducts shall be made by means of angles of approved size welded to the plating. Joint bolts shall not be less than 15 mm diameter with a pitch of not more than 100 mm. All bolted joints shall be made with sealing tape approximately 3 mm thick over the full width of the flange or with an approved type of jointing material.

Low friction bearing plates if required by the design for the accommodation of duct expansion shall be stated in the Bid.

Duct work shall be designed in accordance with the following deflection criteria.

a. Duct plate work shall be designed to limit the deflections to 1/100 of the span of plate between stiffeners, taking advantage of multi-span continuity where appropriate, for normal operating conditions.

b. Duct stiffeners shall be designed to limit the deflection to 1 / 240 of the stiffeners span for normal operating conditions. Stiffeners shall be assumed to approximate an unrestrained pinned condition at exterior ends and full continuity where continuous over interior supports.

c. Duct normal operating conditions shall include dead load (defined as the actual weight of plates, pipe trussing and stiffeners) plus pedestrian live loading at normal interior pressure loadings.

Mechanical expansion indicators and strain gauges shall be installed at appropriate locations to measure the duct expansion and deflection.

Exhaust gas velocity in the duct shall be limited to 25 m/s. Bidder shall state in the Bid method/procedure to check the exhaust gas velocity in the duct.

The duct work shall contain drainage points of adequate size inside and outside for rain removal, which shall be piped to the station, drain system.

Flue gas Duct plate minimum thickness shall be 6 mm. All duct work surfaces shall be shot-blasted to remove all mill scale, with anti corrosive coat before site assembly and after site works touch up and finish coat shall be applied.

4.1.12 **Diverter Damper**

The connection for the bypass stack in GT exhaust duct to HRSG inlet, shall have one diverter type damper for gas tight closure of HRSG inlet when operating in open cycle mode (i.e. with HRSG not in operation) and for gas tight closure of bypass duct when operating in cogeneration mode (i.e. with HRSG operating).

The diverter damper shall be electrically operated having single flap, twin seal type toggle lever mechanism for the drive system.

The diverter damper shall have a normal Open / Close time of 60 seconds and also shall have provision of emergency closure depending upon the HRSG requirement.

The diverter damper shall ensure a sealing efficiency without seal air of 99.95% based on volume of gas at its operating pressure and temperature at base load of GT at site design conditions. With seal air fans working, the sealing fan efficiency shall be 100%.

Bidder shall furnish a guarantee on sealing efficiency for the diverter damper.

Two, 2(1w+1s) of 100% seal air fans shall be provided for each damper located sufficiently away from the high temperature zone at ground level. Fans shall have a margin of 25% on capacity and 50% on head to arrive at test block rating.

The diverter damper shall be modulating control type. The damper shall be power operated with percentage opening clearly marked on each damper. Manual operation facility shall also be provided.

4.1.13 **Guillotine Damper**

A zero leak motor operated guillotine damper shall be provided in the downstream end of the diverter damper i.e. towards HRSG in order to ensure complete gas tightness in closed position for the safety of maintenance personnel working on the downstream side with the gas turbine in operation at full load. The Bidder shall indicate the total time required for closing of the damper.

The Guillotine damper shall be single blade, which shall move in and out of the damper frame. This isolation damper shall provide 100% sealing of one part of duct from the other. The guillotine damper shall be only ON / OFF type. No regulation shall be performed by this damper. Only complete retraction or complete insertion of the blade in or out of the ductwork shall be ensured.

The guillotine damper shall be electrically actuated with manual over ride. The actuator shall be mounted on the damper frame and proper access for actuator maintenance shall be provided. In addition, manual operation facility shall also be provided by hand-wheels accessible from platforms attached to ductwork support steel.

Seal Air fans, 2 x 100 %, (1w+1s), shall maintain pressure of 75 mm WC above the duct pressure. The seal air fan should be sized with adequate margin to ensure 100% isolation at specified duct pressure / temperature & 100% sealing efficiency shall be achieved with seal air fan in operation, whereas 99.95% sealing efficiency shall be ensured without seal air fan in operation.

The guillotine damper blades and damper drive arm shall be made of SS304 & SS410 respectively. The material for insulation (internal) of dampers shall be of ceramic fibre. The Internal liners shall be of stainless steel, having a minimum thickness of 2 mm.

Interlocking

The interlocking between the diverter damper and the guillotine damper shall be such that

a. The guillotine will not close when the diverter is closed to the bypass stack.

b. The guillotine will close only when the diverter is 100% closed to the HRSG side.

c. While opening, the guillotine will open fully and only then the diverter will close towards the bypass side.

d. All necessary signals for providing the above and other control/alarm functions and necessary interfaces with Field Bus Control system (FCS) / GT control, shall be provided.

e. The Guillotine damper and the seal air fan shall be operated either from FCS or local control panel.

4.1.14 **Expansion Joints**

Expansion joints shall be a proven design and sized by the manufacturer of the joints to meet the conditions specified and the arrangement of the Contractor's duct work with respect to expansion, contraction and offsets in all directions. Expansion joints shall be capable of withstanding temperature excursions and vibration. Internal design pressure for expansion joints shall be the same as duct work.

The expansion joint materials shall consist of corrosion-resistant steel bellows or reinforced heat-resisting fabrics. Metal bellows type expansion joints shall be of appropriate grade stainless steel. Expansion joint flanges and bolting shall be of appropriate grade corrosion-resistant materials. The exterior surfaces of expansion joints shall be restriction free insulated.

Adequate number of fabric type non-metallic expansion joints shall be installed to accommodate duct expansion and to prevent excessive thermal stresses in the duct work under all operating conditions so that transfer of all forces and moments to the gas turbine or HRSG is avoided.

All expansion joints shall be flanged for removal without disturbing the main sections of the ducting. The lagging shall be sectionalized for removal local to the expansion joints.

Appropriate roof covering shall be provided for all expansion joints for rain / weather protection.

4.1.15 **HRSG Stack**

HRSG will be provided with a steel stack. The exhaust stack shall meet the requirements specified data while designing the stack, the maximum wind speed, and earthquake factor as furnished in

General technical specification shall be taken into consideration. The exhaust stack shall be insulated for personnel protection.

The minimum height of stack above grade level and the exit gas velocity must confirm to the requirements of both National and Local authorities.

The top 9 m of the stack exterior shall be protected from attack by corrosive gases which, may be deflected by down draught. Unless otherwise specified, the inner lining of the top 9 m should be of acid resisting materials.

Drain shall be provided, so that rain water does not collect at the bottom of the HRSG exhaust stack incase of HRSG with horizontal layout.

To avoid wind excited sway oscillations and consequent possibility of fatigue in chimney shell or damage to linings, all steel stacks should be fitted with helical strakes or suitable wind spoilers.

The stack shall be equipped with external ladder with necessary safety rings and periodic landing platforms around complete circumference at the top of the stack and aviation day light marking and necessary warning lights.

4.1.16 **Duct Burner System**

The burner frame assembly will include the following components:

- Main gas piping header pre-assembled on burner frame terminating with one inlet flange.
- Pilot gas piping header pre-assembled on burner frame terminating with one inlet flange.
- Scanner cooling air distribution headers pre-assembled on burner frame terminating with one inlet flange.
- Interruptible spark ignited gas pilots.
- Pilot ignition transformers.
- Two ( 2) self checking Flame scanners per burner element.
- Two (2) seal air fans.

**Fuel Control Assembly**

The rack assembly will consist of the following components mounted to a rigid steel frame:

- Pilot piping train with an inlet strainer, pressure regulator, safety shut-off valves, vent valves, and gas plug cock.
- Main fuel piping train with a flow control valves, gas plug cock, Pneumatic safety shut-off valves and pneumatically actuated safety valve.
- One (1) set of pressure gauges for main gas supply pressure, main gas header pressure, pilot gas pressure, scanner cooling air pressure and instrument air pressure.

**Flame Safety System**

The flame safety system shall be designed for automatic-manual supervisory start up control panel. The flame safety control enclosure shall have the necessary indicating lights, switches, pushbutton, meters, and annunciators mounted on the front panel. Safety interlocks will be included to insure the proper operation of the system.

**Scanner Cooling Air Fans**

Two (2) scanner cooling air fans (1 no. AC + 1 no. DC) will be furnished complete with drive motors, air filters, air check valves and flex connectors. The blowers and their accessories will be mounted on a common skid and piped to a common outlet.

Fans shall have a margin of 25% on capacity and 50% on head to arrive at test block rating.

**Seal Air Fans**

Openings for peep holes, steam lance openings etc. shall be provided with pressurised air from seal air fans, to prevent flame leaking out of the casing.

Two (2) seal air fans will be furnished complete with drive motors, air filters, air check valves & flex connectors. The blowers and their accessories will be mounted on a common skid and piped to common outlet.

Fans shall have margin of 25% on capacity and 50% on head to arrive at test block rating.

**Observation Ports**

The burner outlet duct will be furnished with observation ports downstream of the burner. The ports will be located on two sides of the duct and will be provided with platforms and stairs for accessing observation ports and burner scanners.

**Burner Outlet Duct**

The outlet duct will be fabricated from carbon steel plate and reinforced with structural steel members seal welded to casing thus providing an all-welded construction, designed for internal pressure as required. The duct will have an access door, test connections as required.

The duct shall be provided with shop installed internal insulation covered by a stainless steel liner. The ductwork shall be shipped in "donuts", "C-sections" or "flat panels" based on final shipping clearances for unescorted truck shipments.

4.2.0 **Deaerator**

The deaerator shall be of spray or spray cum tray type. The deaerator should be located to provide adequate NPSH to the boiler feed pumps under all operating conditions including transients. Necessary supporting structures and platform shall also be provided.

The outlet pipes from the FWT shall be provided with a vortex breaker and project with adequate length above the bottom of the storage tank so as to prevent sludge from getting into the suction pipes of the Feed pumps.

Fittings such as suitable gauge glasses for the entire range of storage tank, relief safety valve, drain, air vent, overflow control, access door and manhole shall be provided. Operation of overflow control shall have annunciation in control room.

Also it shall be rigid enough to prevent undue vibration and consequent damage to connecting pipes, valves and instruments.

4.3.0 **Boiler Feed pumps**

The pumps shall have continuously rising head (up to shut off) characteristics with the minimum shut off head of 115% but not exceeding 125% of the head at best efficiency point for the rated impeller.

The pumps shall be designed to have best efficiency between the rated & normal point. However, in no case the rated point should be beyond 115% of the best efficiency point. Moreover the minimum continuous stable flow shall not be less than 20% of the best efficiency point.

Difference in NPSHA and NPSHR shall be as per the Performance and Design Data. The said NPSHR based on 3% head drop shall correspond to the maximum value of NPSHR from minimum continuous stable flow to maximum continuous stable flow.

Mechanical seal shall be provided at both ends of the shaft of pump and the same shall be inside mounted balanced type. The pump shall be directly coupled to the motor and gearbox shall not be used in between pump & motor.

The pump shall be provided with a suitable axial thrust balancing arrangement preferably a balancing drum. The balance drum leak off shall be led back to the deaerator through orifice plate, NRV, safety relief valve.

Pump bearings shall be anti friction roller bearing or hydrodynamic journal type. The bearing shall be non-pressurized ring oil lubricated type. Bearing housing shall have provision for cooling water connections. Bearing housing shall be provided with temperature indication and alarm and also with oil level gauge. Bearing shall be easily accessible without disturbing the pump.

Non lubricated flexible type coupling with coupling guard shall be provided between the pump and the drive motor.

A common base plate for pump & its driver shall be provided & the same shall be steel fabricated.

4.4.0 **Excess Condensate Dump System**

Excess condensate dump system shall dump the excess condensate in condenser hotwell to the Condensate Storage Tank (CST) through an excess condensate dump line downstream of condensate extraction pump discharge. The excess condensate dump line shall be provided with an excess condensate dump control valve sized for not less than 10 percent steam turbine maximum Valve Wide Open ( VWO) flow.

CST shall be provided with motorized valves. The valves shall be interlocked to close on a very high level in the respective tank. Necessary remote level indications (low-low, low, high and high-high) shall be available at both the DM plant operator console and plant DCS. The CST shall also be provided with necessary redundant very low level (low-low) interlocks for hot well make-up pumps.

4.5.0 **HRSG Fill Pump**

Bidder shall supply, 2 x 100%, (1w+1s) HRSG fill pump skid. The HRSG fill pump shall draw water from the condensate storage tank and fill the HRSG unit before start-up. In addition, the fill pump discharge shall be connected to deaerator feed storage tank of steam turbine. The rated capacity of the pump shall be such that it shall be capable of filling one HRSG in three (3) hours.

4.6.0 **Cycle Chemical Injection System**

General

The cycle chemical feed equipment shall supply water conditioning chemicals to the condensate, feed water and all drums for the HRSG for maintaining the water chemistry. Phosphate treatment for the HRSG and all volatile treatment shall be provided to maintain cycle chemistry.

The chemical feed system shall consist of phosphate dosing for injecting into the HRSG drums and Cyclohexylamine / Oxygen Scavenger dosing for injecting into condensate and feed water system. Hydrazine shall be used as oxygen scavenger.

Each subsystem shall be skid mounted consisting of its own chemical solution tanks, motor operated agitators, metering pumps, piping, instrumentation and controls. The system shall be designed for automatic operation. Each pump shall be capable of start / stop remotely from DCS. The injection rate shall be controlled by adjusting the stroke of the metering pumps. All pipe work shall be of stainless steel unless otherwise approved by the Owner/Owner's representative.

The chemical injection system shall conform to the requirements specified in this section including relevant data sheet. A calibration column shall be provided on the suction line of each pump to check the performance and calibration of the pump. All drains from the dosing skids shall be directed to a sump from where it may be transferred to the guard pond. An approved type of platform operated drench shower complete with eye bath shall be provided adjacent to the dosing skid area.

**Phosphate Dosing System**

Phosphate shall be dosed to the HRSG drums to maintain the desired water chemistry, inhibit corrosion and to react with any hardness present for subsequent removal in the blow down process. Contractor shall furnish necessary calculations to prove that the treatment method selected would meet the steam turbine purity requirements while minimizing HRSG blow-down.

Each drum pressure level of HRSG shall be provided with two separate phosphate dosing metering pump with motor, 2(1w + 1s). The dosing system to HRSG drum at each pressure level shall be remote operable from DCS. Solution tanks with motor operated agitators / stirrers stainless steel interconnecting piping and supports shall be provided for the phosphate dosing system. The suction of each of the metering pumps shall be suitably inter connected to both the tanks with necessary isolation valves. Basket type strainers shall be fitted to the tanks. Tank shall be covered with tight shut-off flanged cover. The tanks shall be provided with level gauges and drain valves. Necessary pressure gauges, relief valves, non-return valves and isolating valves shall also be provided.

**Cyclohexylamine / Oxygen Scavenger Dosing System**

The oxygen scavenger injection and the Cyclohexylamine injection subsystems shall each consist of a solution tank with mixer and two (2) 100% metering pumps with stroke adjustments.

Each dilute solution shall be prepared in the solution tanks. One (1) pump from each subsystem feeds to the CEP pump discharge / Boiler feed pump suction with the second pump acting as a spare.

Oxygen Scavenger dosing shall have provision for dosing at CEP discharge and boiler feed pump suction for scavenging residual oxygen from the feed water. The oxygen scavenger shall minimize corrosion by reducing the dissolved oxygen levels in the feed water system. Control of oxygen scavenger feed shall be in proportion to feed water flow.

Cyclohexylamine dosing shall be carried out at the discharge of the condensate extraction pumps. The cyclohexylamine shall neutralize carbonic acid and maintain a high pH level. Control of the cyclohexylamine feed shall be in proportion to the condensate flow with a bias to the specific conductance of the condensate after chemical feed.

4.7.0 **Blow down System**

The blow down system shall consist of Continuous Blowdown (CBD) Tank and Intermittent Blow Down (IBD) tank, all piping, headers, Valves, supports, hangers, insulation etc., from steam drums to CBD tank and from CBD tank to IBD tank and CBD tank level control system & instrumentation. All piping headers, valves, supports, hangers, Insulation etc for emergency blowdown from steam drum to IBD tank shall also be included.

The sizing of tank shall take into consideration the continuous operation of HRSG at its MCR conditions.

CBD Drains and other drains, if any shall be brought to the IBD tank operating at atmospheric pressure. The flash steam from the CBD tank shall be led to the deaerator and the flash steam from the IBD shall be led to atmosphere at a safe height. Steam drum to IBD drain isolation valve shall be motorized.

4.8.0 **Sampling System**

Adequate number of sampling points shall be provided for HP & LP steam, HP & LP Saturated steam, HP & LP drum, feed water and condensate samples to measure the conductivity, pH, silica and dissolved Oxygen, $O_2$. Refer relevant Section 4 of Volume II for further details.

The sampling points shall be complete with valves and connections. The sample piping shall be of SS construction & shall be connected to central Steam & Water Analysis System (SWAS).

Sampling ports with access platforms and access ladders shall be provided as per statutory regulations for flue gas sampling at HRSG stack. The number size and the location of the sampling ports shall be as per the guidelines indicated in the regulations of the Central Pollution Control Board of Government of India and State Pollution Control Board requirements. The sampling ports shall be connected to emission monitoring system.

5.0.0 **SPECIFIED DESIGN DATA SHEET**

**Data Sheet For HRSG System And Auxiliaries**

| Sl. No. | Descriptions | Units | Values/Requirements |
|---|---|---|---|
| 1.0 | Number of HRSG | No. | One (1) |
| 2.0 | Installation | | Outdoor |
| 3.0 | Type | | Horizontal Fired, Dual steam pressure (HP / LP), natural circulation. |
| 4.0 | Duty | | Continuous |
| 5.0 | Maximum Continuous Rating of HRSG | | To meet combined cycle power plant MCR requirements for maximum base load operation. |
| 6.0 | HP and LP steam Temperature | | To be optimized by the BIDDER based on proven design and not to exceed 565°C. |
| 7.0 | HRSG start-up feed water supply | | Shall be capable of using un-deaerated water during start-up |
| 8.0 | HRSG flue gas exit Temperature | | Shall be 10°C above acid dew point temperature of sulphur. Bidder to furnish calculations for dew point temperature. Suitable design shall be provided to maintain condensate preheater inlet temperature based on sulphur in the Gas and provision for liquid fuel in future. |
| 9.0 | Condensate pre-heater material | | SS 316 |
| 10.0 | Tube / Header material | | **Material Selection Table Based On Metal Temperature**<br>For temp range 0 – 400 ºC<br>Tubes (Seamless) – SA 210 Gr A1/C,<br>Headers – SA 106 Gr.B/C<br><br>For temp range : 400 - 470 ºC:<br>Tubes (Seamless) – SA 209 T1,<br>Headers – SA 335 P1<br>For temp. range : 470 - 525 ºC<br>Tubes (Seamless) – SA 213 T11,<br>Headers – SA 335 P11<br>For temp. range : 525 - 540 ºC<br>Tubes (Seamless) – SA 213 T22,<br>Headers – SA 335 P22<br>For temp range : 540 - 575 ºC<br>Tubes ( Seamless) – SA 213 T91,<br>Headers – SA 335 P91<br>For temp range: 575 - 625 ºC<br>Tubes (Seamless) – SA213 TP 347H |

| Sl. No. | Descriptions | Units | Values/Requirements |
|---|---|---|---|
| 11.0 | HP Superheater steam control range | | 60 – 100% |
| 12.0 | Steam purity | | Shall meet the steam turbine manufacturer's steam purity requirements over entire operating range. |
| 13.0 | Evaporator pinch point | | Not less than 9 ºC |
| 14.0 | Economiser approach | | Not less than 6 ºC |
| 15.0 | Tube layout | | Staggered |
| 16.0 | Tube thickness | | Minimum thickness as per IBR based on diameter and method of manufacture and with corrosion allowances equivalent to Case for pressure of circuit <70 kg/cm$^2$ (g). |
| 17.0 | Minimum spacing between the bundles | | 800 mm |
| 18.0 | Cold start, warm start and hot start time | | So as to achieve a combined cycle start-up times as per section 1 of General Technical Specification |
| 19.0 | Step load | | HRSG to respond to 20% of step load on gas turbine generator with rated steam parameters. |
| 20.0 | Rapid load combination | | HRSG to respond to maximum gas turbine load change per minute and to attain respective predicted steam parameters. |
| 21.0 | Material of HRSG casing / duct | | Carbon steel |
| 22.0 | Minimum thickness of HRSG casing plates and duct | | Not less than 6.0 |
| | **HRSG Stack** | | |
| 23.0 | Type | | Self supporting steel stack |
| 24.0 | Material of stack | | As per IS:2062 and SS for top most 5 metres. |
| 25.0 | Minimum thickness of stack plate | | As per IS : 2062 |
| 26.0 | Corrosion allowance | | 3.2 mm |
| 27.0 | Sampling ports, access platforms and ladder up to full height | | Required |
| 28.0 | Rain water collection and disposal system | | Required |
| 29.0 | Aviation warning lighting System. | | Comprising of LED light |
| 30.0 | Aviation day light Markings | | Required |
| 31.0 | Stack height above ground level | | During Detail Engineering (DDE) to meet statutory requirement |

| Sl. No. | Descriptions | Units | Values/Requirements |
|---|---|---|---|
| | **Insulation** | | |
| 32.0 | Outside surface Temperature at still air conditions considering 30°C ambient | | Not to exceed 60 °C |
| 33.0 | Inlet ducting, HRSG Casing and exhaust ducting | | |
| | a) Insulation type | | Internal |
| | b)Insulation material - For flue gas temperature > 350°C | | Ceramic wool |
| | - For flue gas temperatures < 350°C | | Mineral Wool |
| 34.0 | Insulation Cladding | | |
| | a) Flue gas temperature greater than 600°C | | SS 316 or superior material |
| | b) Flue gas temperature greater than 400°C and less than 600°C | | SS 316 or superior material |
| | c) Flue gas temperature less than 400°C | | Carbon Steel |
| 35.0 | Thickness of Cladding | | |
| | a) Inlet ducting | | Minimum 2 mm |
| | b) Casing | | Stainless Steel<br>- For flue gas velocity equal to or greater than 40 m/s minimum cladding thickness shall be 3.0 mm.<br><br>- For flue gas velocity less than 40 m/s. side top cladding shall be minimum 2.0 mm and bottom cladding thickness shall be minimum 3.0 mm. |
| 36.0 | HRSG Stack | | |
| | a) Insulation type | | External for personnel Protection |
| | b) Insulation material | | Light resin bonded mineral wool. |
| | c) Cladding thickness | | Aluminium with minimum 1 mm thickness |
| 37.0 | Noise Level | | Not to exceed 85 dBA at 1.5 m from the outline of the equipment |
| 38.0 | Ceramic Fibre Blanket OR Ceramic Wool Insulation | | |
| | a)Type | | Flexible asbestos free insulation manufactured as a needle felted product that does not contain organic or inorganic binders. |
| | b) Density | $kg/m^3$ | 128 +10% |

| Sl. No. | Descriptions | Units | Values/Requirements |
|---|---|---|---|
| | c) Thermal conductivity | kCal/m h, °C | 0.073 at 300 °C<br>0.101 at 450 °C<br>0.144 at 600 °C |
| | d) Slot content unfiberised | % | Not to exceed 25 |
| | e) Thermal shrinkage | % | Maximum 3 (after heating for 8 hours at 1100 °C) |
| 39.0 | Mineral Fiber Board Or Mineral Wool Insulation | | |
| | a)Type | | Semi-rigid insulation composed of felted inorganic fibres having a minimum of organic binding |
| | b) Density | kg/m³ | 120 +10% |
| | c) Thermal conductivity | kCal/m h, °C | Max. 0.037 at 70 +5 °C |
| | d) Content of particles | % | Max. 4 (500 microns screen shall be used). |
| 40.0 | DEAERATOR | | |
| | Shell Tank and Header | | SA 516 Gr. 70 / Eqv. |
| | Dished ends | | SA 516 Gr. 70 / Eqv. |
| | Nozzles connections | | SA 106 Gr. B / Eqv. |
| | Tray and Tray enclosures | | SA 240 TP 304 / Eqv. |
| | Covers for Man holes | | SA 105 / Eqv. |
| | Spray Valve | | SS 304 |
| | Minimum corrosion allowance | mm | 3.2 |
| 41.0 | Blow Down Tanks | | |
| | a) Number | | One CBD tank<br>One IBD tank |
| | b) Location | | Outdoor |
| | c) Corrosion allowance | | 3.2 mm (Minimum) |
| | Materials of Construction | | |
| | a) Shell and head | | Boiler quality plate, SA 516 Gr. 70 or equivalent. |
| | b) Internal piping and nozzles | | ASTM – A 106 Gr. B |
| | Gasket | | Spiral wound gasket SS304 / CNAF |
| 42.0 | HRSG Hydro Test Pump | | Bidder to furnish data sheet for parameters, Material of construction<br>etc. |
| | | | |

| Sl. No. | Descriptions | Units | Values/Requirements |
|---|---|---|---|
| | **NOTE**<br>i) Diverter damper and guillotine damper should be motor driven.<br>ii) Bidder to provide facility for measurement of temperature profile on each heating module. | | |

**Datasheet for GT Exhaust and HRSG Inlet Gas System**

| Sl. No. | Descriptions | Units | Values/Requirements |
|---|---|---|---|
| 1.0 | Material of construction | | Carbon steel |
| 2.0 | Minimum thickness | Mm | 6 |
| 3.0 | Insulation type | | Internal |
| | Insulation material | | Pyro Block |
| 4.0 | Material of cladding | | |
| 4.1 | - Flue gas temperature greater than 600ºC | | SS 316 or superior material |
| 4.2 | - Flue gas temperature less than 600ºC | | SS 310 or superior material |
| 5.0 | Thickness of cladding | | |
| 5.1 | - Gas velocity equal to or greater than 40 m/s | | Minimum 3 mm |
| 5.2 | - Gas velocity is less than 40 m/s | | |
| 5.3 | i) Side and top cladding thickness | | Minimum 2 mm |
| 5.4 | ii) Bottom cladding thickness | | Minimum 3 mm |
| | **Ceramic Fiber Blanket or Ceramic Wool Insulation** | | |
| 6.0 | Type | | Flexible insulation manufactured as a needle felted product that does not contain organic or inorganic binders as per 3.0 below. |
| 7.0 | Density | kg/m³ | 128 +10% |
| 8.0 | Thermal conductivity | kCal/m h, ºC | 0.073 at 300 ºC<br>0.101 at 450 ºC<br>0.144 at 600 ºC |
| 9.0 | Slot content unfiberised | % | Not to exceed 25 |
| 10.0 | Thermal shrinkage | % | Maximum 3 (after heating for 8 hours at 1100 $^{0}$C) |

**Data Sheet for Boiler Feed Pump**

| Sl. No. | Descriptions | Units | Values/Requirements |
|---|---|---|---|
| 1.0 | **HRSG Feed Pumps and Accessories** | | |
| 1.1 | Number | | 3 x 50% |
| 1.1 | HP/LP Pressure | | HP feed water pump system with inter-stage tap-off for LP feed water |
| 1.2 | Type of pump set | | |
| | (a) Type of pump | | Centrifugal multistage<br>☐Barrel or ring type, bidder to mention |
| 1.3 | Drive transmission | | Direct drive with Variable frequency driven motor |
| 1.4 | Mode | | Continuous, either in single or in parallel, from minimum flow to run-out flow |
| 1.5 | Liquid handled | | Feed water and un-deaerated feed water during start-up. |
| 1.6 | Minimum temperature | | Ambient |
| 1.7 | Rated capacity of each Pump | | Total combined flow of normally working pump(s) shall be 110% of the total feed water flow at TG max. VWO, 3% MU and design cooling water inlet temperature or 100% HP-LP bypass operation, 3% MU and design condenser cooling water inlet temperature together with any other feed water requirements, or any other condition causing maximum feed water flow to be a maximum, rounded off to nearest higher 10 cubic metre per hour. |
| 1.8 | Best efficiency point of each pump | | Shall be of at feed water flow equivalent to 100% TG MCR and 3% MU |
| 1.9 | Total dynamic head at rated capacity | | Shall include 10% margin on equipment and piping pressure drops for VWO condition or 100% HP-LP bypass operation and shall be rounded to next higher mlc. Shall be selected such that:<br><br>a) Normally working pump would be capable of meeting the actual requirement during an under frequency operation of 47.5 Hz.<br><br>b) Normally working pump would be capable of meeting the requirements<br>of HRSG's MCR flow when drum highest set pressure safety valve is relieving |

| Sl. No. | Descriptions | Units | Values/Requirements |
|---|---|---|---|
| 1.10 | NPSH available at pump centre line for HP / LP pump | | |
| 1.11 | Normal operation | | Shall not be less than three hundred percent NPSH required at 3% head drop |
| 1.12 | Transient operation | | Shall not be less than one hundred and twenty five percent the NPSH required at 3% head drop |
| 2.0 | **Design speed for pumps** | | |
| 2.1 | For barrel type main pump of HP pumps with variable speed Hydraulic coupling | rpm | Around 5000 |
| 2.2 | For barrel type HP pump of constant speed type. | rpm | < 3000 |
| 2.3 | Maximum suction specific speed | US units | Preferably not greater than 9500. |
| 2.4 | Shut-off head | | Shall be continuously rising from runout to shut off and shut-off head shall be not less than 120 and not greater than 125 percent |
| 2.5 | Load sharing between Pumps | | Not exceeding 5% over entire operating range when operating in parallel with other pumps |
| 2.6 | Minimum capacity of low flow recirculation | | Not less than 25% of pump rated capacity |
| 2.7 | Type of recirculation Control | | Separate modulating type / automatic modulating type recirculation valve (ARC) |
| 2.8 | Maximum noise level at all operating conditions for the pump set comprising main pumps hydraulic coupling, booster pump, drive motor | | a) Not to exceed 85 dBA at a distance of 1.0 m from outline of equipment. If maximum noise level exceeds same, an acoustic enclosure shall be provided.<br><br>b) Acoustic enclosure if provided, shall be of pre-fabricated modular type with ease for assembly / disassembly |
| 2.9 | Maximum vibration level at all operating conditions | | As per ISO 7919 |
| 2.10 | Type of impeller | | Enclosed |
| 2.11 | Seals | | Mechanical seal confirming to API 682 |
| 2.12 | Shaft Coupling | | Flexible type |
| 2.13 | Type of thrust bearing | | Kingsbury type or equivalent type |
| 2.14 | Strainer | | a) Fine mesh type with mesh size such that same is less than minimum internal clearance of the pumps during commissioning.<br><br>b) Normal operation coarse strainer mesh size as recommended by manufacturer |

| Sl. No. | Descriptions | Units | Values/Requirements |
|---|---|---|---|
| 3.0 | **Materials of Construction** | | |
| 3.1 | Outer casing applicable for barrel type pump | | Forged Carbon steel |
| 3.2 | Inner casing applicable for barrel type pump and all stage casings for ring section type pump. | | ASTM A743 CA 6 NM |
| 3.3 | Impellers | | ASTM A743 CA 6 NM |
| 3.4 | Wearing rings | | 13 - 17% Chrome steel (Material shall be nongalling type with differential hardness not less than 100 BHN) |
| 3.5 | Stuffing box bushing and stuffing box | | 13% chrome steel |
| 3.6 | Pump shaft | | 13% forged chrome steel |
| 3.7 | Shaft sleeves | | Stellite on 13% chrome Steel |
| 3.8 | Base plate | | Structural steel |
| 3.9 | Diffuser / Volute | | 13% chrome steel |
| 3.10 | Strainer | | Stainless steel mesh |
| 3.11 | Balancing drum | | 13% Chrome steel with anti galling properties |
| 4.0 | **Hydraulic Coupling** | | |
| 4.1 | Coupling wheels | | Alloy steel |
| 4.2 | Coupling wheels casing | | Alloy steel |
| 4.3 | Scoop tube | | Stainless steel |
| 4.4 | Thermal insulation | | Calcium silicate with cladding. Design thickness shall be based on outer surface temperature of 600ºC under still air condition with station ambient temperature of 30 ºC |

**Data Sheet for Condensate Storage Tank**

| Sl. No. | Description | Units | Values/Requirements |
|---|---|---|---|
| | **Condensate storage tank** | | |
| 1 | Number | No. | One (1) |
| 2 | Capacity of tank | | 10% higher of Total water Volume |
| 3 | Maximum temperature | | Ambient Maximum 50ºC |
| 4 | Material | | IS 2062 |
| 5 | Design code | | IS 803 |
| 6 | Corrosion allowance | | 3.2 mm |
| 7 | Spiral approach ladder with hand rail at top level indicator around tank | | Required |

| Sl. No. | Description | Units | Values/Requirements |
|---|---|---|---|
| 8 | Surface preparation | | Sand blasted to SA 2-1/2 and dry air blasted before painting. Shade as per Owner/Owner's representative's requirement. |
| 9 | Final painting of tank internals, externals and external steel surfaces | | Epoxy paint shall be to AWWA-D-102. Film thickness 6 mil. |
| 10 | Other requirement | | Carbon-dioxide absorber to be provided |
| | | | |

**Data Sheet for HRSG Fill Pumps**

| Sl. No. | Description | Units | Values/Requirements |
|---|---|---|---|
| 1.0 | **HRSG Fill Pumps** | | |
| 1.1 | Pump designation | | HRSG fill pump |
| 1.2 | Location | | Outdoor |
| 1.3 | Design capacity | m3/hr | Subjected to Owner/Owner's representative approval |
| 1.4 | Total Dynamic Head | mlc | Shall include 10% margin on system pressure losses |
| 1.5 | Maximum rated speed | rpm | 1500- HRSG fill pump |
| 1.6 | Liquid handled | | Passivated DM water DM Water |
| 1.7 | Temperature of liquid | | Ambient |
| 1.8 | Shut-Off Head | | Shall be continuously rising towards shut-off head. |
| | | | Shall not be less than 110% of rated total dynamic head. |
| 1.9 | Noise level allowable at all operating conditions | dBA | < 85 at 1.0 m from outline of pump |
| 1.10 | Vibration limit at all operating conditions | | VDI 2056 Degree "Satisfactory". |
| 1.11 | Rating of electric prime mover | | 120 % of the power required by pump at duty point. |
| 2.0 | **Construction Features** | | |
| 2.1 | Type | | Horizontal centrifugal back pullout electric motor driven |
| 2.2 | Drive transmission | | Direct |
| 2.3 | Coupling | | Flexible |
| 3.0 | **Material Of Construction** | | |
| 3.1 | Impeller | | SS 304 |
| 3.2 | Casing | | CI to IS 210 Gr. 260 |
| 3.3 | Shaft and shaft sleeve | | SS 304 |

| Sl. No. | Description | Units | Values/Requirements |
|---|---|---|---|
| 3.4 | Impeller ring and casing ring (Renewable type) | | SS 304 |
| 3.5 | Flexible coupling | | SS |
| 3.6 | Bolts and nuts | | Cadmium plated high tensile steel |
| 3.7 | Base plate | | Fabricated steel to IS 2062 |

**Data Sheet for Phosphate Dosing**

| Sl.No. | Description | Units | Values/Requirements |
|---|---|---|---|
| 1.0 | **Phosphate Tanks** | | |
| 1.1 | Designation | | Phosphate dosing tanks (Common preparation tank cum-measuring tank) |
| 1.2 | Number | | One |
| 1.3 | Material of construction | | Carbon steel rubber lined or stainless steel |
| 1.4 | Size | | Each tank to hold one day maximum chemical requirement under worst operating condition of HRSG |
| 1.5 | Shell thickness (Min.) | mm | 6 for carbon steel |
| 1.6 | Ladder | | To be provided |
| 1.7 | Solution concentration | | 3.0% |
| 1.8 | Level indicator / Low level Switch | | Required, Analog remote level indicator for monitoring and level switches for pump protection |
| 1.9 | Materials of construction of shaft and impeller of agitator | | SS 316 |
| 1.10 | Dissolving basket / tank of material SS 316 | | Required |
| 2.0 | **Phosphate Dosing Pump for HRSG** | | |
| 2.1 | Designation | | Phosphate dosing pump |
| 2.2 | Number and type | | Each drum pressure level of HRSG to be provided with 2 Nos. (1 Working + 1 standby) duplex reciprocating plunger type metering pumps. |
| 2.3 | Capacity and total dynamic head | | Refer notes |
| 2.4 | Capacity variation | | |
| 2.5 | Stroke length adjustment | | Remote from DCS and locally while running. |
| 2.6 | Material of construction of wetted surface (in contact with liquid) | | SS 316 |

| Sl.No. | Description | Units | Values/Requirements |
|---|---|---|---|
| 2.7 | Pressure relief valve | | One for each pump with outlet piping back to tank |
| 2.8 | Discharge pressure Indicator | | One per pump of diaphragm type |
| 2.9 | Discharge pressure Indicator | | One per pump of diaphragm type |
| 2.10 | Material of construction of body, cover & strainer of suction strainer | | SS 316 |
| 2.11 | Ball check valve | | Built-in type on discharge side |
| 2.12 | Accessories | | Common base plate, flexible |
| 3.0 | **Test and Inspection** | | |
| 3.1 | Hydro test | | Yes.<br>1.5 times maximum working pressure subject to IBR compliance |
| 3.2 | Standard running test (with water / with fluid to be handled) | | Required |
| | **Note** | | |
| 4.0 | **Dosing pumps sizing criteria** | | |
| | (a)Residual phosphate level to be maintained in the system shall be based on the following :<br>i) 40 mg/l for drum pressure < 50 ata<br>ii) 10 mg/l for drum pressure > 50 ata & < 70 ata.<br>iii) 5 mg/l for drum pressure > 70 ata and < 175 ata | | |
| | (b) Dosing shall be based on 2.53 mg/l of phosphate for every 1 mg/l of $CaCO_3$ hardness | | |
| | (c) Sizing shall be based on the requirements considering the maximum blowdown quantity of 1% at HRSG MCR condition, the residual phosphate loss shall be arrived as per the basis in item<br><br>(a), for each drum pressure levels of HRSG.<br>-Sizing based on $CaCO_3$ hardness level of 2 mg/l in the HRSG feed water to be treated. The phosphate dosing requirement shall be arrived for HRSG MCR condition. | | |
| | (d) Total dynamic head shall be with 20% margin on the drum pressure at full load plus static height of the drum and piping losses. | | |
| | (e) Heavy duty flexible SS bellows to withstand maximum working pressure shall be provided for short length on suction and discharge dosing pumps to prevent vibration transmission. | | |

## Data Sheet for Cyclohexylamine and Oxygen Scavenger Dosing System

| Sl. No. | Description | Units | Values / Requirements |
|---|---|---|---|
| 1.0 | **Dosing Tanks** | | |
| 1.1 | Number | | Two (2), One(1) for each sub-system |
| 1.2 | Size | m x m | Each tank to store one day's capacity under worst operating condition of HRSG |
| 1.3 | Material of construction | | Carbon steel rubber lined |
| 1.4 | Ladder | | To be provided |
| 1.5 | Level indicator / Low level switch | | Required |
| 1.6 | Materials of construction of shaft and impeller of agitator | | SS 316 |
| 2.0 | **Dosing Pumps** | | |
| 2.1 | Number | | 2 x 100% duplex reciprocating plunger type metering pumps for each system. |
| 2.2 | Capacity | | By Bidder |
| 2.3 | Total dynamic head | | By Bidder |
| 2.4 | Capacity variation | | 0 – 100% |
| 2.5 | Stroke length adjustment | | Remote from DCS and locally while running. |
| 2.6 | Material of construction of wetted surface (in contact with liquid) | | SS 316 |
| 2.7 | Pressure relief valve | | One for each pump with outlet piping back to tank |
| 2.8 | Discharge pressure Indicator | | One per pump of diaphragm type |
| 2.9 | Material of construction of body, cover & strainer of suction strainer | | SS 316 |
| 2.10 | Ball check valve | | Built-in type on discharge side |
| 2.11 | Accessories | | Common base plate, flexible coupling |
| 2.12 | Hydro-test / Hydro-test Pressure | | Yes / 1.5 times maximum working pressure |
| 2.13 | Standard running test (with water / with fluid to be handled) | | Required |

NOTE:

EPC Contractor shall submit HRSG Package description, filled in data sheet, list of drawings, interface table, testing commissioning & Start-up procedure, performance guarantee, Auxiliary power consumption continuous & Intermittent / standby load list, special tools & tackles, mandatory spares, Inspection & Test procedures, Quality Assurance plan, Operation & Maintenance (O&M) manual, thermography camera / thermo gun for temperature graphs measurements, etc.

# VOLUME – III

# SECTION - 2

# DETAILED TECHNICAL SPECIFICATION – MECHANICAL

## SUB-SECTION - 2.3

## STEAM TURBINE GENERATOR & AUXILIARIES

# VOLUME - III

## SUB-SECTION - 2.3

## STEAM TURBINE GENERATOR & AUXILIARIES

### 1.0.0 GENERAL

This section is intended to provide the scope, design, constructional and functional requirements for Steam Turbine Generator & Auxiliaries.

The bidders are requested to note that only the major equipments are covered below. Any other minor equipment / system not specifically mentioned below but mentioned elsewhere in the specifications and any other equipment / system essential for smooth and efficient functioning of the system shall be considered in the scope of the bidder at no extra cost.

This specification is generally written as described in Cl.1.1.0, Section-1 (General Technical Specifications), Volume-II. Bidders shall suitably interpret and modify the stated requirements (if offered by Bidders) and submit their Tenders accordingly.

### 2.0.0 SCOPE OF SUPPLY

The scope of supply shall include but not limited to, the following:

### 2.1.0 Steam Turbine (ST)

- One (1) no. straight condensing steam turbine directly coupled to the generator. Capacity of ST shall match the HRSG steam parameters.
- ST shall include the following auxiliaries (unless otherwise stated specifically).
- Emergency stop valves, governor valves and turbine casings (to the extent necessary) for HP & LP steam entry including the necessary blowout provisions.
- Steam strainers for installation in the emergency stop valves including housings for installation in the main steam and injection steam lines as well as additional steam strainers for the commissioning phase.
- Necessary hydraulically operated control valves for the turbine.
- Electro Hydraulic Governing and Protection system.
- Motorized / Hydraulic turning gear complete, including manual turning provision.
- Explosion diaphragms for outer casing.
- Coupling and coupling guards.
- Gland sealing steam system complete, including all necessary control valves, pressure reducing and desuperheating stations, condensers, 2 x 100 % motor-driven vapour suction fans.
- Turbine Integral Drain System.

- Turbine Exhaust Hood Spray System.
- Complete noise and thermal insulation, to the extent necessary.
- Turbine cladding / covers / enclosures complete.
- Flush / cleaning provisions.
- Sealing fixtures (for hydraulic pressure testing of steam lines) at HP Valve blocks.
- All primary Instruments and final control elements.
- Turbine Supervisory Instrumentation.
- Transport Fixtures along with all special Tools & Tackles.

### 2.1.1 Turbine oil system

- Main oil tank including oil strainers with drains in each compartment, maintenance opening, vents with vent connections and connection for oil purification system unit.
- Main Oil Pump (1 x 100%) shaft driven or with AC motor drive.
- Auxiliary Oil Pump (1 x 100%) with AC motor drive.
- Emergency Oil Pump with DC motor drive
- Turning gear Oil pump (if applicable) with AC motor drive power sourced from Emergency Diesel Generator (EDG).
- Emergency Oil Pump with DC motor drive and with AC motor drive backed-up with emergency power supply.
- 2 x 100% Jacking oil pumps with one pump provided with DC motor or AC motor with emergency power supply.
- Oil vapour extraction fans (2 x 100%) with 3-Phase AC motor drive with oil separator in the piping.
- Two lubrication oil coolers (each 100%) shell & tube type, for ST equipped with change over device allowing continuous operation without interruption of oil flow and automatic oil temperature control device.
- Duplex filter (2 x 100%) for ST for the complete lubricating oil flow.
- Lube oil purifier complete with all auxiliaries and tank for separation.
- Accumulators (if required), Re circulation pump for Control oil system.
- Duplex filter (2 x 100%) for the complete control oil flow, if required.
- Oil level indicators and level switches/transmitters for oil systems.

- Sheet metal ducts or cover for oil piping and other oil spray protection equipment.
- One dirty oil tank with same capacity as the main oil tank including the necessary interconnecting pipe work between the two tanks as well as the required pumps.
- One centralized oil storage and purification system including clean oil tank, transfer pumps, purification unit (20% capacity of lube oil system) with interconnectivity piping, necessary instrumentation and control hardware to make the system complete in all respects. Capacity of dirty and clean oil tanks shall be to hold complete lube oil filled in the system for one GTG / STG and auxiliaries.

**2.2.0 Condensing Equipment**

Two pass divided water box surface condenser with hotwell comprising of condenser tubes, tube sheets, condenser tube support plates, nozzle connections, and all other accessories.

- Cooling water inlet and outlet pipe connection nozzle (flanged) with counter flanges and accessories, with isolating valves.
- Steam and water side drain and vent valves.
- Sealing water system (if applicable).
- S.S. bellows with connecting pieces for turbine exhaust to condenser neck connection.
- Rupture disc on the turbine exhaust hood to condenser neck connection.
- Vacuum breaker with provision for manual operation locally and from the central control room.
- Cathodic protection equipment for water boxes.
- Water expansion relief valve.
- Automatic venting of cooling water chambers at outage of cooling water pumps.
- 2 x 100% Condensate Extraction Pumps (CEP) with AC drive motors, having couplings and coupling guards, mechanical seal, vibration monitoring system and minimum flow device.
- Suction strainers for condensate extraction pumps.
- One HP Drain flash box with 2 manifolds with pump if necessary.
- One Condensate drain flash box.
- One turbine flash box.
- All steam turbine drains up to condenser flash boxes.
- HP / LP Bypass Dump tubes.
- Hotwell module with vortex breakers, removable screens, debris barrier.

**2.3.0 Air Evacuation System**

- 2 x 100% vacuum pump for each block with drive and all required accessories such as cooler, silencer integral piping, isolation valves. Alternatively, bidder can offer 1 x 100% start up steam jet air ejector ( for hogging) and 2 x 100% steam jet air ejector(for holding)

- Necessary air rotameters on the exhaust air piping.

**2.4.0 DM water make up system**

- Condensate Storage Tank with hot well normal and emergency make up pumps along with HRSG and Deaerator fill up pumps.

**2.5.0 Turbine Bypass System**

- Turbine bypass system for HP, LP steam complete with PRDS station and for LP steam complete with pressure control valve with the associated actuations & control equipment Isolation valves; manual bypass valve and piping.

**2.6.0 Piping, Valves, Fittings Supports**

The complete piping system as required along with valves, control valves, fittings and supports, insulation and cladding.

**3.0.0 DESIGN REQUIREMENTS**

**3.1.0 Steam Turbine**

Steam turbine shall be multi pressure, condensing type complying with relevant IEC Standards or equivalent. The steam turbine and accessories shall conform to the design and duty conditions specified and shall be located indoors.

The turbine and accessories shall be suitable for both constant and sliding pressure modes of operation.

The turbine generators shall be capable of operating continuously without any restriction at each load between no-load and maximum continuous load. The turbine shall be guaranteed for continuous operation at any frequency from 47.5 Hz to 51.5 Hz.

Long barring periods without any restriction shall be considered for the design of the turbine generators.

Control valves shall be hydraulic/pneumatically operated. Direct acting control valves and control loops are not acceptable. The necessary stop valves and bypasses shall be installed, so as to be able to repair important control equipment. This shall not apply to the turbine governor valves.

The start up and drainage system shall comply with relevant ANSI / ASME Standard TDP-1 or equivalent regarding prevention of water damage to steam turbines.

The turbine shall be provided with protective devices as per relevant IEC or equivalent, including the following:

(a) Separately actuated over-speed trip device.

(b) Emergency hand trip devices to facilitate manual tripping of the turbine locally and from control room.

Hydraulic / pneumatic / D.C. operated device shall be provided for rapid reduction of vacuum in condenser to bring turbine rotor to rest as quickly as possible under emergency conditions.

Quick acting non-return valves shall be provided in the steam extraction lines as required for protection from over speed that may result from sudden load throw off or turbine trip.

### 3.2.0 Condenser

The design and construction of the condensing unit shall follow HEI standards in general. Condenser shall be Axial turbine exhaust.

The pressure design on the steam side must at least cover the range from full vacuum to 1 bar gauge and on the water side from full vacuum to the maximum pressure it shall be subjected which shall be decided after conducting water hammer study.

In dimensioning the heat exchange surfaces it must be assumed that all the load cases must be met even the condenser tubes are blocked as per the tube plug margin specified in the design data sheet. Under-cooling of the condensate is to be avoided.

The condenser shall be suitable for accepting all drains occurring during start-up operation. The condenser pressure corresponding to a sustained HP-LP bypass operation (100% fully open) at maximum cooling water inlet temperature shall be less than the turbine alarm value for the high condenser back pressure by a reasonable limit.

Suitable cathodic protection system shall be considered for the condenser water box.

The water side of the condenser is to operate on the two pass system and be divided into two independent halves. Each half must be so dimensioned that the turbine generator can be operated with correspondingly decreased load while the other half is out of action.

The condenser has to meet the requirements of the main cooling water system with respect to material. Extra tube thickness shall be provided in the impingement zone. The Bidder must show that sufficient experience with the chosen material is available and in particular reference shall be made to the expanding of the tubes into the tube plates and the welding of different materials as well as of the connection of the tube plates to the condenser shell.

The cleanliness factor shall be considered as 0.85 for the design of the condenser.

The capacity of the hotwell (between normal and low-low level) shall correspond to a condensate flow of at least three (3) minutes during full load condenser operation at design condition. However the selected hotwell capacity shall be sufficient to allow all the operating (normal and transient) and control functions of the condensate system.

### 3.3.0 Air evacuation System

The control system shall be such that the entire operation from hogging through holding can be carried out automatically.

Unit shall be completely assembled & tested at the manufacturer's works prior to shipment to site.

**Vacuum Pump**

2 x 100% duty electric motor driven vacuum pump having a capacity to remove all air and non-condensable from the water cooled condenser. However, in no case shall the capacity be less than the recommended capacity for air ejection equipment in steam condensers as per HEI standards.

**Steam Jet Air Ejector**

The condenser air removal system shall primarily consist of one (1) start up (hogging) ejector and two (2) main (running) ejectors.

The capacity shall be as recommended in the latest edition of HEI standard. The hoggers shall be designed to lowest possible parameters to achieve vacuum as quickly as possible during start up. It should be able to achieve 225-mm Hg vacuum in the condenser within 30 minutes.

### 3.4.0 Condensate Extraction Pumps

The pump shall be designed, manufactured, tested and supplied strictly in accordance with the HIS or equivalent.

Each pump shall be capable of supplying starting requirements of the plant & satisfactorily accommodate steady and transient loading of the plant.

The pump head curve must be continuously rising with a shut off head of atleast 120% of rated head.

The pump and driver shall be capable of continuous operation at 110% of rated flow.

The pump shall select such that it provides the required TDH to supply 50% of the maximum normal water flow to the LP drum (if condensate supply to LP drum) with the LP drum relief valves lifting and all other consumers of the condensate pump.

Pump best efficiency shall be close to the normal operating point.

The minimum recirculation of the CEP shall preferably meet the minimum flow requirements of gland steam condenser.

CEP discharge valves shall be motor operated.

The CEPs shall have independent suction from respective condenser hotwell.

### 3.5.0 Steam By-pass System

100% capacity HP / LP bypass system of Hydraulic / pneumatic type shall be provided for STG.

The HP - LP bypass system shall be designed to control the flow and temperature of steam bypassing the HP- LP sections of steam turbine during the steam turbine trip or during major load rejections, so that the HRSG can safely be kept on-line, without risk of lifting of HRSG safety valves.

Each bypass station shall be designed for the respective maximum steam pressure, i.e. the safety valve set pressure in the respective section and sized for maximum steam capacity generated taking into account the condensate injection for attemperation.

Attemperating water for the HP Bypass valves shall be taken from feed water pump.

The HP-LP bypass system shall rapidly shutdown upon detection of low spray water pressure/high steam temperature downstream of desuperheating stations and condenser pressures.

Special attention shall be paid to the provision of draining the warm up drains as close to the bypass valves as possible in order to minimize steam hammer / thermal shock on bypass valves and upstream pipe work when bypass comes into operation.

The systems downstream of bypass valves shall be capable of withstanding the thermal shock due to failure of spray water.

## 4.0.0 CONSTRUCTIONAL REQUIREMENTS

### 4.1.0 Steam Turbine

### 4.1.1 Casings

In order to facilitate rapid assembly and dismantling, the turbine casings shall be of horizontally split and supplied with guides to permit safe lifting of the casing.

The casing and its built-in features shall be supported symmetrically as far as possible. Thermal expansion shall be considered in the design and surface preparation of the supports. Packing plates shall be provided to enable good alignment to be achieved.

Casing shall be thermally treated to minimize possibility of distortion while in service.

All piping connection, in particular MS steam piping shall connect to the lower half of the casing. Bidder to note that only proven arrangement of connection of piping to the casing cross over piping between casings for same turbine model and turbine configuration will be acceptable. Such STG shall also be in satisfactory commercial operation.

Supervisory thermocouples shall be provided at necessary points in the casings as per manufacturer standards, for measurement of temperature and further evaluation of thermal stress levels.

### 4.1.2 Blading and nozzle segments

Rotor and stator blades, nozzle segments and control parts shall be made of erosion and corrosion proof material (stainless steel). For all rotor blades, only fully-machined or pre-forged and mechanically machined designs shall be permitted. Alternatively, the rotor could also be proven welded construction. For the first rotor blade stage only milled shrouds shall be permitted. The low pressure rotor blades shall be provided with an additional edge protection, where necessary. The turbine stages operating in the wet Steam region are to be provided with sufficient water drains and suitably protected against erosion.

The design of the blading shall be such as to avoid the possibility of damage from vibration with the turbine operating at any load up to MCR. Blading design shall also ensure minimum steam leakage.

Adequate measures shall be considered in the design to avoid resonance and to ensure that the natural frequency of un-shrouded free standing rotor blades is compatible with the rotational frequency of the machine.

Dummy shaft shall be provided for checking of seals clearance and shaft alignment, this shall be included under special tools.

### 4.1.3 Rotors

The coupled critical speeds of the turbine and generator rotors shall lie outside the range of 85% to 125% of the rated speed. The rotors shall be statically and dynamically balanced in the factory so that the maximum effective vibration speed measured on each bearing housing would not exceed the limits under the region “GOOD” AS PER VDI 2056 / ISO 10816 under steady running conditions for all loads. All rotors complete with turbine blades and completed shafts shall be subjected to over speed testing and dynamic balancing at shop.

It shall be possible to re-balance the rotor on site without any practical difficulty.

The rotor shall be tested at an over speed of 20% for 3 minutes.

The design of the rotor shall ensure to avoid fatigue failures.

Bidder shall state in the bid, procedures for inspection of the rotors.

### 4.1.4 Bearings

The bearings shall be designed as horizontally split plain bearings and provision shall be available for adjustment and alignment of the rotor. Even loading of the bearings shall be ensured by suitable measures. The thrust bearings shall be tilting pad type and shall be capable of taking load from both sides and be self-aligning. They shall be axially adjustable.

It shall be possible to check the thrust bearing wear during operation.

Earthing brushes shall be provided to protect the bearings. Similarly the necessary bearing and pipe insulation shall be provided to give protection against eddy currents. In order to prevent oil leaks, suitable bearing seals shall be provided.

It shall be possible to dismantle the bearing shells without removing the turbine casings or dismantling the generator.

### 4.1.5 Gland seals

Labyrinth seals shall be provided for the steam turbine gland sealing. The labyrinths to be provided shall have spring elements (as far as possible) for external shaft glands and inter stage shaft glands. These components shall be made of material that is compatible with operating environmental at each specific stage of turbine. Care should be taken not to have wear & tear in the seal resulting is excessive leakage in future.

### 4.1.6 Gland Steam Sealing System

Turbine gland-sealing steam shall be obtained from HP steam line during start up and from LP steam line during normal operation. An automatically controlled sealing steam system shall be provided.

The gland steam system shall be provided with a gland steam and vapour condenser and 2x100% vapour suction fans. The gland steam condenser shall be arranged in the main condensate line.

The gland steam condenser and exhauster system shall be sized for condition with severely worn-out labyrinth gland seals of the turbine.

### 4.1.7 Emergency stop valves / Interceptor Valve, Governor valves & Reducing valves

Spindles, fittings and control parts shall be manufactured from stainless steel material. The guide surfaces shall be manufactured from hard-wearing materials or they shall be armoured and be compatible with guided components. Spindle leakage losses shall be avoided by suitable seals.

The emergency stop valves, Interceptor Valve (if applicable) shall allow for removal of stop valve internals for blowing out the steam pipes (HP and LP). Suitable provisions shall be supplied to protect valve seats and other internals surfaces, and to deflect the blowout steam where inlet and outlet are not in a straight line. The blowout outlet from the emergency stop valves shall be included and shall have a flanged or butt-weld connection for the attachment of the temporary blowout piping during commissioning.

In order to facilitate the safe and reliable shut-down of the machine, the emergency stop valves and governor valves shall be arranged with easy access as near as possible to the appropriate turbine casings. In so far as flange connections are provided on the live steam side, these are to be executed a high quality designs.

Provision shall be made for tripping of turbine from the unit control room and for local manual trip from the steam turbine front stand.

### 4.1.8 Turning device

Electrically AC and DC motor driven / hydraulic ratchet turning devices shall be employed during start up and shut down. The turning device shall disengage automatically as soon as the turbine speed exceeds the turning speed.

A higher turning speed will be preferred because of the better temperature balance between the upper and lower casing parts due to the fan effect. If jacking oil pumps are used, one AC and one DC pump shall be supplied and interlocked so that turning without jacking oil supply is prevented, in order to avoid mixed frictional effects in the bearings during starting of the turning device. An AC motor driven jacking pump is acceptable in place of DC motor driven pump if the AC motor is provided with emergency power supply.

Interconnection between the lubricating oil supply and turning operation shall be ensured by automatic interlocks. In addition, a manually barring facility shall also be provided.

### 4.1.9 Couplings

Flexible couplings shall be provided. Coupling hubs and sleeves shall be individually balanced, statically and dynamically, at a speed corresponding to the operating speed. If toothed couplings are provided, these should be force lubricated.

### 4.1.10 Turbine Insulation

In order to avoid a possible penetration of oil, insulation with an oil-tight hard cover or mattress type prefabricated jackets covered with oil proof silicon coated glass cloth shall be provided for the turbine. Heat radiation which might cause damages to the foundations shall be avoided.

The insulation shall allow easy dismantling of the turbine. Housing flanges shall be provided with reusable insulating sections.

Hot sections which cannot be insulated, such as observation openings, shall be provided with a corresponding contact protection.

### 4.1.11 Turbine cladding

The turbine cladding shall be designed as a sheet metal cladding and provided with sufficient corrosion protection. It shall cover the complete turbine area including the bearings. Heat build-up within the turbine cladding shall be avoided by suitable ventilation. Particular importance shall be attached to a good overall appearance of the turbine generator set with the turbine cladding installed. Furthermore, the cladding shall be easily dismantled/re-installed.

The turbine cladding shall be provided with access openings for inspection and maintenance.

### 4.1.12 Steam Strainer

The strainers shall pass the full steam requirements for rated turbine output and they shall be arranged for easy inspection and cleaning. The strainer shall be accessible without removing the inlet steam piping. Strainer integral to steam admission stop valve as per manufacturer standard will also be acceptable. Temporary fine mesh strainers shall be provided for use during commissioning period.

### 4.1.13 Flush Cleaning Provisions

Provisions for flush cleaning shall be available. With these flush cleaning provisions it should be possible to clean water soluble deposits from the turbine blades without dismantling the turbine using wet steam.

### 4.1.14 Turbine Governing System

An electro-hydraulic governor shall be provided for turbine speed regulation during normal on-load operation and during turbine run-up control.

The steam turbine generator shall normally be operated in the turbine follow mode i.e., the setting of gas turbine influences the steam turbine output through variation of steam generation in HRSG using gas turbine.

The turbine governing system shall be throttle controlled in combination with sliding steam pressure.

Governing shall be provided on HP Governing Valves to permit both turbine speed and load control.

The governing system shall include other governing system equipment viz. load shedding relay, interceptor control valves. Such fast responses may be required in the event of sudden load reduction to either a partial or zero load.

The governing system in association with over speed prevention device shall limit the speed of the unit to a value less than the trip setting in case of full load trip out.

Suitable provision shall be made for testing the action of the governing system equipment without taking the steam turbine unit out of service.

**Start up Governor Control**

A start-up speed governor shall be provided for the control of the turbine from barring speed to the normal rated speed. The governor is to be used in conjunction with the automatic run-up control system which will generate the speed reference signal to the wide range speed governor.

**Over Speed Governor**

There shall be minimum two (2) entirely separate systems to protect the turbine against over speed in the event of failure of the normal speed governing facilities of the turbine governor.

The over speed protection device shall cut off steam by closing the main steam emergency and governing valves when the speed rises to 110% of normal rated speed. For electronic protection system the preferred arrangement is to have two out of three logic, such that any two electronic devices sensing an over speed condition will trip the machine.

The additional speed rise after failure of the normal governing devices following an over speed trip at full load above the maximum value of the over speed at which the trip may operate shall have an adequate margin below the 120% over speed test of the rotor.

An over speed trip testing system shall be provided for testing at regular intervals at rated speed, on or off load, without over speeding the rotor.

### 4.1.15 Other turbine equipment

Initial Pressure regulators, Vacuum unload device (if necessary), vacuum breaker valves, Exhaust temperature limiting equipment, Pressure relief diaphragms, Protection against water induction shall also be provided to ensure reliability of the system.

In order to protect the condenser from excessively high temperature an automatically acting cooling device has to be supplied for the exhaust steam. The cooling shall be from main condensate pump discharge side.

For safety against overpressure on the exhaust part of the steam turbine, rupture disk shall be arranged on the condenser neck. The explosion diaphragms shall be designed for the maximum possible steam flow.

The ingress of seepage steam into the turbine during standstill of the turbine and operation of the boiler shall be prevented. The turbine injection shall be provided with a control valve and a power operated NRV. In addition to these valves in the injection lines, stop valves shall be provided in order to make possible repair and maintenance work on turbines during shut-down.

The HP Steam turbine exhaust shall be provided with hydraulically operated quick closing non return valve. These shall be closed automatically when steam turbine is tripped.

### 4.1.16 Turbine Oil System

The lubricating and control oil system shall supply the lubrication points and the control equipment of the complete turbine generator. The oil supply equipment is to be arranged in a separate oil enclosure.

The temperature rise of the lubricating oil in the bearings shall not exceed 30°C, and the oil drain temperature of the bearings shall not exceed 75°C.

The oil tanks shall be equipped with a strainer to trap solid particles which are being carried by the return oil line into the tank. Sample point shall be provided at suitable locations on the oil tank.

The turbine oil tanks are to be dimensioned so that the contents are not changed more than 10 times per hour.

The tank shall be of welded construction and manufactured from high quality mild steel plate and shall have sufficient capacity to hold all the oil within the system.

In order to avoid welding at site which could damage the tank internal painting all necessary pipe connections, pump seating facilities, pipe supports, steelwork or hand - railing supports shall consist of pads welded to the tank. Where such facilities are provided around tank penetrations they shall be welded during manufacture both internally and externally to the penetration. All pads should be tapped for the supply of studs to effect connections. Alternatively, pipe connections to the tank may be made by means of butt-welding, and in this case the tanks shall be provided with stubs or nozzles extending out from the tank wall, at sufficient distance to prevent the heat of welding causing any damage to the internal painting.

Two (2) 100% duty AC / DC motor driven oil vapour suction fans and oil separators shall be provided. The possibility of unacceptable concentration of the oil vapour shall not exist at any point of the oil system. The impeller and casing of Vapour extraction fans shall be of material that will not cause sparking when they contact with each other. All the oil vapour vents shall be provided with oil strainers/oil traps arrangements to prevent oil carry over to the atmosphere.

All oil-carrying parts shall be separated from equipment subject to hot steam so that premature aging of the turbine oil and the danger of fire would be excluded. The oil pipes shall be run in separate covered oil ducts or protection piping.

The oil pipes shall be seamless and connections between oil-carrying parts shall not be made with compression ring joints and shall be secured against unintentional loosening. Flange connections of the oil pipes outside oil ducts shall be encapsulated. The fastening of the oil pipes shall be such that excessive vibrations are excluded. Oil drain points shall be equipped with double stop valves.

The main oil pump shall be either AC motor driven or directly driven from the turbine shaft. The AC (sourced from EDG) motor driven auxiliary oil pump, shall be able to start automatically in the case of a drop in oil pressure. If positive displacement pumps are employed, pressure relief valves shall be provided in each case for the full flow quantity. A pressure accumulator shall be installed in the oil system, if required, to avoid an excessive drop in pressure during switch over of oil pumps.

A D.C motor driven emergency pump shall come into operation on failure of Auxiliary pump. The control of the emergency oil pump shall be electronically fail-safe. It shall be ensured by proper means that the pump would always work in emergency cases.

Two (2) 100% duty (1 AC Motor Driven + 1 D.C Motor Driven) positive displacement high pressure jacking oil pumps shall be provided. Alternatively AC motor driven jacking oil pump can be provided instead of DC motor, if it is backed-up by an emergency power supply.

Separate supplies shall be provided to each bearing to enable the rotor to be lifted in the bearings and consequently reduce the starting torque load on the motor or hand operated barring gear.

Two (2) no. 100% oil coolers connected to the closed circuit cooling water system shall be interchangeable during operation without interruption of the oil flow and shall be easy to clean.

The lube oil temperature shall be maintained constant during all cooling water inlet temperature conditions. Necessary oil temperature control methods like lube oil cooler bypass shall be provided to maintain a constant lube oil temperature so that the lube oil is not over cooled during winter seasons which may reduce the flow ability of lube oil.

Filters in the lubricating oil main circuit and in the control oil circuit shall be arranged as duplex filters which can be switched over without interruption at high control oil pressures the standard of oil purity to be achieved must meet increased requirement. The pipes from the filter to machine connection points shall be fabricated from stainless steel.

In addition, an oil purifier with all its auxiliary equipment shall be provided, with a throughput of atleast 20% of the lubricating oil flow. The purifier shall be capable of being used both when the turbine is in operation and when it is at rest. Those parts in contact with fluid shall be manufactured from stainless or superior material. The oil purifier shall be able to remove dirt, water and all solid particles greater than 5 microns. If necessary, oil vapour extraction shall be provided for this equipment. The purifier shall be self-cleaning. The purifier shall be complete with all required accessories, instrumentation and controls. Operating status shall be available in the DCS.

Fire resistant fluid shall be employed for the control oil system to minimize fire hazards, if separate control oil system is offered. Use of mineral oil for control oil system is acceptable only if Bidder has proven experience for the same. Necessary double wall piping shall be included for the same. The system shall comprise of fluid reservoir, 2 x 100% control oil pumps, coolers, motors, strainers, piping, valves, fittings, I&C hardware and purification equipment. Duplication of pumps, coolers, accumulators and filtration equipment shall be adopted to ensure maximum availability of control oil system during steady state and transient operating condition. Provision shall also be made for initial air purging of control oil system.

The different oil systems shall be easily distinguished by a clear arrangement and different colouring.

A central lube oil storage system for GTG and STG unit shall be provided for transferring and storage of oil to facilitate replacement oil during maintenance and cleaning of main oil tank.

The oil pipes shall be pickled and on commissioning, oil flushing shall be carried out with alternatively cold and heated oil. The oil which has been used for oil flushing shall be replaced by the first oil filling for operation of the Turbo-Generator. All the facilities necessary for commissioning shall be provided.

### 4.1.17 Turbine and Integral Piping Drains

The steam turbine drain system shall be designed in accordance with the recommendations outlined in ASME standard TWDPS-1 for protection against water induction to the steam turbine.

All drain valve required to be operated during start up and shut down shall be power operated and arranged for remote operation.

Each drain shall be separately controlled and piped separately to its point of discharge to avoid preferential draining which would tend to occur under conditions of different system resistance. Drain pipes shall be sloped continuously towards the point of discharge.

Drains and vents to be recovered into the condenser will be discharged into an enclosed drain vessel or a number of enclosed drain vessels for different pressure groupings. The design of the vessels, the condenser and any drain or vent connections or vent orifice shall be such that preferential draining due to pressure effect does not occur.

Drainage from the turbine cylinders, steam chest, and loop pipes shall be controlled by one motorized isolation valve and one manual isolation valve mounted in series arranged to operate sequentially.

**4.2.0 Condenser**

The water boxes shall be made of carbon steel with suitable lining/ coating as corrosion protection for the quality of cooling water being used. The water side shall be provided with covers which may be easily opened using appropriate opening equipment.

Sufficient space shall be provided for withdrawal of the condenser tubes. The tubes shall be arranged so as to be self draining. The inlets of the tubes must be protected by nylon protection inserts.

The condenser may be either spring supported with a rigid turbine/condenser joint or solidly supported with a flexible joint. In the case of springs supports these shall be arranged and adjusted to take the whole of the weight of the complete condenser under working conditions, and to relieve, as fast as possible, the exhaust connections of the turbine from all suspended weight and from all stress due to expansion.

Each half of the water chamber shall contain venting and water drain connections of adequate size. Sufficient automatic air release cum vacuum break valves shall be provided for venting at the cooling water side, as required by transient analysis, in case of sudden outage of the main cooling water pumps..

In all cases, means shall be provided to prevent any load being imposed on the turbine exhaust connections when the condenser steam space is filled with water to the LP blade tips portion of the turbine (for testing purposes) and the design of the shell and supports shall be adequate for this test without the provision of temporary supports.

The water losses of the cycle shall be covered by an in feed of make-up water. The choice of material must take into account the corrosive properties of the make-up water.

Condenser atmospheric relief devices shall be installed either on the condenser neck or on the LP turbine exhaust hood. The devices may be of the replaceable rupture disc or re-seating diaphragm type.

A suitable number of manholes with internally held covers shall be provided on the steam, water sides and hot well sections of the condenser having atleast a nominal bore of 600 mm. Furthermore, means of observing the vulnerable condenser tube regions must be provided.

The condenser hotwell shall be provided with atleast four sampling points for analytical measurement. These sampling connections shall be arranged (e.g. one at each corner of the hotwell) so that each shall give a sample which is representative of the condensate from approximately one quarter of the condenser. An online conductivity measuring analyzer shall be provided to monitor condensate conductivity.

Hotwell connections to suction of condensate extraction pumps shall have anti-vortex baffling and the material of screen mesh shall be of stainless steel.

All necessary tube leak detectors, fittings and pumps shall be included. The condenser shall be provided with sensors at atleast four locations to detect the leakage of the condenser tube.

**Corrosion protection equipment**

A cathodic protection system shall be provided for the condenser water boxes and waterside surfaces within the condenser. The CW system piping shall be provided with cathodic protection system.

The cathodic protection system has to be compatible with the construction materials and media involved.

The cathodic corrosion protection system has to function safely with respect to cooling water quality, soil conditions and temperature and at each condition of operation.

**Condenser Circulating Water Valves and Joints**

The Bidder shall provide the necessary pipework, flexible joints and valves between the circulating water piping near the condenser at the power house and the water box inlet and outlet flanges.

There shall be one valve available for remote operation at each inlet and outlet pipe to and from the water boxes.

Inlet and outlet valves shall be electrically or hydraulically operated and complete with a limit torque or approved equal combined worm gear actuator, in addition to a local mechanical indicator and slide wire position transmitters.

The valves actuators shall be arranged so that, in the event of a failure in the power supply (either hydraulic or electric), the valve shall remain safely fixed in the position it was prior to the power supply failure.

Each valve shall be fitted with arrangements which provide for the valve to be securely locked into either the fully open or fully shut positions by means of a manually inserted locking pin. With the valve locked in position by means of this pin it shall be possible, while the unit is on load to remove the actuator drive unit for maintenance purposes.

Suitable flexible rubber expansion joints shall be included in each inlet and outlet branch for vibration isolation; and to absorb limited differential movement and misalignment. The expansion joints shall be suitable to withstand full internal vacuum as well as the design pressure.

**4.3.0 Air Evacuation System**

**4.3.1 Vacuum Pumps**

The pump assembly shall be fully self contained and shall include, base plate, coupling and guard, gauge glass, make-up and overflow valves, all necessary piping, valves (including vents and drains), Instrumentation and control equipment (including local panel having necessary vacuum and D.P switches) to provide signals for starting the standby unit, and Air-discharge flow meter with thermometer on the air outlet of each pump.

The vacuum pump shall require no internal lubrication and shall not be damaged by long term usage due to water vapour, entrained droplets of water, from the air suction piping.

The vacuum pump shall be conveniently arranged for operation and maintenance, with control valve and other related equipment easily accessible from platforms or floors.

Seal water makeup to the liquid ring pump shall be of DM water.

**4.3.2 Steam Jet Air Ejector**

The Hogging ejector shall be single - stage steam-jet ejector and shall be used to evacuate the turbine and condenser steam space during the start-up of the unit.

The outlet piping of starting ejector shall be provided with a silencer and the piping shall be terminated outside the building at a safe elevation (3 m above roof).

The main steam jet air ejectors shall be a multi-stage multi-element unit having individual inter / after condensers with provisions for isolating either elements. The ejector shall be equipped with following accessories.

a) Steam strainer
b) Drain traps for after condenser
c) Air rota meters & complete air piping
d) Pressure gauges at the throat of all ejectors, shell side of inter and after condenser.

**4.4.0 Condensate Extraction Pump**

The condensate extraction pumps may be supplied preferably in vertical configuration (vertical canister).

The construction shall ensure removal of pump shaft and impeller without disturbing the can.

Casing and rotors are to be provided with wear rings in order to permit easy replacement of the parts subject to wear. The pumps are to be provided with mechanical seals. Pumps and driving motors are to be supplied on a common base plate.

The installation height of the pumps and the NPSH value of the pumps are to be matched to one another so that there shall be sufficient suction head even under the most extreme operating conditions. CEP suction and discharge isolation valves shall be motorised.

**Condensate Extraction Pump Suction Strainers**

A suitable permanent strainer shall be provided for each extraction pump suction to prevent foreign matter being drawn into the pumps particularly during the initial commissioning period and subsequently after any maintenance work involving the condenser steam space.

The strainers shall be generally sized so as to keep the pressure drop across them to a minimum.

These strainers shall be provided with complete back-washing arrangements enabling them to be cleaned quickly and effectively without dismantling the strainer, or the use of tools.

The mesh size of the strainer element shall be chosen as necessary to prevent the risk of damage to the extraction pump from debris and foreign matter. If appropriate the strainer shall be provided with both coarse and fine mesh elements. One complete replacement set of strainer elements shall be provided with turbine unit (i.e. one spare element of each mesh size.).

**4.5.0 Excess Condensate Dump System**

Excess condensate dump system shall dump the excess condensate in condenser hotwell to the Condensate Storage Tank through an excess condensate dump line downstream of condensate extraction pump discharge. The excess condensate dump line shall be provided with an excess condensate dump control valve sized for not less than 10 percent turbine VWO flow with bypass valve.

Condensate storage tank of 30 minutes storage of total design condensate flow of turbine MCR shall be provided with DM water transfer line with motorized valve receiving the DM water make - up pumped from the DM water storage tank. The valve shall be interlocked to close on very high level in the condensate tank. Necessary remote level indications shall be available in plant DCS. The CST shall also be provided with necessary redundant very low level interlock for hot well make - up pumps.

**4.6.0 Hotwell Make-up System**

The hot well make-up system shall supply de-mineralised water from the Condensate Storage Tank to the surface condenser of the steam turbine. Hotwell makeup system shall also be used for initial fill of turbine cycle system. In addition to that condenser shall also be provided with an emergency make-up control valve sized for hotwell make-up pump rated flow condition.

2 x 100% DM water make - up pumps of centrifugal type shall be provided for hot well (normal and emergency).

**4.7.0 HRSG Fill Pumps**

2 x 100% HRSG fill pump of centrifugal type shall be provided. The HRSG fill pump shall draw water from condensate storage tank and fill the HRSG unit before start up. Fill pump discharge shall also be connected to deaerator feed storage stank.

**4.8.0 Steam By-pass System**

Each bypass station shall comprise a quick acting stop valve and a pressure control valve on steam line (operated by separate actuator), a desuperheater, a stop valve and a control valve on spray water injection line (operated by separate actuator).

The spray water system for temperature control shall be compatible with the bypass control valve requirements. The valves actuators shall be of eletro-hydralic or pneumatic type. If the oil system is a self-contained unit, it shall have 100% standby oil pump connected to main system with necessary valves for isolation and maintenance. Hydraulic accumulators shall be provided on the hydraulic system to ensure positive supply of oil to hydraulic actuators even when hydraulic oil pumps are not available. Accumulator shall be adequately sized to ensure supply for three complete stroking operations of all connected actuators. All control valves shall be of tight shut-off design and the actuators shall be designed for maximum shut-off differential pressure acting across the valve.

The valve stem should be protected against contact with the hot fluid. Complete assembly shall be designed as single unit. Constructional details of body and internals shall be designed based on above requirement.

Valve trim shall be designed and selected so as to give required steam outlet parameter in stable manner and within the specified sound level.

Bypass valves shall be capable of handling atleast 120% of the stated maximum flow at the full open condition for HP valves and 125% for LP valves.

Sizing of control valves shall be done as per the latest edition of the ISA handbook.

Valves shall be designed to give class v leakage when the valve is fully shut and subjected to maximum inlet pressure as per ANSI B 16.104.

Valve trim material shall be selected based on the service conditions. However SS316 trim material shall be offered as minimum. Stelliting or other equivalent treatment shall be done for all valves offered for all steam service and high pressure reduction service. Cage guided valves may be offered for steam service. For water service it shall be preferably top or heavily top guided type.

Cage guided valves shall be avoided for water service. Seat rings shall be replaceable type. Seat rings shall securely lock in place to prevent leakage past the body. Where required as per the service condition seat surface shall be stellited. Anticavitation trim shall be offered where cavitation and flashing is expected.

For pneumatic operated valves , one no (1) of air storage vessel for each HP / LP bypass assemblies should be provided by the Bidder with sufficient storage volume for 5 operating cycles to increase the plant availability.

The Bidder shall provide necessary blowout tools to protect the bypass valve, when the bypass steam pipes are blown out during cleaning of the steam lines before commissioning the plant.

## 5.0.0 SPECIFIED DESIGN DATA SHEET

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| **1.0.0** | **GENERAL** | | |
| 1.1.0 | Type of steam turbine | | Straight condensing type with HP and LP steam injection |
| 1.2.0 | Maximum continuous rating of steam turbine (MCR) | MW | Power generation corresponding to the maximum possible steam generation in the HRSG |
| 1.3.0 | Operation mode | - | Throttle governing in combination with sliding pressure |
| 1.4.0 | Performance test | | As per IEC 953 / DIN 1943 |
| 1.5.0 | Speed | rpm | 3000 |
| 1.6.0 | Type of governor | | Electro-hydraulic |
| 1.7.0 | Bearing vibration at all conditions | | As per ISO 10816 |
| 1.8.0 | Shaft vibration at all conditions | | As per ISO 7919 |
| **2.0.0** | **OIL SYSTEM** | | |
| 2.1.0 | Maintenance oil Tank | | One set of clean and dirty maintenance oil tank to facilitate maintenance and cleaning of unit main oil tank and system. |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| 2.2.0 | Capacity of Maintenance oil Tank | | 120% of total lube oil quantity in lubrication oil system |
| **3.0.0** | **CONDENSER** | | |
| 3.1.0 | Type | | Double pass water cooled, surface Condenser, Axial turbine exhaust |
| 3.2.0 | Design code | | HEI |
| 3.3.0 | Location | | Indoor |
| 3.4.0 | Design margin on heat load at TG VWO,0% make up, Design Cooling water Inlet Temperature | % | 5% |
| 3.5.0 | Tube plug in margin | % | 10% |
| 3.6.0 | Hotwell storage capacity (Between normal level to low level) | | 3 minutes storage of total design condensate flow of turbine MCR |
| 3.7.0 | Hotwell water level | | Very high water level in condenser shall be at least 150 mm lower than the tip of longest blade of low-pressure turbine. Turbine shall be tripped on very high water level. |
| 3.8.0 | Maximum oxygen content at the outlet of hot-well / CST. | ppb | 10 |
| 3.9.0 | **Material of Construction** | | |
| 3.9.1 | Tubes & Tube sheet cladding | | SA 249 TP316 |
| 3.9.2 | Shell | | Carbon steel |
| 3.9.3 | Hotwell | | Carbon steel |
| **4.0.0** | **AIR EVACUATION EQUIPMENT** | | |
| | **VACUUM PUMP** | | |
| 4.1.0 | Number of pumps | Nos. | Two (1 w+ 1 s) |
| 4.2.0 | Duty | | Continuous |
| 4.3.0 | Vapour to be handled | | Mixture of air, steam and non-condensable gases |
| 4.4.0 | Design capacity and margin on capacity | | As per HEI |
| 4.5.0 | Source of sealing water | | Condensate |
| 4.6.0 | Type of coupling | | Flexible coupling |
| 4.7.0 | Vibration | | As per ISO 10816, ISO 7919 |
| 4.8.0 | Material of construction | | |
| 4.8.1 | Casing / End plate | | Cast iron |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| 4.8.2 | Impeller | | CF8M |
| 4.8.3 | Shaft | | ASTM A 473 type 316 |
| 4.8.4 | Heat Exchanger | | |
| 4.8.5 | Shell | | CS to ASTM 285 Gr. C |
| 4.8.6 | Tubes | | SS |
| 4.8.7 | Tube sheet | | SS |
| **5.0.0** | **STEAM JET AIR EJECTOR** | | |
| 5.1.1 | Hogging ejector | | |
| 5.1.2 | Type | | Single-stage, steam jet with silencer |
| 5.1.3 | Capacity | | As per latest edition of HEI |
| | Start-up time down to 225 mm Hg | | 30 minutes (maximum) |
| 5.1.4 | Main (running) ejector | | |
| 5.1.5 | Nos. required | | 2(1w + 1 s) |
| 5.1.6 | Capacity of main SJAE | | Shall not be less than 120 percent the capacity obtained from HEI standards. |
| 5.1.7 | Type | | Multi-stage, multi element |
| 5.1.8 | Steam strainer | | Yes |
| 5.1.9 | Diffusers | | Carbon Steel |
| 5.1.10 | Nozzle | | SS 304 |
| 5.1.11 | Inter and after cooler shell | | IS 2062 |
| 5.1.2 | Inter and after cooler tubes | | Sa 213 Gr TP304 |
| 5.1.3 | Tube sheet | | SS 304 |
| | | | |
| **6.0.0** | **CONDENSATE EXTRACTION PUMPS (CEPs)** | | |
| 6.1.0 | Type | | Vertical can type. |
| 6.2.0 | Number of pumps | Nos. | Two, 2(1w + 1s) |
| 6.3.0 | Design code | | HIS |
| 6.4.0 | Design basis for pump rated flow | | (110% of condensate flow at 100% steam turbine MCR or flow requirement for 105% HP/LP turbine bypass)+ flow requirement for gland seal de-superheater and exhaust hood spray + make-up water flow + any other flow. |
| 6.5.0 | Design basis for pump rated head | | 125% of deaerating feed water heater operating pressure at TG VWO, A 10% margin on pressure drop at TG VWO or HP/LP by-pass operation, Pump shall be capable of meeting the actual requirement during an under frequency operation of 47.5Hz. |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| 6.6.0 | NPSH required | | NPSH required at 3% head drop condition shall be well below NPSH available during all conditions of operation and Not greater than 50% of minimum NPSH available under steady state conditions at design point of the pump. |
| 6.7.0 | **Material of construction** | | |
| 6.7.1 | Suction bell, Bowl or casing, Discharge casing | | Cast steel |
| 6.7.2 | Discharge elbow, Column pipe | | Carbon Steel |
| 6.7.3 | Diffuser & guide vanes, cannister | | Carbon steel |
| 6.7.4 | Impeller | | Stainless steel |
| 6.7.5 | Shaft sleeves | | 13% chrome steel |
| 6.7.6 | Pump shaft | | 13% Forged chrome steel |
| 6.7.7 | Suction strainer | | Stainless steel |
| 6.8.0 | Condenser water box isolation valves | | |
| 6.8.1 | Type | | Motorised Butterfly valve |
| 6.8.2 | Material | | Rubber lined body with duplex steel internals. |

NOTE:

EPC Contractor shall submit STG Package description, data sheet, list of drawings, mechanical interface table, characteristic / performance curves, testing commissioning & Start-up procedure, performance guarantee, Auxiliary power consumption continuous & Intermittent / standby load list, special tools & tackles, specialised testing equipment, mandatory spares, Inspection & Test procedures, Quality Assurance plan, Operation & Maintenance (O& M) manual, etc.

# VOLUME – III

# SECTION - 2

# DETAILED TECHNICAL SPECIFICATION – MECHANICAL

# SUB-SECTION - 2.4

# FUEL SYSTEM

# VOLUME - III

# SUB-SECTION - 2.4

# FUEL SYSTEM

## 1.0.0 GENERAL

This section is intended to provide the scope, design, constructional and functional requirements for fuel system.

## 2.0.0 SCOPE OF SUPPLY

**2.1.0** Valve station at the existing Natural Gas supply header, Gas conditioning skid in proposed power plant area, Fuel Gas dew point Heater, Pressure reducing valve station, Gas metering for GT # 4, condensate collection tank, inert gas purging and venting of natural gas from skids and pipes at the time of GT is shut down / not in operation, cathodic protection, gas detection in skid area, etc.

**2.2.0** Natural gas distribution from Gas Conditioning Skid (GCS) area towards proposed Gas Turbine (GT # 4), HRSG # 4 and existing one GT area.

**2.3.0 Natural Gas System**

The Fuel Gas System to be supplied for the plant shall include, but not limited to, the following:

- Emergency Shut Down (ESD) valves complete with manual isolation valves, 100% capacity by-pass valve and de-pressurisation arrangement at Gas tie-in point.
- Fuel gas metering (tariff metering) station with flow computer.
- Gas Conditioning Skid (GCS) with Scrubber (multi cyclone) and filter-separators with redundant equipment to facilitate maintenance.
- 1 x 100% natural gas heater (by steam).
- Fuel gas dew point heater complete with all accessories.
- Fuel gas pressure reducing station complete with control valves, isolation valves, slam shut-off valves, relief valves, check valves, instruments.
- 2 x 100% capacity GT area final filters.
- GT fuel gas metering station with flow computer.
- Emergency Shut Down (ESD) valve complete with manual isolation valves & de-pressurisation arrangement at GT inlet.
- Gas condensate tank for Gas conditioning skids and fine filters.

- 2 x 100% Condensate Pump with motor for condensate tank.
- Vent system complete with piping and cold vent stack.
- Inert Gas System complete with permanent piping system for purging of Natural gas pipeline & skid during GT shut down.
- Piping and valves with support; spring hangers; root valves for tapping points; valves and piping for drains and vents; flow meters; strainers; filters and isolation flanges, cathodic protection, etc.
- Silencers and sound insulation if required.
- Impressed current cathodic protection and monitoring system for buried external coated piping, tanks, etc.
- All necessary Control & monitoring instruments for safe & efficient operation.
- Fuel Gas Leak Detection System including alarm facility at indoor area.
- *Sample point provision for collecting fuel gas for analysis shall be made in the fuel gas line.*

**3.0.0 DESIGN REQUIREMENTS**

**3.1.0** All skids equipment's shall be designed considering corrosion allowance and capacity to supply to GT # 4, HRSG # 4 and existing one GT under full load.

**3.2.0** The valves used on natural gas pipelines, Gas Conditioning Skid shall be fire safe.

**3.3.0 Natural Gas System**

**3.3.1 General**

Natural gas supply header is there at ONGC, Hazira plant and EPC vendor shall extend the fuel pipeline up to the proposed power plant as per route shown in Hook – up drawing. Hot tapping shall be done for Natural Gas interface on the existing NG supply header. The Bidder shall provide, isolation valve, ESV, tariff gas metering station at point of gas supply, gas conditioning to the acceptable limit of GT on the boundary of the power plant, Gas dew point heater, the necessary pressure regulation, final filter at GT and all other systems as per the scope of supply specified in this section.

Fuel supply and conditioning system shall be designed to meet the statutory requirements and relevant Indian Standards for hazardous area and all subsequent amendments / revision of these Standards. Further Bidder shall also carry out a HAZOP study / Risk assessment study for the fuel gas system and shall obtain necessary approval from the Owner/Owner's representative. The recommendation of the study shall be incorporated in the plant.

The fuel gas supply system shall be so designed that the gas turbines can start, generate up to full load and shutdown gas as required by GT operation. The fuel gas supply and conditioning system shall be sized such that the maximum fuel gas demand of the GT operating continuously at maximum load is met along with the gas requirement of 1 no. existing gas turbine and HRSG.

Design of fuel gas system shall be as per the provisions of the latest version of relevant ANSI Standards or equivalent. The complete system shall be designed as per the requirement for Hazardous area classification and as per NFPA 70 / API / IS / EU standards.

The gas condensate from the drain tanks shall be transferred to the existing slop oil tank through using sump pumps located in the drain tank.

All vents and safety relief valve discharge lines from the system shall be collected and disposed off in the gas condensate tank. The gas collected in the tank shall be vented out to the atmosphere at a safe height through a flame arrestor.
An inert gas system shall be sized adequately for purging of all fuel gas system equipment and distribution piping.

All the equipment shall be fitted with isolating valves to permit repair and maintenance without interrupting the gas supply. All gas vessel nozzles shall be flanged.

Vents shall be fitted with flame arrestor.

All the control valves shall be of tight shut-off type & leakage rating as per ANSI B 16.104 class VI.

**HAZOP Study**

The Contractor shall conduct and document a full HAZOP study of the design. The Contractor shall make available all appropriate personnel to participate in the study.

The Contractor shall arrange, organise and facilitate HAZOP studies once the preliminary designs (including P&IDs, PFDs and SLDs) for all systems are complete. The Contractor shall undertake a structured formal review at early stage of design of the plant with respect to layout, external hazards, operational access etc. Such studies shall be independently facilitated. The Owner/Owner's representative reserves the right to participate in the HAZOP study.

These studies shall examine the design of the Facility and determine whether the design during operation, including abnormal modes of Facility operation, complies with this Specification. Drawings and documents for HAZOP shall be issued to the Owner/Owner's representative no later than six weeks prior to the date of the HAZOP.

The scope of the studies shall also include the configuration of the control system and the provision of adequate safeguards to permit unmanned operation. Changes as a result of the HAZOP studies shall be at no cost to the Owner/Owner's representative.

The results of this review shall be documented and a copy provided to the Owner/Owner's representative.

### 3.3.2 Emergency Shut-Down Valves

The emergency shutdown (ESD) valve capable of being operated either from the control room or locally shall be provided at the gas tie-in point. A key switch shall be provided for selecting the local or remote operation.

Opening of the valve shall only be executed locally by hand.. For resetting a compensating line shall be installed across the ESD valves for pressure balance. The compensating line shall be provided with a block ball valve.

The emergency shutdown valves shall not be associated with any interlocks and shall be de-energized to be open if operated by a solenoid valve. Loss of instrument air for the actuation of emergency shutdown valves should not close the valves.

At the ESD valve, depressurizing valves shall be provided, which shall open automatically on closure of ESD valve by way of an interlock to allow safe system isolation in the event of a fire.

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Since this valve is for depressurizing any loss of air / power to actuator should not change the status of the valve.

Interlocks shall be provided to prevent the depressurizing valve from opening before the ESD valve is closed.

The depressurizing valve shall be sized in accordance with the requirements of API RP 521.

At the GT inlet, 1 x 100% ESD valve with emergency venting arrangement shall be provided. The ESD and the vent valves shall be actuated on signal through Gas Turbine controls.

### 3.3.3 Gas Conditioning Skids

The Gas conditioning Skid (GCS) equipments provided shall be capable of removing solid and liquid contaminants from the gas fuel to achieve the required quality and of supplying the required quantity of gas at the required dry and clean conditions. The equipment shall be selected based on the expected quality of gas and based on the quality of gas required by the GT.

The system shall be designed for a minimum dust loading of 100 g per million $Nm^3$/day (assumed) of gas throughput and occasional liquid slugs of up to 20 litres.

Gas conditioning skid shall be provided with Scrubber (Multi cyclone type) and filter separator to remove free / entrained liquid and particulate matters in the influent natural gas before admitting to pressure reducing station. Gas scrubber shall remove 100 per cent of solid and liquid particles 8 microns over the range of gas supply temperature and pressures when handling all specified types of fuel gases supply system. Standby equipment shall be provided to facilitate maintenance. The gas stream shall be sized to cater to the maximum fuel gas demand of proposed power block along with that of existing 1 no. gas turbine & HRSG. Corrosion allowance shall be determined based on the gas supply conditions, with a minimum allowance of 5 mm provided for the vessel and a minimum of 3.2 mm allowance provided for piping connected to the separator vessel. Gas conditioning scrubber skid station shall be provided with isolating valves, vents and drains and shall be designed to allow changeover to the standby unit whilst on load under GT operation.

The filter can be inertial type, cyclone type, filter /separator type or a combination of these types. The heavy particles including liquid particles shall be removed and re-carrying of liquid droplets shall be avoided. The filter elements shall be replaceable, suitable for the specified gases and meet the necessary requirements for protection of the gas turbine units. The minimum efficiency of the gas filter under normal operation shall be 100 per cent of all solid particles 3 microns and larger and 99 per cent of particles from 0.5 to 3 microns, when handling all specified types of gases. The bottom of the filter sump shall be equipped with valves and pipe work leading to a condensate tank such that accumulated fluids & contaminants may be drained off on a regular basis. The equipment shall have quick opening covers for easy replacement of elements. Gas conditioning filter & separator on skid at GCS station shall be provided with isolating valves, vents and drains and shall be designed to allow changeover to the standby unit whilst on load under GT smooth operation.

The equipment shall be fitted with drain valves, a lockable vent valve connection leading to the vent system, a pressure safety valve and a vessel purge connection. Equipment inlet and outlet, changeover valves shall be pneumatically operated.

All safety vents shall be connected to separate stack and all other vents shall be connected to separate stack with flame arrestors.

Gas condensate shall be drained from the scrubbers / filters / separators to the gas condensate tank through drain pipes with slope via. automatic valves initiated by level equipment. High and low

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level instruments shall also be provided to visible & audible alarm with display in Central Control Room (CCR).

There shall be Natural Gas heater and the gas shall be heated by steam with bypass system. Heating of the filtered gas shall be provided to ensure that the gas is maintained at a temperature above its dew point to prevent the possibility of freezing during pressure reduction at valves. One (1) no. (1w) heater of 100 % capacity horizontal steam type heater and a bypass system for fuel gas heating service provided with sensing temperature of Natural Gas forwarded to GT to condition the Gas temperature with in required limits and purge facilities. Heater system offered by the EPC Contractor shall be suitable for the hazardous area classification for its location. The bidder shall provide details of the proposed fuel gas dew point heating system by steam along with the Tender.

All pressure vessels shall be designed in accordance to ASME Section VIII Div. 1 with latest amendments and welding shall conform to ASME Section IX for welding as well as for welder's qualifications. The weld joints shall be 100 % examined by appropriate non-destructive technique.

### 3.3.4 Pressure Reducing Station

The fuel gas pressure reducing station shall consist of 2 x 100% gas pressure reducing control valves. The capacity of pressure reducing control valve shall match the gas requirement as mentioned in Cl. 3.3.1 of this section .The shut off valve shall be pneumatically operated with fail safe position.

Necessary fuel gas pre-heating system (dew point heaters) shall be provided upstream of the pressure reducing station to compensate for the temperature drop due to expansion in the pressure reducing station and ensure that no icing or condensate formation occurs in the system.

The temperature of the gas delivered to the gas turbine shall be at least 20 $^{0}$C higher than hydrate forming temperature or gas dew point whichever is higher.

Pressure reducing control valves shall be of an approved type and shall be perfectly stable, quiet and free from vibration in operation when operating at any flow up to the maximum flow and shall be suitable for continuous use at the operating pressure and temperature. The operation of the pressure control station shall be automatic over its complete flow and pressure range. Upon failure of a duty reducing valve or stream, the standby reducing valve or stream as appropriate, shall automatically commence operation in a bump less manner for continuous smooth & stable operation of Gas based combined cycle power plant.

### 3.3.5 GT final filter

These filter / separators shall have two sections. The first section shall be a coalescing section and the second a separator section. The condensate collected in the first section shall be routed to the condensate collection tank through a separate solenoid operated drain valve. Also the condensate collected in the second section shall be routed to the condensate collection tank through a separate solenoid operated drain valve. The tank shall be designed as a pressure vessel and shall have a blow off line on top equipped with two ball valves connected to vent stack with flame arrestors, a safety relief valve with block ball valve and a purge line connection with block ball valve and NRV. The blow off and the safety valve discharge shall be connected.

### 3.3.6 Flow Metering

A complete integrating gas flow metering system with bypass shall be provided at tie-in point as well as for GT. The flow meters shall not be used for control of any plant operations. The flow meters shall be capable of accurately measuring the gas flows with (±) 1% accuracy in the whole range from minimum to maximum gas flow rates. The bypass line shall be equipped with double block

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valves with center bleed valve to verify that the block valves are holding. The bypass valves shall have provisions to lock the valves closed.

The function of flow metering is to measure and record the total gas quantity used by the power plant as well as the unit consumption. Gas line metering shall have independent pressure and temperature measuring tapping used for converting gas quantity from actual pressure to standard pressure and temperature quantity.

The flow meters shall be provided with isolating valves and a full flow bypass to facilitate maintenance.

Flow transmitters shall be provided to transmit the flow signal to the DCS to be displayed on the VDU's in the CCR.

The flow meter shall be of turbine type with necessary inspection facility. The turbine type flow meter shall be with pressure & temperature compensator (w.r.t. compressibility factor) for total Gas consumption in DCS for the operational GT and HRSG.

## 4.0.0 CONSTRUCTION REQUIREMENTS

### 4.1.0 Pressure Vessels

All pressure vessels shall be designed in accordance with ASME Boiler and Pressure Vessel, Section VIII Unfired Pressure Vessels. All weld joints shall be subject to 100% radiography test. Minimum corrosion allowance shall be taken 5.0 mm for pressure vessels. The pressure vessels shall be provided with safety valves.

### 4.2.0 Layout Considerations

A safe and proper layout conforming to the codes shall be developed considering the hazard involved and safety of personnel. The hazard area classification shall be in line with applicable code and statutory requirements. Approval for the layout of Fuel Gas supply system and piping shall be obtained from Chief Controller of Explosives (CCOE), Nagpur. In general, the layout shall comply with requirements of the Indian Petroleum Act & Oil Industry Safety Directorate (OISD).

All equipment for the gas conditioning station shall be installed outdoors. A gas detection system shall be provided for indoor equipment. All equipment shall be selected to suit the hazard area zone. All outdoor equipment shall be suitable for outdoor service.

The fence shall be provided with two lockable gates suitably located. Proper lighting shall be installed inside the fenced area. Fire fighting equipment shall be installed as per code requirements.

### 4.3.0 Pipework and Valves

All the gas pipes shall be designed, constructed and tested in accordance with BS or ANSI B31.1 or ANSI B31.8 Gas Transmission and Distribution Piping System, as appropriate.

Within buildings and / or enclosures, only one flanged joint shall be permitted at each user point.

All isolating valves shall be ball type with double block and bleed function. These valves shall be "fire safe" in accordance with API - 607 or BS-5146 and of anti-static design in accordance with BS-5351.

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The shut off valves in the vent line from the safety valves shall be locked open by an approved master key system.

### 4.4.0 Purging and Testing

An inert gas / Nitrogen gas purging system shall be provided for the complete fuel gas system when the GT is not operational. Inert gas / nitrogen purge system along with the continuous supply as required shall be provided to purge equipment and piping so that direct contact between fuel gas and air is minimized, which otherwise might cause unexpected explosion or any abnormal fire due to gas/air mixing. Sufficient permanent valve connections and vents shall be provided to permit the gas system to be purged with inert gas, the location and quantity shall be in accordance with the start-up, shutdown and maintenance procedure requirements. However, section-wise system isolation and purging shall be possible without the need of systems shutdown (e.g. filter, heater, ESD maintenance). NRV's shall be installed on the inert gas lines. For lengthy fuel gas piping line, Inert Gas / $N_2$ purge shall be made part by part by dividing the fuel gas conveying system into various sections. Suitable valve connections shall be provided at all necessary points in the system to allow Inert Gas / Nitrogen purging to take place in case of emergency. One hose connection of minimum 7 m length with arrangement for quick connection for each battery shall be supplied.

### 5.0.0 SPECIFIED DESIGN DATA SHEET

| Sl. No. | Description | Unit | Data | |
|---|---|---|---|---|
| **1.0.0** | **Fuel Gas Supply System** | | | |
| 1.1.0 | Location of tie-in | | At one point in power plant expansion area. | |
| 1.2.0 | Gas Terminal pressure / temperature | | 33 to 56 kg/cm$^2$ (g) at 35 $^0$C | |
| 1.3.0 | Gas fuel design flow rate | kg/s | To suit plant max. power output plus gas requirement of 1 (one) no. existing gas turbine and HRSG | |
| **2.0.0** | **Emergency Shutdown Valve(ESV-1)** | | | |
| 2.1.0 | Location | | Upstream of Gas Conditioning Skid | |
| 2.2.0 | Material of construction | | Carbon steel | |
| **3.0.0** | **Gas Conditioning Skid (GCS)** | | **Scrubber (Multi Cyclone)** | **Cartridge Filter & separator** |
| 3.1.0 | Numbers | | 1 x 100% | 2 x 100% |
| 3.2.0 | Rated Capacity | kg/s | To suit plant max. power output | To suit plant max. power output |
| 3.3.0 | Internals | | SS Demister/ Cyclones | Hollow tubes of Glass fibre |
| 3.4.0 | Construction code | | ASME Sec.III,Div. I | ASME Sec.VIII, Div. I |
| 3.5.0 | Material of construction (Shell, Head) | | ASTM A 106 Gr. B | ASTM A 106 Gr. B |
| **4.0.0** | **Condensate collection tank** | | Gas conditioning skid area | |
| 4.1.0 | Type | | Horizontal, Atmospheric | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| 4.2.0 | Fluid | | Natural gas condensate |
| 4.3.0 | Construction code | | ASME Sec.VIII, Div. I |
| 4.4.0 | Material of construction (Shell, Head) | | ASTM A 106 Gr. B |
| **5.0.0** | **GT Final Filter** | | |
| 5.1.0 | Flow rate | kg/s | Max GT demand at worst compressor inlet conditions. |
| 5.2.0 | Internals | | Fibre Glass Cartridge / AISI 316 Vanes |
| 5.3.0 | Droplet removal efficiency | % | To suit GT requirement |
| 5.4.0 | Dust removal efficiency | | To suit GT requirement |
| 5.5.0 | Construction code | | ASME Sec. VIII, Div. I |
| 5.6.0 | Material of construction(Shell, Head) | | ASTM A 106 Gr. B |
| **6.0.0** | **Condensate collection tank for GCS skid & GT Final Filters skid area** | | |
| 6.1.0 | Type | | Horizontal |
| 6.2.0 | Fluid | | Natural gas condensate |
| 6.3.0 | Design Pressure | | Bidder to decide based on Gas blow by condition from final filters and vapour pressure of condensate. |
| 6.4.0 | Type of head | | 2:1 Ellipsoidal |
| 6.5.0 | Safety devices | | Pressure / Vacuum Relief Valve shall be provided. |
| 6.6.0 | Construction code | | ASME Sec.VIII, Div. I |
| 6.7.0 | Material of construction(Shell, Head) | | ASTM A 106 Gr. B |
| 7.0.0 | **Emergency shutdown valve (ESV-2)** | | |
| 7.1.0 | Material of construction | | Stainless steel |

NOTE:

EPC Contractor shall submit Flow scheme, Fuel system design criteria calculations with Package description, data sheet, list of drawings, testing procedure, performance guarantee, mandatory spares, Inspection & Test procedures, Quality Assurance plan, Operation & Maintenance (O& M) manual, etc.

# VOLUME – III

# SECTION - 2

# DETAILED TECHNICAL SPECIFICATION – MECHANICAL

# SUB-SECTION - 2.5

# CONDENSER & AUXILIARY COOLING WATER SYSTEM

**VOLUME - III**

**SUB-SECTION - 2.5**

**CONDENSER AND AUXILIARY COOLING WATER SYSTEM**


| CLAUSE NO. | DESCRIPTION | SHEET NO. |
|---|---|---|
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| 2.0.0 | SCOPE OF SUPPLY | 185 |
| 3.0.0 | DESIGN REQUIREMENTS | 189 |
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VOLUME **- III**

**SUB-SECTION - 2.5**

**CONDENSER & AUXILIARY COOLING WATER SYSTEM**

## 1.0.0 GENERAL

This section is intended to provide within the scope which includes design, constructional and functional requirements for Condenser & Auxiliary cooling water system.

The bidders are requested to note that only the major equipment are mentioned below. Any other equipment / system not specifically mentioned below but mentioned elsewhere in the specifications and any other equipment / system essential for smooth and efficient functioning of the system shall be considered in the scope of the bidder at no extra cost.

This section covers the technical aspects of design, manufacture, testing at works and transportation to site, supervision of erection, testing and commissioning of Condenser and Auxiliary Cooling Water system. .

Supply and services shall be rendered in conformity with proven design principles, taking into account the current technology. The requirements of the contract must be fulfilled in its entirety.

The supply and services shall be rendered inclusive of all appliances and interconnecting arrangements with other supplies needed for proper and reliable continuous operation and for satisfactory maintenance and repair.

## 2.0.0 SCOPE OF SUPPLY

The CCW & ACW system shall essentially consist of the following. Each Block shall include the following auxiliaries (unless otherwise stated specifically).

- One Mechanical Induced Draft Cooling Tower along with necessary accessories.
- Three Circulating water Pumps for supplying condenser cooling with self cleaning strainers
- Two ACW pumps and self cleaning strainers.
- Cooling water and auxiliary cooling water piping along with necessary valves, rubber expansion joints, fittings for completion of the system.
- Sluice gates, coarse screens.
- Handling arrangement for Screens.
- Handling arrangement CCW / ACW Pumps.

### 2.1.0 Cooling Tower

A cooling tower shall essentially consist of the following:

- Multi-cell RCC counter flow Induced draft cooling tower with all equipment & accessories necessary for safe, suitable and efficient operation, along with spare cell.
- Suitable facility to handle fans, drive shafts, gearboxes, associated motors and other equipment at and above the fan deck level and lower them to ground level.
- Over flow and sludge removal (Sludge pumps).
- Vibration limit switch with alarm & trip provision for fans with all the switch contacts wired to a junction box located at ground level.
- Level switch for gear box oil sump.

- Material of construction for all the items shall be selected considering the corrosion effect.

### 2.2.0 Cold Water Basin and CCW channel

- RCC basin portioned into compartments with supporting structures and foundations.
- Cooling tower basin outlet channel to CCW forebay.
- Sluice gates and coarse screens of material stainless steel shall be provided.
- Over flow and sludge removal (Sludge pumps)
- Cold water channel
- The water distribution system, basin and cold water discharge channel shall be designed in such a way that it can handle 120% of rated water flow without any overflow in basin and hot water distribution system.
- The CCW forebay shall be designed as per the guide lines of BHRA/HIS standards.
- The CCW forebay shall be sized to ensure that all pumps get uniform flow of water without causing any disturbance like vortices, swirls etc. which may affect satisfactory function of the pumping system.
- The coarse screen shall be designed for 50% choking condition.
- The velocity of CT outflow should be restricted to 1.2 m/s for design of the channel from the minimum water level of the channel.

### 2.3.0 CCW /ACW Pumps and auxiliaries

This consists of the following:-

### 2.3.1 CCW pumps

- Three, 3(2w + 1s), 50% capacity CCW pumps.
- Three, 3(2w + 1s) strainers at pump suction.
- Three, 3(2w + 1s) NRVs at CCW pump discharge.
- Motor operated Butterfly Valves at CCW pumps discharge/Condenser Inlet and exit.
- Rubber Expansion Joint at each CCW pump suction.
- Drive motors along with base plate, coupling, coupling guard etc. for the equipment.
- Vibration monitoring system.

### 2.3.2 Cranes & Hoist

- One hoisting arrangement shall be provided in the CCW pump area for handling the CCW / ACW pumps, motors, etc. during maintenance.

### 2.3.3 Auxiliary cooling water pumps

Auxiliary cooling water pump shall be provided in the CCW pump house area.

- Two, 2(1w+1s), 100 % capacity ACW pumps.
- Two, 2(1w+1s) strainers at pump suction.
- Two, 2(1w +1s) NRVs at ACW pump discharge.
- Motor operated Butterfly Valves at ACW pumps discharge.
- Rubber Expansion Joint at each ACW pump suction.
- Drive motors along with base plate, coupling, coupling guard etc. for the equipment.
- Vibration monitoring system.

### 2.4.0 CCW chemical treatment system

- Hypochlorite dosing including regular as well as shot dosing shall be provided in the CCW system.
- In addition to above dosing, suitable provision for biocide / polymer dispersant dosing systems shall also be provided for control the growth of bacteria, fungi and algae in the system.
- Also scale cum corrosion inhibitor shall be provided for avoiding scale and corrosion.
- Necessary corrosion racks and deposit monitors to monitor the water characteristic will be installed.
- Biofilms are used to measure the presence of bio organisms in water.
- 2 x 50 % Side Stream Filters (SSF) to be provided along with filter back wash water storage tank with filter back wash pumps. SSF backwash water shall be collected in the waste water collection pit from where it shall be pumped to the existing OWS system network. Entire piping from waste water collection pit upto existing OWS network shall be in bidder scope.

### 2.5.0 CCW Make-up and CCW Blow down system

CCW make-up shall be through CT make up pump which shall take suction from filtered water storage tank of suitable capacity. The COC in CCW system shall be maintained as 5 with proper blow down in the system. CCW blow down line shall be from the Cold water side at the discharge of the CCW pump. CCW blow down shall be connected to the existing OWS network. It is bidders responsibility to check the adequacy of the existing system i.e. bidder shall check weather existing OWS network can take the additional flow load of the proposed CCPP cooling tower blow down. After connecting the CCW blow down line to existing OWS network, there shall not be any flooding or overflow shall happen in the OWS network.

### 2.6.0 Piping, valves and Fittings

- CCW and ACW pipes shall be Steel pipe conforming to IS-3589 with “Pipecoat ” or equivalent coatings externally applied on buried / underground (u/g) pipes. These pipes shall be factory made and spiral welded.
- ACW pipes of size less than 150 to 600 NB shall be of IS 1239 & above 600 NB of IS 3589.
- Cooling water piping shall be designed for both above ground and buried in ground.
- Holiday test shall be conducted for the pipe coat materials.
- The main CCW pipe headers run below ground. Buried pipe shall be designed considering both internal pressure and external pressure. Buried pipe thickness shall be designed as per AWWA M11 standard for Steel pipes. Designs with external stiffeners welded to the main CCW buried pipe headers are not acceptable. All large diameter buried pipe headers shall be spiral welded pipes with coating material.
- The internal pressure is mainly due to hydrostatic pressure while external loads are those caused by external soil pressure and surface (live) loads.
- The above ground pipes shall be designed based on internal fluid pressure and full vacuum condition during trip condition.

- All piping systems shall be capable of withstanding the maximum pressure in the corresponding lines at the relevant temperatures.
- All piping systems shall be properly designed to take care of hydraulic shocks and pressure surges which may arise in the system during operation. Bidder should provide necessary protective arrangement like anchor blocks / anchor bolts, etc. for the safeguard of the piping systems under above mentioned conditions.
- External and internal attachments to piping shall be designed so as not to cause flattening of pipes, excessive localized bending stresses or harmful thermal gradients in pipe walls.
- Piping and fillings shall be manufactured by an approved firm of repute. They should be truly cylindrical of clear internal diameter specified, of uniform thickness, smooth and strong, free from dents, cracks and holes and other defects. They shall allow ready cutting, chipping or drilling, welding etc.
- For complete CCW system, bidder shall carry out a detailed hydraulic transient / surge analysis by method of characteristics using a approved software.
- Head loss in valves and fittings like elbows, tees, manholes, expansion bellow etc shall be calculated using by Hazen William's formula.
- L/D ratio or K –factor for the fittings shall be referred from Crane Handbook on flow of fluids.
- For calculating the pump head, at least 10% margin shall be taken over the pipe friction losses.
- Minimum corrosion allowance of 3.2 mm shall be provided for all buried underground pipes.
- Cathodic protection system shall be provided for CCW pipes complete with an anode array, a cathodic protection rectifier, control equipment and devices necessary to maintain constant metal-to-electrolyte potential and facilities as required to monitor system performance.
- The number and size of air release valves shall be based on the transient analysis study.
- Mitre bends shall not be accepted for pipes of 350 NB and below. For sizes above 350 NB the mitre, bends shall conform to BS: 534. The bend radius shall be used for all pipes 1.5 times the nominal pipe diameter.
- The material of construction for the valves, rubber expansion bellows, fittings provided shall be subjected to Owner/Owner's representative's approval.
- All necessary interconnecting piping, pipe fittings, valves, rubber expansion joints etc. as per requirement for the system along with pipe supports.
- All valves located at elevations shall be provided with operating platform with access ladder / chain sprocket arrangement.
- Manholes shall be provided at every 150 m distance in CCW buried pipeline with suitable access for maintenance.

## 3.0.0 DESIGN REQUIREMENTS

### 3.1.0 CCW & ACW system

The Condenser Cooling Water System shall be designed to meet the cooling water requirement of steam turbine condenser. The Auxiliary Cooling Water (ACW) system cools the STG/GTG/BOP auxiliaries directly The CCW system shall be closed circuit re-circulating type with Mechanical Induced Draught Cooling Tower. The hot water return from Condenser and Auxiliary cooling water system shall be cooled in the cooling tower.

The Condenser Cooling Water Pumps shall be sized to meet the cooling water requirement of steam turbine, condenser, Plant auxiliaries and CCW treatment.

The delivery head of the pump shall be selected suitably considering static head, frictional drop in the entire CCW system with sufficient margin.

The cooling tower shall be designed to meet the requirement of CCW & ACW systems. The design atmospheric wet bulb temperature shall be as per specified data sheet .The Bidder shall add necessary recirculation allowance to the design ambient wet bulb temperature to arrive at the tower inlet wet bulb temperature to be used for design.

CCW Make-up water is required to compensate for the evaporation and drift loss in the cooling tower and blow down from the CCW system.

The motor rating of the Cooling tower fan shall be at least 125% of the fan power requirement and base of the motor shall be corrosion resistance material.

The pumping system shall be designed, manufactured, tested and supplied strictly in accordance with Hydraulic Institute Standard (HIS).

Material of construction for all the items shall be selected considering the corrosion effect.

### 3.1.1 CCW Studies

a) CCW Sump Model Studies

The sump design for the pump house shall be based on BHRA / HIS. CFD analysis and the physical sump model hydraulic studies shall be conducted to achieve streamlined flow for CCW Pumps.

b) CCW Transient Analysis

The hydraulic transient analysis shall be carried out for complete CCW system by method of characteristics for various possible starts / stop / trip eventualities of CCW pumps to avoid pressure surges in the system.

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## 4.0.0 CONSTRUCTION REQUIREMENTS

### 4.1.0 Cooling Towers

The RCC cooling tower is required to cool continuously, throughout the year, all the hot water returning from the main condenser and auxiliary cooling equipment.

The cold water from the tower basin outlet channel will flow by gravity to the cooling water and pumps forebay by RCC channel.

Each cell shall be identified and so designed that each one of them could be operated independently of the rest of the other cells and can also be repaired / maintained and cleaned while other cells are in service.

A suitable sump shall be provided in the basin to facilitate draining of the basin with the use of a permanent dewatering pump.

Fill shall be of film type fills, supported on RCC beams. Recycled PVC shall not be used for the fill material. PVC shall be made fire resistant by suitable treatment. Material of construction for all the items shall be selected considering the corrosion effect.

The basin shall be below or above ground and shall have sufficient holding capacity of 6 min flow to Cooling tower. A minimum of 300 mm free board shall be provided in the basin. The basin shall be divided into compartments by providing concrete partition wall designed for pressure on one side only. Maximum, minimum and normal operating water levels in the basin shall be clearly indicated in the data sheets.

RCC staircase at both the ends of the cooling tower from ground level to fan deck shall be provided.

### 4.2.0 CCW / ACW Pumps

- The CCW / ACW pumps shall be of horizontal centrifugal type.
- The pump shall be supplied with complete design, with all equipment and accessories necessary for safe, efficient and reliable operation.
- The pumps shall be supplied with all necessary items but not limited to below items for Horizontal centrifugal pump:
  - Pump casing.
  - Impeller.
  - Casing and Impeller wearing ring.
  - Direct drive high voltage constant speed motor and thrust bearing.
  - Coupling between pump and motor.
  - Foundation ring/soleplates and holding down bolts.
  - Bearings lubricant, sealing and cooling systems.
  - Shaft and shaft sleeves.
  - Bearings.
  - Motor along with coupling and coupling guards.
  - Counter flanges with bolts, nuts and gaskets at pump discharge.
- All local instruments and any integrated controls and associated necessary electrical wiring.

- Rubber expansion joints shall be installed at the outlet of pumps.
- Air release valves at each pump discharge.
- Manholes at buried pipe header in supply & return line.
- Vibrating monitoring & reverse rotation monitoring system.
- One Lifting arrangement of adequate capacity to lift the motor/pump in the pump area.
- The pumps shall be designed for 40% to 120% of rated flow for sustained period of operation.
- The noise level shall not exceed 85 dBA overall sound pressure level reference 0.0002 microbar (the standard pressure reference for air sound measurement) at a distance of 1 m from the equipment surface.
- Bidder shall confirm that the NPSH requirements are satisfied and pump shall be capable of sustained running in a trouble free manner at any water level between the minimum and maximum water level in the Cooling tower forebay.
- The maximum efficiency point of the pumps shall preferably lie within 10% of the rated design flow.
- The design shall ensure equal load sharing among the pumps operating in parallel. These pumps shall be identical to one another, shall have identical characteristic curves and shall be capable of running in parallel continuously without any problems. Components of such pumps shall be interchangeable.
- The pump shall operate satisfactorily in isolation and in parallel with other working pumps without cavitations, any deleterious effects, undue vibrations and noise at all water levels, from minimum to maximum.
- Water for motor cooling and bearing cooling, if required, shall be tapped from the discharge of the pumps. All piping, valves, strainer, instruments etc. required for this purpose shall be provided by the Contractor.
- Pump speed shall be based on the suction specific speed available.
- The pump suction bell diameter shall be such as to limit the flow velocity as per relevant HIS standard.
- Suitable arrangement shall be provided to take care of the discharge hydraulic thrust due to an untied expansion joint.
- The vibration limits shall be designed as per ISO – 2372, VDI 2056, BS 4675 Class -II.
- Design life (minimum) of equipment supplied by contractor shall be 25 years.
- The shaft shall be designed such that the complete pump and motor assembly satisfies the following: The operating speed shall not be too close to the first critical speed. i. e. N should be less than 0.8 NC1 or N should be more than 1.3 NC1 Where N is the Operating Speed and NC1 First Critical speed.

- The design, construction and speed of the pumps shall be such as to minimize cavitations and ensure a long and trouble free service.
- The sump model study (Physical as well as CFD analysis) shall be conducted for CCW system to ensure adequate and smooth flow of water to all pumps.
- CCW sump shall be adequately sized for ensuring minimum requirement for pump and other clearance as per BHRA / HIS norms.
- Material of construction for all the items shall be selected considering the corrosion effect.
- Model test shall be conducted as per Japanese standard JIS-B-8327 or any equivalent International Standard. Proto type test shall be conducted at manufacture site in presence of the Owner/Owner's representative & the test shall include the cavitations test & Net positive suction head required.
- Necessary valves, rubber expansion bellows, air release valves, manholes at pump discharge side, necessary instruments for monitoring the flow, pressure, temperature and counter flanges shall be provided along with the pump.

## 5.0.0 SPECIFIED DESIGN DATA SHEET

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| **1.0.0** | **COOLING TOWER** | | |
| 1.1.0 | No. of Cooling Towers | No. | One (1) |
| 1.2.0 | No of cells | | Three, 3(2w + 1s) |
| 1.30 | Type tower | | Induced draft, counter flow type |
| 1.4.0 | Tower Capacity | Cum/hr | 5200 |
| 1.5.0 | Design ambient wet bulb temperature | °C | 29.5 |
| 1.6.0 | Design inlet WBT | °C | Bidder to specify |
| 1.7.0 | Wind Velocity | | As per IS 875, Part - 3 |
| 1.8.0 | Drift eliminators<br>Drift loss | | Required<br>Not to exceed 0.005 % of circulating flow |
| 1.9.0 | Type of fill | | Film type |
| 1.10.0 | Liquid Handled | | Clarified water |
| 1.11.0 | **Material of construction** | | |
| 1.11.1 | Fill | | PVC |
| 1.11.2 | Fill support | | RCC |
| 1.11.3 | Drift Eliminator | | PVC UV Stabilised |
| 1.11.4 | Water distribution nozzles | | Polypropylene |
| 1.11.5 | Water distribution system | | PVC / FRP / GRP |
| 1.11.6 | Tower casing / Tower basin | | Cast – in situ concrete/RCC |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| 1.11.7 | Fan Stack | | GRP / RCC |
| 1.11.8 | Fan blades | | FRP / GRP |
| 1.11.9 | Fan hub | | MS HDG |
| 1.11.10 | Fan drive shaft | | Carbon Fibre / SS 304 |
| 1.11.11 | Sluice gate | | CI |
| 1.11.12 | Coarse screens | | MS HDG with SS mesh |
| 1.11.13 | Codes and standards | | CTI code- standard III: BS 4485 |
| 1.11.14 | Operation of CT fans | | Through plant DCS |
| 1.11.15 | Gear box oil level, Vibration and fan ON/OFF indications | | To be provided in plant DCS<br>Oil level – Low alarm<br>Vibration – High ( alarm) & high - high (trip) |
| **2.0.0** | **CONDENSER COOLING WATER PUMPS** | | **CCWP** |
| 2.1.0 | Type of pumps | | Horizontal |
| 2.2.0 | No. of pumps | nos. | Three, 3(2w+1s) |
| 2.3.0 | Pump capacity | Cum/hr | 2100 |
| 2.4.0 | Total Dynamic Head | mwc | 25 (Tentative) (Exact value to be calculated by Bidder) |
| 2.5.0 | Location | | Indoor |
| 2.6.0 | Type of line bearing lubrication | | Self |
| 2.7.0 | Liquid for lubrication | | Pumped liquid |
| 2.8.0 | Prime mover | | Direct with AC Electric motor |
| 2.9.0 | **Material of Construction** | | |
| 2.9.1 | Casing | | CI : IS- 210- FG 260 |
| 2.9.2 | Impeller | | CF8M |
| 2.9.3 | Shaft | | Forged Steel |
| 2.9.4 | Casing wearing rings | | ASTM A 273 Gr. 410 |
| 2.9.5 | Impeller wear rings | | Bronze IS:318 Gr LTB2 |
| 2.9.6 | Shaft sleeve | | ASTM A 276 Gr. 316 |
| 2.9.7 | Lantern ring (If applicable) | | CI : IS 210-FG 260 |
| 2.9.8 | Gland Packing | | Graphite asbestos |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| | | | |
| 2.9.9 | Counter flange | | Carbon Steel IS –2062 |
| 2.9.10 | Base plate | | Carbon Steel IS – 2062 |
| 2.9.11 | Bearing make | | SKF / FAG |
| 2.9.12 | Body | | CI to IS 210 FG 260 |
| 2.9.13 | Working Parts | | SS 304 |
| **3.0.0** | **RUBBER EXPANSION JOINTS** | | |
| 3.1.0 | Designation | | CCW / ACW Pump suction |
| 3.2.0 | Fluid handled | | Filtered water |
| 3.3.0 | Hydro test pressure | | 1.5 times of design pressure |
| 3.4.0 | Vacuum test | mm of Hg | 700 |
| 3.5.0 | **Material of construction** | | |
| 3.5.1 | Bellow / body | | High grade abrasion resistant EPDM / Neoprene rubber |
| 3.5.2 | Tie Rod/ Limit Rod/ Control Rod | | Carbon steel (Galvanised) |
| 3.5.3 | Stretcher Plate | | IS 2062 Gr A (Galvanised) |
| 3.5.4 | Metal Reinforcements | | SS Steel annular rings |
| 3.5.5 | Retaining Ring segments | | Min 10 mm thick split ring MS (Galvanised) |
| 3.5.6 | Counter Flange | | IS 2062 Gr A |
| 3.5.7 | Hardwares | | IS 1367 CL. 4.6 |
| **4.0.0** | **BUTTERFLY VALVES** | | |
| 4.1.0 | Hand wheel required | | Yes |
| 4.2.0 | Location | | Indoor / Out door |
| 4.3.0 | Face to face dimension | mm | As per AWWA C504 / BS 5155 |
| 4.4.0 | Actuator for BF valves | | To be suitable for step operation |
| 4.5.0 | **Material of construction** | | |
| 4.5.1 | Body | | IS : 2062 Gr. B / ASTM-A- 216 WCB |
| 4.5.2 | Disc | | IS : 2062 Gr. B / ASTM-A- 216 WCB |
| 4.5.3 | Shaft | | AISI 410 |
| 4.5.4 | Companion flanges | | IS : 2062 Gr. B / ASTM-A- 216 WCB |
| 4.5.5 | Internal hardware | | SS |
| 4.5.6 | External hardware | | IS : 1367 Gr. B8 / Gr. 8 |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| **5.0.0** | **AUXILIARY COOLING WATER PUMPS** | | **ACWP** |
| 5.1.0 | Type of pumps | | Horizontal |
| 5.2.0 | No. of pumps | nos. | Two, 2(1w+1s) |
| 5.3.0 | Delivery rate | Cum/hr | 1000 |
| 5.4.0 | Delivery head | mwc | 35 (Tentative) (Exact value to be calculated by Bidder) |
| 5.5.0 | Location | | Indoor |
| 5.6.0 | Type of line bearing lubrication | | Self |
| 5.7.0 | Liquid for lubrication | | Pumped liquid |
| 5.8.0 | Prime mover | | Direct with AC Electric motor |
| 5.9.0 | **Material of Construction** | | |
| 5.9.1 | Casing | | CI : IS- 210- FG 260 |
| 5.9.2 | Impeller | | CF8M |
| 5.9.3 | Shaft | | Forged Steel |
| 5.9.4 | Casing wearing rings | | ASTM A 273 Gr. 410 |
| 5.9.5 | Impeller wear rings | | Bronze IS:318 Gr LTB2 |
| 5.9.6 | Shaft sleeve | | ASTM A 276 Gr. 316 |
| 5.9.7 | Lantern ring (If applicable) | | CI : IS 210-FG 260 |
| 5.9.8 | Gland Packing | | Graphite asbestos |
| 5.9.9 | Counter flange | | Carbon Steel IS –2062 |
| 5.9.10 | Base plate | | Carbon Steel IS – 2062 |
| 5.9.11 | Bearing make | | SKF / FAG |
| 5.9.12 | Body | | CI to IS 210 FG 260 |
| | | | |
| **6.0.0** | **Side Stream Filter** | | |
| 6.1.0 | Vessel design standard | | IS 2825 |
| 6.2.0 | Type | | Vertical filter. |
| 6.3.0 | No. of units | | 2 x 50% |
| 6.4.0 | Material of Construction | | MS with epoxy paint |
| 6.5.0 | Gross capacity | $M^3$/hr | 3 % of Circulation rate |
| 6.6.0 | Design pressure | | Suitable considering the shut-off head of MGF feed pump. |
| 6.7.0 | Hydrostatic test pressure | | 1.5 times design pressure |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| 6.8.0 | Specific normal flow rate | $m^3/hr/m^2$ | 15 (max.) |
| 6.9.0 | Back wash flow rate | $m^3/hr/m^2$ | 36 (max. for MGF) |
| 6.10.0 | Filtering medium | | Sand / Gravel / Anthracite |
| 6.11.0 | Minimum bed depth | mm | 1000 |
| 6.12.0 | Minimum shell thickness | mm | 6 |
| 6.13.0 | Minimum free board | | 50 % of bed depth |
| 6.14.0 | Material of construction | | IS: 2062 |
| 6.15.0 | Thickness tolerance / allowance | | 3.2 mm corrosion allowance, 0.2 mm mill tolerance & 2 mm thinning allowance for dished end. |
| 6.16.0 | Other accessories / Instruments | | Refer control & instrumentation |
| 6.17.0 | Type of under drain and distributor system | | As per manufacturers' standard |
| 6.18.0 | Internal coating | | Epoxy painting |
| 6.19.0 | External painting | | As per painting specification. |
| | | | |
| **6.2.0** | **SSF Back wash tank** | | |
| 6.2.1 | Capacity | $m^3$ | 1 back wash water requirement. |
| 6.2.2 | MOC | | MSEP |
| 62.3 | Quantity | no. | One (1) |
| | | | |
| **6.3.0** | **SSF Backwash pumps** | | |
| **6.3.**1 | Capacity | $m^3/hr$ | Suitable |
| 6.3.2 | MOC | | CI |
| 6.3.3 | Quantity | nos. | Two, 2(1w +1s) |
| | | | |
| **6.4.0** | **SSF Backwash waste water collection pit** | | |
| 6.4.1 | Capacity | $m^3/hr$ | Suitable for handling 1 back wash water quantity |
| 6.4.2 | MOC | | RCC |
| 6.4.3 | Quantity | no. | One (1) |
| | | | |
| **6.5.0** | **SSF waste water transfer pumps** | | |
| 6.5.1 | Capacity | $m^3/hr$ | Suitable |
| 6.5.2 | MOC | | CI |
| 6.5.3 | Quantity | nos. | Two, 2(1w + 1s) |
| **7.0.0** | **COOLING TOWER CHEMICAL DOSING SYSTEM.** | | |
| | | | |
| **7.1.0** | **Sulphuric Acid Dosing system** | | |
| **7.2.0** | **Bulk acid storage tank (Cooling Tower)** | | |
| i) | Design standard | | BS:4994/IS 803 |
| ii) | Material of construction | | MS |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| iii) | Disposition | | Horizontal |
| iv) | Quantity | nos. | Two (2) |
| v) | Fluid handled | | 98% $H_2SO_4$ |
| vi) | Total capacity of tanks | $m^3$ | 12 $m^3$ or 30 days requirement whichever is high. |
| | | | |
| **7.3.0** | **$H_2SO_4$ unloading pump (Cooling Tower)** | | |
| | | | |
| i) | Type | | Centrifugal, horizontal |
| ii) | Material of construction | | |
| | i) Casing / impeller | | Poly propylene |
| | ii) Shaft | | EN 8 |
| | iii) Base plate | | MSEP |
| iii) | Fluid handled | | 98% $H_2SO_4$ |
| iv) | Quantity | | 2 x 100% (1w+1s) |
| v) | Capacity of each pump | | 10 $m^3$/hr @ 15mwc |
| vi) | Suction pressure | | Flooded |
| vii) | Shaft sealing arrangement | | Mechanical seal (Material suitable for the intended service) |
| | | | |
| **7.4.0** | **$H_2SO_4$ measuring tank (Cooling Tower)** | | |
| i) | Design standard | | IS 803 / BS 4994 |
| ii) | Material of construction | | FRP |
| iii) | Quantity | | 1 no. common for CCW flow of three cells. |
| | | | |
| iv) | Fluid handled | | 98% $H_2SO_4$ diluted to required concentration |
| v) | Capacity | | One day dosing requirement with 20% margin |
| vi) | $H_2SO_4$ Dosing Pump | | |
| vii) | Quantity | nos. | Two, 2(1w+1s) |
| viii) | Capacity of each pump | | To suit process requirement |
| ix) | Type | | Positive displacement |
| x) | Material of construction of pump head | | PP |
| | | | |
| **7.5.0** | **Bio dispersant / Biocide dosing system** | | |
| i) | Chemical Solution tank | | |
| ii) | Quantity | no. | One (1) |
| iii) | Capacity of each tank | Ltr. | To suit process requirement |
| iv) | Material of construction | - | FRP / MSRL |
| v) | Chemical Dosing Pump | | |
| vi) | Quantity | nos. | Two, 2(1w+1s) |
| vii) | Capacity of each pump | | To suit process requirement |
| viii) | Type | | Positive displacement |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| ix) | Material of construction of pump head | | PP |
| x) | Agitator for the above dosing tank | | |
| xi) | Type | | Turbine type |
| xii) | Material of construction | | |
| xiii) | Impeller / shaft | | SS-316 |
| xiv) | Mounting | | Clamped / flanged |
| xv) | Impeller type | | Propeller |
| xvi) | Transmission | | Direct coupled |
| xvii) | Quantity | no. | One (For each dosing tank) |
| | | | |
| **7.6.0** | **Scale cum corrosion inhibitor dosing system** | | |
| | | | |
| i) | Chemical Solution tank | | |
| ii) | Quantity | no. | One (1) |
| iii) | Capacity of each tank | Ltr. | To suit process requirement |
| iv) | Material of construction | - | FRP / MSRL |
| v) | Chemical Dosing Pump | | |
| vi) | Quantity | nos. | Two, 2(1w+1s) |
| vii) | Capacity of each pump | | To suit process requirement |
| viii) | Type | | Positive displacement |
| ix) | Material of construction of pump head | | PP |
| x) | Agitator for the above dosing tank | | |
| xi) | Type | | Turbine type |
| xii) | Material of construction | | |
| xiii) | Impeller / shaft | | SS-316 |
| xiv) | Mounting | | Clamped / flanged |
| xv) | Impeller type | | Propeller |
| xvi) | Transmission | | Direct coupled |
| xvii) | Quantity | no. | One (For each dosing tank) |
| | | | |
| **7.7.0** | **NaOCl dosing system** | | |
| | | | |
| i) | Chemical Solution tank | | |
| ii) | Quantity | no. | One (1) |
| iii) | Capacity of each tank | Ltr. | To suit process requirement |
| iv) | Material of construction | - | FRP |
| v) | Chemical Dosing Pump | | |
| vi) | Quantity | nos. | Two, 2(1w+1s) |
| vii) | Capacity of each pump | | To suit process requirement |
| viii) | Type | | Positive displacement |
| ix) | Material of construction of pump head | | PP |
| x) | Agitator for the above dosing tank | | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| xi) | Type | | Turbine type |
| xii) | Material of construction | | |
| xiii) | Impeller / shaft | | SS-316 |
| xiv) | Mounting | | Clamped / flanged |
| xv) | Impeller type | | Propeller |
| xvi) | Transmission | | Direct coupled |
| xvii) | Quantity | no. | One (For each dosing tank) |

NOTE:

EPC Contractor shall submit Condenser cooling water & Auxiliary cooling water Package description, data sheet, list of drawings, performance curves, testing procedure, performance guarantee, power consumption, mandatory spares, Inspection & test procedures, Quality Assurance requirement, Operation & Maintenance (O & M) manual, etc.

# VOLUME – III

# SECTION - 2

# DETAILED TECHNICAL SPECIFICATION – MECHANICAL

# SUB - SECTION - 2.6

# CRANES AND HOISTS

**VOLUME - III**

**SUB-SECTION - 2.6**

**CRANES AND HOISTS**

## 1.0.0 GENERAL

This section is intended to provide the scope, design, manufacture, erection, testing & commissioning of EOT crane and hoist requirement.

## 2.0.0 SCOPE OF SUPPLY

Electric Overhead Travelling (EOT) cranes shall be provided for ease of dismantling and maintenance of major plant equipments. The crane shall comprise a main hoist & auxiliary hoist each to be capable of lifting and accurately positioning all heavy loads within their specified rating.

Each cranes or hoists shall be complete with its accessories, supporting structure, power supply, safety devices and controls and shall conform to local statutory rules and regulation and an internationally recognised standard suitable for their intended application.

### 2.1.1 EOT cranes

The EOT crane shall be provided for the following areas,

- EOT crane in GTG and STG common hall.

### 2.1.2 Hoists

**Electrical Operated Hoists**

The hoists shall be of the motor operated type with motor trolley on monorail and shall be provided with pedant control unit.

**Manual Operated Hoists**

The manual operated hoist shall be provided with manual chain drive for hoist and trolley on monorail.

The scope of supply shall include at least:

- Under slug crane with electric hoist, motor operated CT & LT for Air compressor / Workshop building.
- Monorail with hoist for Cooling water pump area (for both pump & motor)
- Monorail with hoist for Boiler feed pumps, BFP area.
- Monorail with Hoist for A/C and Ventilation System.
- Monorail with hoist for cooling tower ( for fan gear box & motor)
- Monorail with hoist on top of the HRSG area.
- Any other hoists / chain pulley blocks as required for normal lifting operation of the system above 50 kg in weight as specified in the design requirement.

### 3.0.0 DESIGN REQUIREMENT

i) Electric Overhead Travelling (EOT) Crane shall be provided in the areas where the weight of the heaviest component exceeds 5 MT and movement of the components will be required in both cross wise and longitudinal direction.

ii) Manual Hoist with geared trolley will be provided for areas with equipment / component to be lifted for erection and maintenance weighing up to 1 MT and below and lift is less than 10 m Electrically operated Hoist with trolley will be provided for handling equipment / component weighing 1 MT or above and / or lift more than 10 m.

iii) Cranes with carrying capacity of more than 10 MT shall be in the form of double-girder cranes with the crab running on top.

iv) Smaller cranes i.e. 10 MT and below shall be in the form of single-girder cranes with the crab running on the lower flange or in the form of suspension cranes.

v) For guidance purposes the following crane speeds, for the turbine hall crane, should be considered as maximums:-

| Sl. No. | Lifting Arrangement | **GTG / STG hall area** | |
|---|---|---|---|
| A | EOT | **Main** | **Auxiliary** |
| 1 | Hoisting | 2.0 | 5.0 m/min |
| 2 | Trolley Travel | 15.0 m/min | 15.0 m/min |
| 3 | Bridge Travel | 10.0 m/min | 10.0m/min |
| 4 | Creep speeds | 10% of operating speeds | 10% of operating speeds |

vi) Speeds for the hoists shall be

Hoisting speed 3 m/min.

Travel speed 4 m/min.

vi) The workshop and stores buildings shall be provided with a suitably sized pendant operated overhead travelling cranes.

### 4.0.0 CONSTRUCTION REQUIREMENTS

### 4.1.0 EOT Crane

The span of EOT cranes shall be derived based on the GTG & STG hall layout with considerations to clearances and hook approach. The lift for the EOT crane shall be based on lifting the tallest piece from the operating floor to grade, with consideration of sufficient clearances for lifting over other equipment on operating equipment. Capacity shall be fixed by considering the heaviest equipment during maintenance with 10% margin. EOT capacity shall be as per heaviest equipment to be lifted and used only during maintenance but not used for erection of GTG / STG. EPC contractor shall arrange separate crane for erection of GTG / STG assembly on respective foundation during installation and alignment.

All other components of EOT crane shall be designed and provided as per IS: 3177.

Auxiliary hoist shall be rated for a minimum capacity 20% of main hoist capacity. Both the hooks will be of swivelling type.

The EOT cranes are designed to operate at 100% load and over load test at 125% of rated load as per codes. The EOT cranes shall be designed with maximum deflection of 1 / 900 of the crane span at rated load.

The crane bridges of the double-girder cranes shall be of box-girder construction.

EOT Crane in STG / GTG Hall shall be as under:

- Indoor.
- Double girder box type, class M5 for mechanical M5 for electrical.
- Pendent push button operated

Pendent push button station shall be used for the operation of the crane and push buttons shall be present for the following motions / operations.

i. To and from motion of the bridge (long travel).
ii. Right and left motion of the trolley (cross travel).
iii. Hoisting (lifting) of hooks.
iv. Lowering of hooks.
v. Creep motion.
vi. Power ON - OFF push buttons.
vii. Emergency off push button.

Indication lamp for power on-off shall be provided in the pendent push button station. pendent push button shall be provided with a lockable (with key) ON-OFF provision. The push button stations shall have an independent motion on a separate track with respect to the cross travel motion.

Load hooks for up to 30 T nominal carrying capacity shall be designed as plain shank hooks. For nominal carrying capacities above 30 T, rams horn type hooks shall be used. It is essential for all load hooks to be equipped with ball - thrust bearings & safety latch.

The turbine building EOT Cranes shall be able to be operated both from cabin located on the crane and also by radio remote operation.

Spring / rubber buffer shall be provided on the trolley and bridge structural frame at suitable places to absorb the shock of impact without transferring to the structure frame.

The cranes shall be provided with walkways (minimum 500 mm wide for turbine building EOT crane) with hand railing along the full span length on either side of crane bridge girders. Walkway shall to be provided at rail level on both sides.

The complete electrical equipment shall include:

- The lockable multi-pole mains isolator switch (main crane switch) operating on all poles, for the main power supply.
- The rising cable from the multi-pole mains isolator switch up to the feed point of the ON/OFF main power supply.
- The main contactor (crane switch) with short circuit protection and thermal protection by means of bimetallic tripping device.

- The necessary equipment to provide precision speeds (creep speed motor, and planetary gear arrangement).
- The motor protection and all the equipment necessary for the crane
- The limit switches for the travel gears, including all the necessary strikers.
- All the necessary contactors and relays as well as the necessary contactor cabinets for these.
- All cable including festooned type cables with caviel clips and miscellaneous material for the complete installation of the crane.
- The control and lighting transformer.
- Resistor panel.
- The work-area light fittings of HPSV / MV with the crane.
- The control panel pendant control with operation switches and other controls.
- Alternating current slip-ring motors, which can be started practically without jolting by means of switched series resistors, (minimum 4 steps) shall be used for the travel and lifting gear drives.

**4.2.0 Hoists**

The final number of hoists, to be supplied, shall be decided later according to the requirements of the equipment. Electrical or manual hoists are selected based on the design criteria given above.

Each hoist installation shall include but not be restricted to the following:

a) Manually operated hoists.

The load chain shall be electrically welded, accurately calibrated, and pitched arid polished conforming to IS: 6216 grade T (8).

The forged hook shall be properly heat treated and so designed that in loaded condition, it is free to swivel without twisting load chain. The hook shall conform to IS: 8610 Min. C-20 acceptable.

The hand chain shall also be electrically welded, calibrated, pitched and polished and shall conform to IS: 3832. All other components of chain pulley block such as anchorage, guide, pawl, stripper etc. shall be designed and provided as per IS: 3832.

Manual hoists shall take the form of chain pulley blocks with load and hand chains. The crabs shall be fitted with a drive also operated by a chain. The runways shall be designed according to approved standard.

b) Electrically operated hoists.

The hoists used shall be standard production hoists. The hoists shall be designed and calculated in accordance with the principles of IS: 3938 Class II, or according to accepted and equivalent standards.

The control panels shall also be equipped with a key-operated switch and a mushroom-shaped emergency “off”. Limit switches shall be fitted to all lifting and travel gear.

The technical requirements of the ropes and shackles to be provided with each hoist installation, shall be similar to the requirements as given for EOT cranes.

Electrically driven hoists and crabs (trolley) shall be equipped with squirrel cage/ slip ring motors. The crab power supplies shall be in the form of trailing cables with cable carriers running in tubular track.

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Electrical switchgear and control gear shall be mounted directly on the hoists in cabinets.

The electrical hoists shall be operated by pendant control units fitted with push-button and shall be fixed to the hoist in such a way that safe operation is guaranteed.

Where hoists are not easily accessible by simple means such as ladders or mobile scaffolds, maintenance platforms with means of access shall be provided.

The complete electrical equipment, basically including:

- The lockable mains isolator switch (main hoist switch) operating on all poles, for the main power supply.
- The rising cable from the mains connection switch up to the feed point of the main power supply.
- The main power supply arrangement vide trailing cable (feestoned cables).

## 5.0.0 SPECIFIED DESIGN DATA SHEET

### 5.1.0 EOT Crane

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| 1.0.0 | Standards | | IS 807 & IS 3177 |
| 2.0.0 | Duty Class | | M5 Mechanical, Structural<br>M7 Electrical |
| 3.0.0 | Capacity | | To lift heaviest equipment during maintenance with 10% margin for main hook |
| 4.0.0 | Wire rope | | IS 2266<br>6 x 36 or 6 x 37 multi strand construction. |
| 5.0.0 | Factor of Safety | | Min. 5.25 |
| 6.0.0 | Lifting hooks | | |
| | i. Main hoist | | Ramshorn type swivelling hook with locking device as per IS 5749 |
| | ii. Auxiliary hook | | Shank Swivelling hook with locking device as per IS 3815 / IS 8610 |
| | Brakes | | 150% rated torque |
| | - Type | | |
| | - Main Hoist | | 1 no. Electro hydraulic thrustor<br>1 no. DC Electromagnetic brake |
| | -Auxiliary Hoist | | 1 no. Electro hydraulic thrustor<br>1 no. DC Electromagnetic brake |
| | - CT | | 1 no. Electro hydraulic thrustor |
| 7.0.0 | Emergency brake for long travel | | Electro hydraulic thruster type emergency parking brake. |
| 8.0.0 | Down shop lead (DSL): | | |
| | Long travel | | Shrouded conductor |
| | Cross transverse | | Festoon cable arrangement |
| 9.0.0 | Limit switches | | Two way type |
| | Cross | | Lever type (2 nos.) |
| | Long travel | | Lever type (2 nos.) |
| | Hoisting<br>-Main<br>-Auxiliary | | Rotary gear & gravity (1+1) |

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### 5.2.0 Electric Hoist

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| 1.0.0 | Standards | | IS 3938 |
| 2.0.0 | Capacity | | To lift heaviest equipment during maintenance with 25% margin. |
| 3.0.0 | Trolley type | | Electrically operated |
| 4.0.0 | Operation | | By pendant push button |
| 5.0.0 | Factor of safety | | As per IS / Not less than 5 |
| 6.0.0 | Wire Rope | | Flexible plough steel with lubricated fibre core as per IS:2266 |
| 7.0.0 | Pendant push button | | Hoisting, lowering, power ON/OFF, emergency ON/OFF with key. |
| 8.0.0 | Motor CDF | | 40% |
| 9.0.0 | Brakes | | 150% rated torque |
| | - Type | | AC thruster brake |
| | - Hoisting | No. | 1 no. |
| 10.0.0 | Limit switch | | DC / ACEM |
| | - Hoisting | No. | 1 No. |

**General**

The manual operated chain hoist and trolley assembly shall be complete with following components with respective constructional features. Hoist & trolley capacity shall be based on maximum weight of the part to be lifted / handled after dismantling during maintenance. This maintenance hoist & trolley arrangement shall not be used for installation or erection of complete Equipment assembly. EPC contractor shall arrange separate crane for Equipment Assembly erection on respective foundation during installation and alignment.

The following maintenance hoist and trolley shall be supplied:

| Sr. No. | Description | Locations | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Boiler / HRSG area | Boiler feed pump, BFP area. | | Emergency DG area | Utility Compressor area | | Cooling Tower Fans area | Main & Auxiliary Cooling water system. | | |
| 1.0 | Hoist Capacity (SWL), T | Suitable capacity (min 5T) | Suitable capacity (min 5T) | | Suitable capacity (min 2T) | Suitable capacity (min 2T) | | Suitable capacity (min 2T) | Suitable capacity (min 2T) | | |
| 2.0 | Quantity (No.) | One | 1 | | 1 | 1 | | 1 | 1 | | |
| 3.0 | Minimum Height of Lift (Mtrs.) | Contractor to specify | Contractor to specify | | Contractor to specify | Contractor to specify | | Contractor to specify | Contractor to specify | | |

NOTE:

EPC Contractor shall submit EOT / Cranes & hoist (lifting arrangement) description, data sheet, list of drawings, testing procedure, performance guarantee, power consumption, special tools & tackles, mandatory spares, Inspection & test procedures, Quality Assurance requirement, Operation & Maintenance (O& M) manual, etc.

# VOLUME – III

# SECTION - 2

# DETAILED TECHNICAL SPECIFICATION – MECHANICAL

# SUB-SECTION - 2.7

# COMPRESSED AIR SYSTEM

. **VOLUME - III**

**SUB-SECTION - 2.7**

**COMPRESSED AIR SYSTEM**

## 1.0.0 GENERAL

This section is intended to provide the scope, design, constructional and functional requirements for Compressed Air System (CAS) to meet total instrument air (IA) and service air (SA) contingency power plant requirement when existing plant air supply is not available. This new compressor shall be standby in the proposed power plant area and shall automatically start if there is no supply of air from the existing plant area.

## 2.0.0 SCOPE OF SUPPLY

The scope of supply shall include but not limited to the following:

### 2.1.0 For Service Air and Instrument Air

a. One (1) no. oil free screw type air compressor with adequate capacity and discharge pressure of 8.5 kg/cm$^2$ (g) or more as required for offered equipments of the CCCPP in whole (at the outlet of after cooler) shall be provided.

b. Two (2) nos. air receivers of adequate capacity shall be provided along with all accessories such as pressure gauges, safety relief valves, for condensate the electronic type auto drain traps, manual isolation / blow off drain valves, pressure indicators. The air receivers shall be vertical self-supporting cylindrical vessels with four (4) supporting legs for resting on their foundation.

c. One (1) twin-vessel type 'heat-less' absorption air drier complete with:

- Duplex 100% duty pre-filters - general purpose
- Duplex 100% duty pre-filters - oil
- Duplex 100% duty post filters - dust
- Automatic desiccant regeneration and drier changeover sequence control and protection facilities
- Interconnecting pipework and valves
- One spare charge of desiccant
- One spare set of filter elements
- Instrumentation

## 3.0.0 DESIGN REQUIREMENTS

- The compressed air system shall consist of common inter connected systems for instrument grade air and service air.
- All exposed rotating parts shall be provided with guards for personnel protection.

- The set pressure of relief valve shall be 110% of the rated discharge pressure.
- The compressor & dryer shall be located in a RCC building with space provision for future compressor of similar size. Space to be allotted for workshop in the proposed compressor house for housing drilling machine & bench grinder.
- Maintenance bay of at least one compressor bay width with adequate handling facilities and rolling shutters of adequate dimensions to enable truck entry shall be provided.
- Pressure requirement shall be based on the data furnished by HRSG and STG and other vendors. Pressure drops across various items shall be included based on the layout.
- If refrigerant is used in the air dryer plant, the same shall be eco - friendly type.
- The service air receiver and instrument air receiver shall have necessary arrangement for interfacing with the existing compressed air system.

## 4.0.0 SPECIFIED DESIGN DATA SHEET

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| **1.0.0** | **AIR COMPRESSOR** | | |
| 1.1.0 | Number | | One (1) |
| 1.2.0 | Type | | Two stage, water cooled, oil free screw compressor with electric motor and all accessories like inter coolers, after coolers, oil coolers, moisture separators, intake filters, suction silencers, vibration isolators, etc. |
| 1.3.0 | Capacity | $Nm^3/h$ | Minimum 15% margin shall be considered over maximum compressed air requirement. |
| 1.4.0 | Discharge pressure | $Kg/cm^2(g)$ | 8.5 (min.) |
| 1.5.0 | Lubrication bearing | | Forced |
| 1.6.0 | Method of control | | 'Dual' control method |
| 1.7.0 | Location | | Indoor |
| 1.8.0 | Galvanization of interconnecting piping | | Yes |
| 1.9.0 | **Codes and Standards** | | |
| a) | Instrument and Service air piping | | IS 1239 / IS 3589, Heavy Class, GI |
| b) | Quality Class for Air | | ISO 8573 - 1 |
| 1.10.0 | **Test Requirement** | | |
| a) | Capacity test at shop required | | Yes |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| **2.0.0** | **INTER COOLERS / AFTER COOLERS** | | |
| 2.1.0 | Type | | Horizontal / Vertical shell and tube type with removable bundles, counter current flow. |
| 2.2.0 | Maximum acceptable outlet air temperature | | 8 $^0$C above cooling water inlet temperature |
| 2.3.0 | Allowable pressure drop of air | Kg/cm$^2$ | 0.2 |
| 2.4.0 | Corrosion allowance | mm | 3.0 (Minimum) |
| 2.5.0 | Operating pressure | | |
| | a) Air side | | Compressor discharge pressure |
| | b) Water side | | By Bidder |
| 2.6.0 | Design pressure | | 1.25 times operating pressure |
| **3.0.0** | **AIR RECEIVER** | | |
| 3.1.0 | Number | Nos. | Two, 2 (one for Service air - SA and one for Instrument air - IA) |
| 3.2.0 | Capacity | m$^3$ | Bidder to specify (Based on GTG, BTG and BOP total air requirement).<br><br>However, air receiver to be sized so that the requirement of instrument air during black start up is available. |
| 3.3.0 | Design pressure | | 1.25 times operating pressure |
| 3.4.0 | Operating pressure | | Compressor discharge pressure |
| 3.5.0 | Corrosion allowance | mm | 3.0 (Minimum) |
| 3.6.0 | Codes and Standards | | As per IS 7938 and IS 2825 |
| **4.0.0** | **AIR DRIER** | | |
| 4.1.0 | Number | | One (1) for Instrument Air - IA |
| 4.2.0 | Type | | HOC |
| 4.3.0 | Capacity | | 1.20 time instrument air capacity |
| 4.4.0 | Operating pressure | | Compressor discharge pressure |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| 4.5.0 | Design pressure | | 1.25 times operating pressure |
| 4.6.0 | Maximum allowable pr. drop | $kg/cm^2$ | 0.3 |
| 4.7.0 | Max. diff. moisture loading | % Weight | 10 |
| 4.8.0 | Outlet air dew point | | |
| 4.8.1 | At atmospheric pressure | °C | (-) 40 for HOC Type. |
| 4.8.2 | Existing instrument air | | 6.5-7.5 $kg/cm^2$<br>(-)15°C (pressure dew point) |

**NOTE**:

EPC Contractor shall submit Utility Compressor description, data sheet, list of drawings, testing procedure, performance guarantee, power consumption, special tools & tackles, mandatory spares, Inspection & Test procedures, Quality Assurance plan, Operation & Maintenance (O& M) manual, etc.

# VOLUME – III

# SECTION – 2

# DETAILED TECHNICAL SPECIFICATION - MECHANICAL

# SUB-SECTION - 2.8

# HEATING, VENTILATION & AIR CONDITIONING SYSTEM

**VOLUME - III**

**SUB-SECTION - 2.8**

**HEATING, VENTILATION & AIR CONDITIONING SYSTEM**

## 1.0.0 GENERAL

This section is intended to provide the scope, design, constructional and functional requirements for complete heating, ventilation and air-conditioning.

The bidders are requested to note that only the major equipment are mentioned below. Any other equipment / system not specifically mentioned below but mentioned elsewhere in the specifications and any other equipment / system and any interface essential for smooth and efficient functioning of the system shall be considered in the scope of the bidder at no extra cost.

## 2.0.0 SCOPE OF SUPPLY

This section sets out the scope of the installations covered by this specification as well as required supplies and services but without excluding other necessary components and services not mentioned.

The scope includes but not limited to the air conditioning system and ventilation system as mentioned in clause no 3.1.0 to 3.3.0 below.

## 3.0.0 DESIGN CRITERIA

Air conditioning and ventilation system will be designed generally as per ISHRAE / ASHRAE methodology to provide specified environmental condition for equipment and/or personnel during all modes of plant operation. Filtering, cooling, heating, humidification/dehumidification of the supply air and its distribution shall be done to maintain the specified condition within the specified limits.

### 3.1.0 Air Conditioning System

Air conditioning system shall be provided for all buildings / areas. Some of which are as specified below:

- Central Control Room in electrical building (Package AC).
- DCS & electrical panel room (Package AC).
- Shift in-charge's room (Package AC).
- UPS room (Package AC).
- Instrument lab (Package AC).
- Conference room (Split Unit).
- Relay panel room in 66KV GIS building (Split Unit).
- Office area in 66KV GIS building (Split Unit).
- Any other area requiring Air conditioning (Package AC / Split AC).

Standby units to be provided as per requirement

### 3.1.1 Water cooled package units / Split Type Air conditioning System

Independent water-cooled packaged type air conditioning units shall be used for control room and other areas as listed above in the main electrical building. Split type air conditioning unit shall be provided for the conference room and any other local control rooms in the plant.

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### 3.2.0 Ventilation System

The ventilation air quantity shall be calculated considering the heat dissipation in the area or as per the air changes per hour whichever is higher.

Following air changes shall be considered while designing the system.

| Sr. No. | Building Name | No. of Air changes per hour (ACPH) |
|---|---|---|
| 1 | T.G Hall and Cable spreader room | 10 |
| 2 | MCC / Switch Gear Room | 15 |
| 3 | General areas / DG, Compressor , Pump area | 15 |
| 4 | Battery Rooms , Toilets | 20 |

### 3.2.1 Dry pressurized ventilation

The supply and exhaust ventilation system shall be provided for the following area:

- Cable cellar in electrical building and 66KV GIS building near existing substation.
- Switchgear room in electrical building and 66KV GIS building near existing substation.
- TG Hall.
- CT MCC room.
- Compressor MCC room.
- Any other areas requiring dry pressurized ventilation.

### 3.2.2 Simple Exhaust Ventilation System

The simple exhaust ventilation system which means positive exhaust ventilation system and natural intake of ambient areas shall be provided for the following areas:

- Battery Room in electrical building and 66KV GIS building near existing substation(S/s)
- Battery rooms shall have Flame Proof , FLP fittings / enclosures.
- CT pump area.
- Compressor area.
- DG area.
- Toilets.
- Any other areas requiring exhaust ventilation system.

For battery rooms, Air intake is through louvers and exhaust by means of exhaust fans. Higher exhaust air flow rate shall be maintained within the room to maintain negative pressure. The fans shall be anti-spark construction with flame proof construction. Each battery room shall be provided with 3 x 50% capacity exhaust fans

### 3.3.0 Common equipment

- All controls, measuring and monitoring equipment, to an extent as well as additional instrumentation necessary for matching to specific designs of equipment and units.

- All equipment, ducts, pipes, controls, etc. shall be fully treated against corrosion and sealed against moisture, sand, dust ingress and proper thermal & acoustic insulation.

- Air distribution system comprising of GSS ducting, dampers, grilles etc.
- Filter with HDPE media having 18 G GSS frame. The efficiency of pre-filters shall be 90% down to 20 microns and that of fine filters shall be 99% down to 5 microns.
- Complete Electrical, Control & instrumentation and any other items / equipments which are not included above but required to make the system safe and successful running.
- All the AC equipments shall be BMS compatible so that the same can be connected to the existing BMS system.

## 4.0.0 TECHNICAL REQUIREMENTS

Each air conditioning, heating and ventilation plant shall be a self contained, functionally reliable unit, which is suitable for the appropriate building, with respect to performance and choice of system and also with respect to the special arrangement, the dimensions and the weights.

Separate plant rooms are to be provided for the air-conditioning and ventilation equipment viz. Package units etc. All equipment shall be placed in such a manner that sufficient space (as recommended by the manufacturer) is available for servicing and maintenance.

### 4.1.0 Air conditioning System

The air conditioning system shall comprise of:

- Water cooled package Units (with sufficient standby) for Central control room.
- Filtered fresh air fan in each PAC room.
- Duct mounted Heaters.
- Pan Humidifiers.
- Piping, valves & accessories.
- Air distribution system (GSS ducting, grilles & diffusers, duct mounted fine filers).
- Hi wall split units.

The make-up water for air conditioning system shall be filtered water.

Humidity shall be controlled by Electric Heaters, & pan type humidifiers through room humidistats.

The air shall be distributed via hot-dipped galvanised sheet metal ductwork, insulated and vapour sealed. Air shall be discharged into the room via supply-air diffusers adjusted at the correct volume.

About 10% more air is supplied to the space than is returned. This shall ensure that the space remains under positive pressure, thus reducing the infiltration of outside air into the conditioned space.

Return air shall be routed back via return air grilles into the space above false ceiling which shall act as a return air plenum and further via hot-dipped galvanised ducts if required.

Volume control dampers shall be provided in all branch ducts and in the main ducts from AHU to throttle the air volume.

Fire dampers shall be provided in supply air duct, return air duct, return air passage crossing wall / slab opening in order to isolate the respective AHU in the event of fire.

**4.2.0 Ventilation System**

**4.2.1 Dry pressurized ventilation**

Fresh air is supplied through wall mounted fan-filter unit comprising of axial fans, intake louvers, bird screen, short ducting and pre filters, complete with supports and hardware.

The air from the room shall be exhausted through wall mounted gravity dampers in order to provide pressurization preventing infiltration of external dust.

The exhaust from the TG hall shall be taken through roof extractor fans mounted on the roof of the building.

**4.2.2 Simple Exhaust Ventilation System**

The air from the room shall be exhausted through wall/roof mounted fan unit comprising of axial fans, cowl with bird screen and gravity dampers, complete with supports and hardware.

Fresh air shall be through wall/ door mounted intake louvers or through infiltration.

For battery rooms, Air intake is through louvers and exhaust by means of exhaust fans. Higher exhaust air flow rate shall be maintained within the room to maintain negative pressure. The fans shall be anti-spark belt-driven axial flow fan with flame proof construction. Each battery room shall be provided with 3 x 50% capacity exhaust fans.

All ductwork and equipment in contact with the battery room air shall be of plastic material or plastic-coated.

**4.3.0 General**

4.3.1 Relevant Indian/International standards such as ISHRAE, ASHRAE etc., as applicable to HVAC system and latest issues of these applicable codes and standards shall be adopted.

4.3.2 10% margin in equipment capacity over peak heat load calculated considering solar load and all internal loads due to equipment, lighting, fresh air, occupants, etc have to be considered.

4.3.3 All windows in the air-conditioned area shall be provided with light coloured venetian blind.

4.3.4 False-ceiling shall be provided in all air conditioning areas.

4.3.5 All the AC area and air handling unit room, shall be provided with insulation on the underside of the roof.

4.3.6 The ventilation system for each area shall be sized based on either air flow rate calculated considering a room temperature of 3°C (Maximum) above ambient DBT during peak summer considering all heat loads or air flow rate calculated considering minimum number of air changes / hour as mentioned above, whichever results in higher air flow rate.

4.3.7 The battery room shall be maintained at negative pressure to prevent leakage of fumes to adjacent areas of the battery rooms.

4.3.8 All equipment, ducts, pipes, controls, etc. shall be fully treated against corrosion and sealed against moisture, sand and dust ingress.

4.3.9 All plant including ducts and pipes as well as machines shall be vibration isolated or otherwise treated that:

- No excessive vibration is felt in the floors or walls of the rooms served by any machine.
- The mechanically induced vibration levels in floors, walls and ceilings of rooms are sufficiently small as to limit the radiation of sound levels to the rooms within acceptable levels.

**5.0.0 CONSTRUCTION REQUIREMENT**

**5.1.0 Water Cooled Packaged Air Conditioners**

Floor Mounted Water cooled package air conditioners comprising of multiple compressor (scroll hermetic/semi-hermitic suitable for R-134/R 407 duty), direct coupled centrifugal fan with motor, refrigerant piping, condenser unit, louvers / grilles at intake, Evaporator cooling coil & Cleanable filters with all standard accessories, supports etc.

The unit shall be single skinned, draw through recirculation type with the following sections and for handling an air quantity as specified.

a) Inlet louver / Grille section.

b) Coarse filters section.

c) DX coil section.

d) Fans section.

The unit shall be Vertical flow disposition for Water cooled Packaged air conditioners and horizontal flow for split air conditioners suitable for indoor installation exposed to normal indoor conditions.

**Support Frame and Foundation**

The condensing unit package shall have a single framework housing the compressor, condenser, receiver and mounted on a common base plate. The complete assembly shall be mounted rigidly on an isolated foundation which shall act as an inertia base. Neoprene vibration pads shall be provided under the foundation to facilitate good vibration isolation.

**Evaporator Coil**

The Evaporator coil shall be of direct expansion type and constructed with copper tube and aluminium rippled type fins mechanically bonded for maximum heat transfer. Equalizing distributor shall be provided to ensure equal amount of refrigerant to each circuit.

**Compressor**

The compressor shall be scroll type. The motor winding shall be cooled by the refrigerant gas. The compressor unit shall be mounted on vibration isolator to minimize vibration transmitted to the AC unit. Safety devices for high inlet and low outlet pressure and other standard accessories shall be

provided. It is preferable to have 2 compressor of 50% capacity in each unit with suction cut off unloader for better part load efficiency and saving in power.

**Condenser**

The condenser shall be of water cooled, fin and tube type. The fin shall be made from tested quality aluminium sheets. Integrally finned copper tube shall be expanded for leak proof joints. The condenser shall be complete with liquid line Shut off valves at the inlet and outlet, safety valves etc.

**5.2.0 Split type air conditioning unit**

Outdoor unit consisting of hermetic / semi-hermetic scroll compressor, on anti-vibration mounts, axial flow fan air cooled condenser of seamless copper with aluminium fins, design & construction. Casing of galvanised sheet metal weather proofed or stored enameled against corrosion.

Indoor unit consisting of direct expansion cooling and dehumidifying coil 3 speed forward curved DIDW centrifugal motor unit, insulated drain pan, coarse filter panel, casing of asesthectically designed ABS moulded plastic construction for direct mounting unit or galvanised sheet steel casing weather proofed or stoved enameled against corrosion in case of ductable type.

Refrigeration circuit with R-407 / R134A refrigerant filling, refrigerant drier, thermostatic expansion valves unit control panel barrier all control interlocks, power supply contactor etc.

**5.3.0 Fresh Air filter**

Inlet filters shall be dry type Filter media shall be HDPE reinforced with galvanized wire-mesh in 3 plies. The pre-filter section shall comprise of 50 mm thick washable filter panel suitably arranged in holding steel frame. The filter efficiency shall be 90% down to 10 microns. The face velocity shall be within 2.5 m/s. pressure drop during clogged condition shall not be more than 10 mmWC.

Along with pre-filter, fine filters shall be provided for fans provided in PAC rooms. The fine filter shall have a minimum efficiency of 99% down to 5 microns size.

**5.4.0 Pan type Humidifier**

Electric humidifier, shall be pan type steam humidifier. The humidifier shall consist of stainless steel basin insulated on outside with 25 mm resin bonded fiber glass thermal insulation of 25 kg/ cm. density covered with 20 SWG GI sheet on outside.

**5.5.0 Centrifugal Fans:**

Centrifugal fans for Ventilation System shall be DIDW/SISW non-overloading type designed. Fan shall be driven with V-belt by a totally enclosed motor and the fan outlet velocity shall not exceed 10 m/sec.

Impeller shall be die formed aerofoil or laminar type of self cleaning and non-overloading characteristics. The impeller shall be statically and dynamically balanced according to ISO standard.

The fan casing shall be of welded construction and provided with flanges on inlet & outlet side for duct connection.

The fan impeller & casing etc. shall be protected by a suitable corrosion resistant.

Accessories like common base frame, anchor bolts, vibration isolators, V-belt guard, inlet guard and outlet damper, canvas etc., shall be provided. Centrifugal fans and drive motors mounted on common base frame to be mounted on spring type vibration isolators to prevent vibration transfer to floors as well as to the downstream side of duct.

### 5.6.0 Roof Extractors

Power roof extractor's impeller shall be of axial type. Casing shall be made of MS and impeller shall be made of aluminium. Hood of the roof ventilator shall be of hinged type providing easy access to motor and impeller. Mounting frame for mounting the roof ventilators shall be provided. Weather proof lockable type disconnect switch shall be provided such that, the hood can be opened only when the disconnect switch is in "OFF" position.

### 5.7.0 Axial Flow Fan

Directly driven axial flow fans with die cast aluminium impeller dynamically balanced, fitted with three-phase induction motor.

The fan casing shall be of galvanized steel material. Fan shall be provided with rain protection hood (for roof exhausted) / inlet cowl, filters (supply air fans), bird-screen, back-draft damper, (where necessary) grouting frame and cadmium plated fixing bolts.

For battery rooms, the wall mounted axial flow fan shall be of FRP coated cast aluminium impeller with blades of aerofoil design. The fan motor shall be externally mounted (outside the air path) on a bracket fixed to the casing with necessary V-belt drive.

### 5.8.0 Flame proof belt driven axial flow fans for battery room

The wall mounted axial flow fan shall be of FRP coated cast aluminium impeller with blades of aerofoil design. The fan motor shall be externally mounted (outside the air path) on a bracket fixed to the casing with necessary V-belt drive. Necessary rain protection exhaust cowls and bird protection screens shall be provided. Motors shall explosion proof, three phase induction motor.

### 5.9.0 Air Distribution System

#### a) Ductwork

All duct work inclusive of accessories such as damper, vanes, access doors, etc. shall be manufactured form hot-dip galvanized sheet metal, complying with IS-277 Gr. 200 or better.

All ductwork support ties to the structure shall be made resilient with the use of 12mm thick non-intercellular neoprene strip, gaskets or washers. All ductwork connections to air handling equipment shall be made via 15 cm long connections of rubber impregnated canvass material.

The following air velocities shall be considered for air conditioning. However, standard sizes of equipment and accessories shall be adopted satisfying the following limiting conditions.

| | | |
|---|---|---|
| Louvers for air inlet | : | 2 m/sec (max.) |
| Main Ducts | : | shall not exceed 7 m/sec. |
| Branch Duct | : | 6 (max.) m/sec. |
| Air supply grills | : | 3 (max.) m/sec. |

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**b) Hangers & Supports for Ductwork**

All ductwork shall be provided with adequate hangers or supports to ensure rigid support and to prevent vibration. Spacing of duct supports shall not exceed 2 m centres.

Hangers shall be suspended from the building steel with provision for necessary auxiliaries, or special steel members, or by hook fixed to the embedded plates provided in the ceiling.

Hangers for all ducts shall be trapeze type with the shelf constructed from 35mm x 35mm x 5mm angle iron and hung by two steel rods each of not less than 10mm dia. for ducts, with larger side less than 2250 mm while for those greater than 2250 mm shall be with 50 x 50 x 5 angles and rods not less than 15 mm dia.

All hangers and supports shall be as per drawings/ specifications. When vertical ducts pass through floor slab, they shall be supported by means of collars, constructed of steel duct and fastened to the floor slab with a filler or bitumastic compound between the horizontal leg of the supporting angle and the floor.

**c) Supply and Exhaust Air Grilles / Diffusers**

Design of grilles and diffusers shall be such as to create desired throw and spread of air All supply air diffusers shall be made up of MS powder coated / powder coated extruded aluminium of suitable colour. Design of all diffusers and grilles shall be made by the contractor matching with the lighting and other fittings and to be approved by the Purchaser.

Each supply air diffusers shall be fitted with opposed blade damper, built-in vanes and louvers arranged as per manufacturer's standard design. maximum diffuser neck velocities shall not exceed 4 m/s and maximum noise levels within 2 m of the outlet shall not exceed ASHRAE noise criterion curve NC 40.

Side throw type supply air grilles with corresponding diffuser material shall have two sets of adjustable louvers with an opposed blades dampers. The front louvers shall be horizontal deflection and the rear set of vertical louvers shall adjust vertical deflection. The dampers shall be horizontal opposed blades, regulated by an operating lever in the frame.

All wall type exhaust/return air grilles shall have one set of louvers in the front. The louvers shall be fitted such as to remain in position by friction grip.

The grille frame and louvers shall be manufactured of at least 20 SWG sheet end 22 SWG M.S. respectively.

No grilles should by any chance make any rattling sound during continuous operation. All grilles shall match the decor of the space.

All grilles / diffusers shall be fitted with suitable gasket to prevent air leakage.

**d) Fire Dampers**

Motorized fire dampers will be provided in Supply Air (SA) ducting and fusible type fire damper will be provided in Return Air (RA) ducting. Such fire dampers will be to be suitably interlocked with fire detection facilities provided in control room actuated by the duct/ room mounted smoke detectors. The fire damper will have fire rating of 120 min.

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**e) Isolating Dampers**

Isolating/Volume Control Dampers shall be provided based on the ducting layout configuration. Damper blades shall be multi blade type minimum 16 SWG thick with operation friendly, adjustable form the outside by a lever and positioning device.

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**f) Weather Louvers**

Weather louvers shall be of hot-dipped galvanized angle-iron frame with built-in rain-rejecting galvanised iron or aluminium lamellas as well as bird protection screen of galvanized iron, Mounting frame of galvanized profile steel.

**5.10.0 Thermal Insulation**

The entire supply / return air ducting shall be thermally insulated with 40 mm thick fibre glass of 32 kg/cu.m.

Any portion of duct running outside the building shall be insulated with 40 mm thick fibre glass of 32 kg/cu.m. and weather proof 12 mm sand cement plaster.

Refrigerant piping (suction line), drain pan and drain piping of PAC shall be thermally insulated with Expanded Polystyrene (TF quality).

**5.11.0 Acoustic Insulation**

The supply air ducting from each AHU outlet up to 5 meters shall be acoustically insulated with 12 mm thick resin bonded fibre glass wool of density 48 kg/cu.m covered with 30 G perforated aluminium sheets.

## 6.0.0 SPECIFIED DESIGN DATA SHEET

### 6.1.1 Air-conditioning system

| Space | Dry Bulb Temp. $^0$C | Relative Humidity | Minimum Fresh Air Changes per hour | Remarks |
|---|---|---|---|---|
| - Main Control Room, Shift in charge, engineer's room, Maintenance engineer's room, UPS room, Shift engineer's room, Instrument lab, office area etc and any other area | 24± 1 | 50 ± 5% | 35 $m^3$/hr per person (or) 1 | DX type Air conditioning system |
| - CW pump area control room<br>- Compressor control room<br>- Conference room at electrical building,<br>- Relay panel room and office area in 66KV GIS building<br>- Any other area | 24 ± 1 | 50 ± 5% | 35 $m^3$/hr per person (or) 1 | Split AC |

### 6.1.2 Ventilation System

| Space | Dry Bulb Temp. $^0$C | Design pressure | Minimum Fresh Air Charges per hour | Remarks |
|---|---|---|---|---|
| - Cable Spreader Room | Outdoor DBT + $3^0$C max | 3 mmWC over pressurisation | 10 | Dry pressurized ventilation with supply air fans and exhaust gravity louvers |
| - Switchgear room | Outdoor DBT + $3^0$C max | 3 mmWC over pressurisation | 15 | Dry pressurized ventilation with supply air fans and exhaust gravity louvers |
| - TG Hall | Outdoor DBT + $3^0$C max | 3 mmWC over pressurisation | 10 | Dry pressurized ventilation with supply air fans and exhaust through roof extractor |
| - CT MCC room/ compressor MCC room / any other MCC room | Outdoor DBT + $3^0$C max | 3 mmWC over pressurisation | 15 | Dry pressurized ventilation with supply air fans and exhaust gravity louvers |
| - Battery Room/Compressor | - | - | 20 | exhaust ventilation |

| Space | Dry Bulb Temp. $^0$C | Design pressure | Minimum Fresh Air Charges per hour | Remarks |
|---|---|---|---|---|
| room / Toilets | | | | |
| - Pantry / stores / any other area requiring exhaust ventilation | - | - | 15 | exhaust ventilation |
| - CT pump house / any other pump house | - | - | 15 | exhaust ventilation |

**NOTE:**

EPC Contractor shall submit HVAC design basis, data sheet, list of drawings, testing procedure, performance guarantee, power consumption, mandatory spares, Inspection & Test procedures, Quality Assurance requirement, Operation & Maintenance (O& M) manual, etc.

# VOLUME – III

# SECTION - 2

# DETAILED TECHNICAL SPECIFICATION - MECHANICAL

## SUB-SECTION - 2.9

## FIRE PROTECTION SYSTEM

**VOLUME - III**

**SUB-SECTION - 2.9**

**FIRE PROTECTION SYSTEM**

## 1.0.0 GENERAL

This section is intended to provide the scope, design, constructional and functional requirements for Fire Protection System.

The Bidders are requested to note that only the major equipment are mentioned below. Any other equipment / system not specifically mentioned below but mentioned elsewhere in the specifications and any other equipment / system and any interface essential for smooth and efficient functioning of the system shall be considered in the scope of the Bidder at no extra cost.

## 2.0.0 SCOPE OF SUPPLY

The scope of supply shall include, but not limited to, the following:

- External and internal fire hydrant system for entire power plant area.
- Automatic high velocity water spray system for all oil filled transformers of rating 10 MVA and above, GTG & STG lube oil tanks and coolers,
- Appropriate fire detection and protection system for fuel systems.
- Automatic medium velocity water spray system for cable spreader rooms in electrical building as well as 66KV GIS building
- Replacement of Deluge valve, if required for the existing transformers in the substation near the existing switchyard area. Addition of deluge valves for new transformer for existing GTG-3 and cable cellar at 66 KV GIS building. Bidder to check the requirement of additional tap off point along with the location and feasibility.
- $CO_2$ system for GT enclosures, GT PCC room and GT fuel gas skid (in GTG vendor scope).
- Control rooms , Switch gear rooms shall have clean agent system for fire protection system.
- Fire detection and alarm system for the complete plant. The proposed fire alarm panels to be hooked up with the existing fire alarm system. Refer relevant control & instrumentation specifications.
- Clean agent fire suppression system for control rooms.
- Online weigh system for fire suppression gas cylinders so that loss of gas causes an alarm.
- Portable and mobile fire extinguishers for all the buildings in the power plant premises.

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- Fire resistant doors and fire seal walls shall be provided as per code requirements.
- All necessary instruction and warning plates.
- Bidder shall obtain all necessary clearances from authorized approving agency through Insurance Company or directly for getting the design and the installation approved. Any changes or additional requirements specified by TAC / approving agency shall be carried out by the Bidder.

## 3.0.0 DESIGN REQUIREMENTS

The design of the fire protection system shall generally be in line with the TAC (Tariff Advisory Committee) recommendations, which are to be followed to obtain maximum rebate on Insurance Premiums from Insurance Companies. However specific designs may be as per relevant NFPA codes (National Fire Protection Association) and OISD standards. The fire-protection system shall be of proven reliability and complete in every respect.

All equipment, special purpose fittings, couplings or accessories shall be approved and certified for use in fire fighting system application by TAC / UL / FM.

The fire protection system shall be designed to satisfy the following:

(i) To provide facilities for fighting all types of fires that can occur in the plant.

(ii) To equip the plant for fighting atleast two simultaneous fires.

(iii) To meet the basic minimum requirements of TAC / LPA.

(iv) To meet the basic requirements for approval by Chief Controller of Explosives (CCOE).

The complete fire protection system shall comprise of the following:

i) Fire hydrant system (External and Internal).

ii) Automatic & manual fire detection & alarm system.

iii) Fixed Water spray system (high velocity and medium velocity).

iv) Gas suppression system for central control room area.

v) Portable fire extinguishers.

## 3.1.0 Fire Water System

The fire hydrant system shall be extension of the existing fire fighting system. Tap off points at two locations shall be provided from the existing system at suitable pressure required for the new system. Bidder to check the isolation and if it is not possible hot tapping shall be considered. The locations of the tap off points are tentative and Bidder to check and confirm the same as per site conditions. The requirement of booster pumps if needed shall be checked by the Bidder.

## 3.2.0 Fire Hydrant System

The hydrant system shall consist of a network of piping which shall feed pressurised water to a number of hydrant valves located outdoor as well as indoor and to a number of outdoor type fixed water monitors.

The piping shall be of medium grade Carbon steel as per IS:1239 and IS:3589 and shall be above ground piping laid 300 to 400 mm above finished ground level. The piping shall be laid on independent pedestals. However the piping shall be laid underground for road crossings and places where it can obstruct operation and vehicle movement and get damaged mechanically. The underground piping shall be heavy grade piping and protected with wrapping and coating.

External hydrants shall be located all around the periphery of the buildings and outdoor equipment & storage areas. Outdoor type fixed water monitors shall be provided for locations where water cannot reach from hydrant hose reel.

The hydrants shall be spaced at 45 m intervals as per OISD 116 section 5.7.1 The location of hydrants shall be decided as per TAC and OISD 116. Hydrants shall be installed with branch connections and not directly over main header.

Within buildings, the internal hydrants shall be arranged in all staircases and hallways in such a manner that all rooms can be reached with the hose-pipe lengths connected to the wall hydrants, and so that escape is possible along the hose route to the building exit.

All the internal and external hydrants shall be double headed hydrants.

The network shall be designed to provide sufficient quantities of water at all points of the External areas and inside building area in the event of fire with sufficient pressure for take-off by means of directly connecting fire hoses. The pressure maintained at the most remote hydrant point in the power plant area shall be minimum 7 Kg/cm$^2$ as per OISD 116 section 5.3.

Hose boxes/ hose houses complete with fire hoses Instantaneous couplings, branch pipe, nozzle, and accessories as per TAC shall be provided.

### 3.3.0 Fixed Water Spray Systems

This system shall be provided as a local fire protection for equipment/ areas identified as fire risk as per TAC and the system shall be supplied with water spray system. The system shall consist of spray water line, deluge valves, isolation valves, Y-type strainers, spray nozzles/projectors, spray nozzles piping network, detection system, instrumentation, junction boxes, control cables etc.

**High Velocity Water Spray (HVWS) system**

High velocity water spray (HVWS) system shall be provided, GTG & STG lube oil tanks and coolers, and all oil filled transformer of rating 10 MVA and above or for transformers whose oil capacity more than 2000 ltrs.

HVWS system automatically shall detect, control and extinguish any out- break of fire and simultaneously give audible alarm. A pipe network fitted with quartzoid bulb detectors shall be provided around each equipment/area to be protected.

This pipe network shall be kept pressurized by water tapped from the upstream side of a deluge valve provided at the riser of fire water ring main network.

The down stream of the deluge valve is kept dry and shall be connected to a pipe network having strategically located spray nozzles around the equipment/area. In case of fire, the quartzoid bulbs shall break thereby releasing the pressure in the detector network. This shall hydraulically open the deluge valve thus allowing water to be sprayed on to the equipment/area through projector nozzles in the form of a solid conical emulsifying spray. Local audible alarm shall be produced by water motor gong.

The system shall be hydraulically so designed that the pressure at the hydraulically most remote nozzle in the network is not less than 3.5 bars in case of an Outdoor Transformer and 2.8 bars in case of an Indoor Transformer. However, the maximum pressure in any nozzle within a network shall not exceed 5 bars. The velocity in the feed pipes shall not exceed 10M/second. The spray water density shall be 10.2 lpm/$m^{2.}$

The deluge system piping shall normally be empty. When a heat detection circuit reaches a preset temperature limit, the fire alarm panel shall automatically operate a solenoid to open the normally closed deluge valve to admit water into the deluge system piping. The deluge valve shall also be capable of manual actuation. Water will then discharge from all spray nozzles in the deluge system.

**Medium Velocity Water Spray (MVWS) system**

The Medium velocity water spray system shall be provided for the protection of Cable cellar in Electrical building and 66KV GIS building.

The medium velocity spray system (MVWS) shall consist of a network of open spray nozzles fitted with a special deflector to give required angle of discharge for the water around the area to be provided. The sprayers shall discharge a cone of water spray consisting of medium size droplets of water. The water supply to the MVWS system shall be controlled by a deluge valve, which shall operate hydraulically on release of water pressure.

In order to avoid total flooding of the entire area the area to be protected by MVWS system shall be divided into number of zones. Each zone shall have separate water supply network controlled by a deluge valve.

Each zone shall be so designed that the pressure at the hydraulically most un-favourable nozzle is not less than 1.4 bars and that at the most favourable nozzle is not more than 3.5 bars and that the velocity in distribution pipes shall not exceed 5 m/s .The spray water density shall be 12.2 lpm/$m^2$ for cable cellar.

A fire detection system provided for the MVWS protected area shall sense fire and shall actuate the deluge valve. In the event of fire in one zone, the deluge valve of corresponding zone and those of adjacent zones on either side shall be opened.

The fixed water spray system protects, automatically and instantaneously, major and essential equipment/ areas against fire hazards. Being stationary, it's arrangement shall depends primarily on the arrangement and disposition of the equipment to be protected.

The design and construction of the spray water system shall be as per TAC rules for Water Spray Systems.

For the high velocity water spray system wet pilot rings mounted with quartzoid bulbs for detection and dry water spray rings shall be provided after the deluge valve with alarm gong and including all accessories. For medium velocity water spray systems, the activation of deluge valve shall be electrical through fire signal from fire sensing devices such as smoke detectors, heat detectors, linear heat sensing cables, gas detectors.

The spray systems shall be designed for an automatic operation. Manual and Remote operation of the system shall also be possible.

### 3.4.0 Portable and Mobile Fire-Extinguishing Equipment

All buildings, plant areas and appropriate special rooms, ducts, channels. are to be protected by portable and/or mobile fire extinguishers as per TAC requirements.

Following types of fire extinguishers shall be installed at strategic locations in all the buildings/ areas within the plant boundary as per TAC requirement:

- Pressurised water type of 9 lit. capacity conforming to IS: 940 (operated by air and not by carbon dioxide cartridge type).
- Carbon dioxide type of 5 kg / 4.5 Kg capacity conforming to IS: 2878.
- Dry chemical powder type of 5 Kg conforming to IS: 2171.
- Mechanical foam type of 9 lit. capacity conforming to IS: 10204.
- Mobile foam type of 50 lit. capacity conforming to IS: 13386.
- Mobile type carbon-dioxide of 22.5 Kg capacity conforming to IS: 2878.
- Mobile type dry chemical powder type of 50 Kg capacity as per IS: 10658.

### 3.5.0 Clean Agent Gas suppression System

Total Flood Inert gas / Clean Agent Fire Suppression System shall be provided for central control room in the electrical building. Clean agents / Inert gases to be considered are HFC227ea, HFC125,IG541, IG100, IG55, IG01, NOVEC 1230 fire protection fluid (FK-5-1-12) as per NFPA 2001.

The system shall cover the below false floor, main room and the above false ceiling voids to ensure total flooding of the risk being protected.

The actual net volume of the risk shall be calculated based on the architectural and structural drawings of the risk. The system shall be designed to meet the minimum requirements of NFPA 2001. All equipment shall be UL / FM / VDS / LPCB approved and the cylinders along with cylinder valve assembly shall be PESO approved.

The Refilling, maintenance facility in India must be approved by UL / FM / VDS / LPCB as per the requirement of PN 111 Issue 5, Generic Factory Production Control Requirements. The system shall have 100% connected reserve set of cylinders.

The Clean Agent / Inert gas system materials and equipment shall be standard products of the supplier's latest design and suitable to perform all functions intended.

The system design can be modular, central storage, or a combination of both design criteria.

Each supply shall be located within the hazard area, or as near as possible, to reduce the amount of pipe and fittings required to install the system.

Tanks (master) shall be actuated by either a resettable electric actuator or by pneumatic means from a nitrogen cartridge located in the releasing device. Explosive devices shall not be permitted. Master cylinder shall have Valve with Integrated Solenoid actuator. Separate removable solenoid actuator shall not be accepted.

Each tank shall have a pressure gauge and low pressure switch (optional) to provide visual and electrical supervision of the container pressure. The low-pressure switch shall be wired to the control panel to provide audible and visual "Trouble" alarms in the event the container pressure drops below 10% of operating pressure. The pressure gauge shall be colour coded to provide an easy, visual indication of container pressure. distribute the clean agent throughout the protected spaces. The nozzles shall be designed to provide proper agent quantity and distribution.

Distribution piping and fittings shall be installed in accordance with the manufacturer's requirements, NFPA 2001/BS, and approved piping standards and guidelines. All distribution piping shall be installed by qualified individuals using accepted practices and quality procedures. All piping shall be adequately supported and anchored at all directional changes and nozzle locations.

The system shall include a mechanical and electrical installation, all detection and control equipment, agent storage containers filled with clean agent, discharge nozzles, pipe and fittings, etc. The system(s) shall be actuated by signal initiated by fire detection and alarm system provided inside the control room building.

Minimum design concentration of INERT gas / clean agent fire extinguishing system shall be as per the listing and as per NFPA 2001 whichever is higher at 70 Degree F by volume. However higher concentration may be used if it is specified by the agent manufacturer / system supplier for the area protected.

Bidder to provide primary supply of gas & its cylinders, along with 100% (one hundred percent) standby gas quantity and cylinders for each room / area.

However if the system design permits provision of a common “ENGINEERED STORAGE SYSTEM” with directional valves for multiple rooms / areas of one unit, such a design is acceptable provided the total primary supply and / or reserve supply is equivalent to the requirement of largest area / room and such rooms / areas are perfectly separated from each other by means of wall or floor of minimum required fire rating (as per TAC regulations). Such common storage system should have been listed & approved by UL / FM / VDS / LPCB and Bidder should produce documentary evidences for design and installation of such systems also where in the past by them.

In either of the cases mentioned above, both the main & reserve supply cylinders shall be permanently connected to the distribution piping through manifold and arranged for easy changeover from the panel. Suitable selector switches shall be provided for “Normal / Standby” supply selection.

The discharge time period shall be such that the design concentration is achieved within 60 seconds. The flow calculations shall establish this criteria. The quality of gas shall conform to NFPA-2001 or as specified by listing authorities.

The design pressure for storage cylinders shall be suitable for the maximum pressure developed at 55 Deg. C and shall be designed to meet the requirements in NFPA-2001.

All cylinders shall bear the marking as detailed out in NFPA-2001 and shall be duly listed by UL/ FM/ VDS / LPCB in addition to approval by CHIEF CONTROLLER OF EXPLOSIVES – INDIA.

The fire detection system to be employed shall be as specified elsewhere. Operating devices shall be by mechanical, electrical and pneumatic means conforming to NFPA-2001. The power supply to electrical actuators shall be backed up with reliable battery supply. Such batteries shall be charged automatically by battery chargers. Required annunciations such as “Gas released”, Failure of automatic actuation” etc .shall be exhibited in the fire alarm panel.

Where pilot cylinders are employed for actuation of the cylinder banks, the number of pilot cylinders shall be as per the listed design manual. Facility for manual release of gas through push buttons be provided along with selection facility of “Auto /Manual” from the panel. In addition to this, local manual release through lever operation shall also be provided near the cylinder banks.

The gas releasing devices at cylinder outlets shall be of re-usable type after discharge at any instant. Supervision of automatic actuation devices, power supply, manual actuation circuits, and complete wiring shall be provided through control system / panel and the healthiness shall be reported or indicated in the panel automatically. Complete control system shall be listed and approved by UL / FM / VDS / LPCB.

The complete installation, testing, commissioning & training shall be carried out by the Contractor under the supervision of the Manufacturer / designer at site. Safety All the safety requirements recommended in NFPA – 2001 or as specified by listing authorities shall be incorporated in the installation by the Bidder.

Appropriate warning signs shall be fixed outside of those areas protected by the system and also in areas where the gas may spread indicating clearly the hazard associated with the system such as Noise, turbulence, cold temperature and, physiological effect on personnel etc.

The gas shall be discharged after a set time delay on receiving signal from the fire detection system. The duration of the timer shall be upto a range of 0-5 minutes settable (adjustable in 1 minute variation) at site after conducting test to find out the duration for evacuation of the personnel from the area.

To prevent the loss / release of gas automatically or manually during maintenance, the system shall have the facility of “LOCKOUT”. The status of the system lockout condition shall be annunciated audio-visually in the panel.

All the fire suppression gas cylinders to be provided with online weigh system so that loss of gas causes an alarm.

Each cylinder requires one gas weigh monitor. The cylinders shall be fixed in hanging condition through gas weigh monitor. When the weight of the gas reduces to a certain level, low weight is indicated. On receipt of this low weight signal, the gas weigh monitor control panel shall generate audio visual indication. Two sets of potential free contacts are available for any other relevant signals. Signal from this control panel shall be communicated to the DCS panel for monitoring.

### 3.6.0 Fire Detection and Alarm System

The detection system shall be fully addressable analog type designed and installed conforming to IS: 2189 and NFPA 72 standard. The fire detection system components including Fire alarm panel, detectors, and annunciator shall be certified by either of UL / FM / TAC as applicable for the specific requirement, manual call points, hooters / horns, wires FRLS type, suitable GI conduit, fittings and other accessories. Manual call point and Hooters / Horns shall be provided at strategic areas-mentioned below. The external shade of fire control panel shall be RAL-7035.

A centralized microprocessor based fire detection & alarm system with a computerised analogue addressable system including a central monitoring station shall be provided and located in Central control room and shall include the following:

- One micro processor based main fire alarm panel along with necessary software shall be provided in the central control room complete with Master system CPU with HDD, Optical mouse and keyboard. Pentium based monitoring station with colour graphic display (Colour monitor shall be of 24 inch size), Printer, power supplies including UPS, batteries and battery chargers. Provision shall be made in proposed fire alarm panel to hook up with existing fire alarm signals. Approximately provision of interface of 60 signals of existing fire alarm panel shall be mad at proposed fire alarm panel.
- One repeater panel with repeat annunciation facility of all major fire in proposed main fire alarm panel and existing fire alarm panel shall be provided in the main fire station control room (2 km away).
- Intelligent addressable smoke/ heat detectors. Photo electric detectors shall be provided facility of connecting response indicators.
- No. of detectors in each area and spacing shall be as per applicable national and international regulations and standard.
- The spacing / area of coverage for detectors shall be selected in general, based on guidelines outlined in TAC / NFPA-72 / IS – 2189.
- Digital type linear heat sensing cables and gas detectors.
- FRLS wires for connecting the detector and call point to the fire detection system panel and annunciation system through GI conduits.
- Switching devices like pressure switches with its own addressable interface units/ modules.
- Software and hardware as required for operation of system.
- Cabling, I / O modules as required with 10% implemented I / O inputs provided as spares in each card.
- Fire alarm panel shall be provided with at least one (01) spare loop capacity.
- Fire alarm panel should capable to accept 110 V AC UPS power supply.
- BATTERY & BATTERY CHARGER AND AC POWER SUPPLY: Adequately rated batteries to give a back time of one hour shall be connected via mains failure relay contact across 24 volts regulated DC supply. In normal condition, battery shall be kept on constant trickle charge. Battery can be boost charged by manually operating trickle/boost toggle switch when battery low indication is observed on the control panel. In case of mains failure, battery shall automatically feed full supply load of the entire system consisting of fire alarm, and exit signs etc. Battery capacity shall be adequate for the system requirement at least for 30 minutes. Bidder has to provide rubber pad, clamps etc. for proper installation of Battery inside the panel.
- Colour coded wires along with GI conduits, fixing brackets, clamps, bolts, nuts, earthing material for panels, LM3 junction boxes, any other hardware required for safe installation shall be included in the Bidder's scope.
- Necessary hardware, erection tools and tackles, testing and measuring equipment required for erection and commissioning of fire alarm detection system are in Bidder's scope.
- The fire alarm system shall also generate potential free contact for Fire Alarm system Alarm; Fire alarm system Fault & Fire detected which will be monitored by the DCS system.
- An industrial siren shall install in the Fire station building. The siren shall have an audible range of 1.5 Km and produce a minimum sound level of 80 dB(A) above any other noise likely to persist for a period longer than 30 seconds. Additionally all exit routes and hallways in each occupied building shall be provided with sounders and flash light to facilitate for safe evacuation in case of fire in the area.
- One more repeater fire alarm panel shall be provided at security room.

**Areas to be covered under Fire detection and alarm system**

| Area / Equipments | Type of Detector |
|---|---|
| GTG / STG Building, mechanical equipment rooms, transformer area, switchyard area and other areas of plant area | Addressable Manual call points (MCP) |
| Central Control Room,( Control Room Above false ceiling Control Room below false floor Control Equipment Room Above false ceiling Control Equipment Room below false floor), Switchgear room, Battery Charger room, Control & electronic cubicle rooms, GIS | Multisensor detectors and Manual cal points (MCP),hooters<br>The detection system shall be provided with necessary contacts to trip the Air conditioning system and close necessary fire damper in Control Room. |
| GTG Room | Flame Detectors, Temperature detectors, gas detectors, hooters |
| Cable galleries / spreader room | Photoelectric type smoke detectors and linear heat sensing cable. LHS cable, Digital type, shall be provided in alternate tray as well as top & Bottom tray and it should be in Zig Zag fashion for cable cellar.<br>The detector shall be cross zoned to facilitate true detection of fire and shall provide alarm annunciation and actuation of MVWS deluge valves and also facilitate tripping of the Ventilation system of the room. |
| Battery room | Rate of rise of temperature detector with fixed temperature element (corrosion proof) and MCP's. |
| Switchgear rooms (including MCC / Control rooms) and electrical cum control room of all the auxiliary buildings | Photoelectric type smoke detectors ,MCP, Hooters |
| Transformer protected by HVW spray system | Quartzoid bulb heat detectors |
| Lube oil skids, Hydraulic oil skid | Rate of rise of temperature detector with fixed temperature element (corrosion proof) and MCP's. Sprinkle system shall be provided. |
| GT Fuel gas skids, HRSG | Gas detector and MCP's. Sprinkle system shall be provided. |

## 4.0.0 CONSTRUCTION REQUIREMENTS

Fire water pipes shall be of Carbon Steel conforming to IS: 1239 (heavy grade) and IS: 3589 (minimum 6.35 mm thick).

All the piping shall be over ground piping and shall be adequately supported at regular intervals.

The underground piping if any shall be buried such that the top of the pipe is at least 1.0 M below the finished ground level.

All buried pipes shall be double coated and wrapped as per IS: 10221 / IS: 15337 -2003.Over ground pipe normally empty but periodically charged shall be Galvanised pipes.

The entire pipe network shall be hydraulically designed in such a way that the velocity of water in any section does not exceed 5.0 m/s as per TAC requirement at any segment of pipe network.

RCC hume pipes of IS-458 NP class II shall be provided for road crossings of fire water pipes.

The yard piping shall be provided with strategically located isolation valves to enable maintenance of defective pipeline and also to achieve maximum pressure at the remotest and highest hydrant at the time of fire as per TAC requirement. These valves shall be housed in underground RCC valve chambers.

All fire hose connection branch pipe and couplings shall be of gun metal construction and in accordance with IS: 903.

The hose pipes shall be RRL hoses as per IS 636 Type A and shall be 15m long. Hose cabinets shall be provided with 18 SWG thick body and 3 mm glass.

The hose shall be provided with key box with break glass and pedestal where required.

The pipework shall be provided with gate valves IS 14846 at suitable location to facilitate repairs or other necessary work on the system, all above ground valves shall be rising stem type. All above ground Gate valves, check valves and globe valves shall confirm to IS 778.

All the accessories used for hydrant system like hydrant valve, nozzles ,branch pipes, hose coupling etc and all the nozzles for spray system shall be of SS construction.

Deluge valve shall be quick release, hydraulically operated diaphragm / piston actuated type of valve, set in closed position, by water pressure through external bypass valve and restriction orifice from the inlet chamber to top chamber. The deluge valve shall be of cast iron construction complete with all accessories.

Rising spindle gate valves to be provided for upstream and downstream gate valve Bypass to be provided for deluge valve and shall be butterfly valve.

The medium / high velocity spray nozzle shall be of forged Brass construction.

## 5.0.0 SPECIFIED DESIGN DATA

### 1.0 Under Ground Piping (Normally Filled with Water)

| | | |
|---|---|---|
| Pipe specification | : | IS: 1239 (part I) - Heavy grade ERW MS Black pipes for sizes 150 NB and below.<br><br>IS: 3589 - Grade 410 (wall thickness min-6 mm) ERW MS Black pipes for sizes above 150 NB. |
| Pipe to pipe joints | : | Butt welded for sizes 50NB & above, socket welding for sizes below 50NB. |
| Pipe to valve joints | : | Flanged with CNAF gaskets in between flanges shall be drilled to ANSI B16.5 150#. |
| Pipe fittings | : | IS: 1239 (Part II) MS |

### 2.0 Above Ground Piping (Normally Filled with Water)

| | | |
|---|---|---|
| Pipe specification | : | IS: 1239 (part I) - Medium grade ERW MS Black pipes for sizes 150 NB and below<br>IS: 3589 - Grade 410 (wall thickness min-6 mm) ERW MS Black pipes for sizes above 150 NB. |
| Pipe to pipe joint | : | Butt welded for sizes 50NB & above, socket welding for sizes below 50 NB. |
| Pipe to valve joint | : | Flanged and drilled to ANSI 150# B16.5 with neoprene gaskets between flanges for sizes 50NB & above. |
| | : | Screwed for sizes below 50NB. |
| Pipe fittings | : | IS 1239 (Part II) - MS for sizes upto 150 NB<br>- Fabricated from parent material for sizes above 150 NB. |
| Pipe protection | : | - Two coats of zinc phosphate -primer after vigorous wire brushing.<br>- Two coats of finish paint to shade fire red of IS:5<br>- Total DFT - 100 micron. |
| Bolts, nuts & washers | : | Hot dip galvanised MS. |
| Pipe supports | : | as per manufacturer's std. |

3.0 **Above Ground Piping (Normally Empty)**

| | | |
|---|---|---|
| Pipe specification | : | IS: 1239 (Part I) - Medium grade galvanised ERW MS pipes. |
| Pipe to pipe joint | : | Butt welding for sizes 50NB & above, socket welding for sizes below 50NB, using zinc rich electrodes or screwed joints. |
| | : | Flanged connection where welding is not preferred with neoprene gaskets in between, drilling shall be as per ANSI 150# B16.5. |
| Pipe to valve joints | : | Flanged for sizes 50NB & above, screwed for sizes below 50NB. |
| Pipe fittings | : | IS 1239 (Part II) galvanised MS |
| Pipe protection | : | Galvanised pipes |
| Bolts nuts & washers | : | Hot dip galvanised MS. |
| Shop testing | : | As per IS 1239 & IS 3589 |

4.0 **Gasket**

| | | |
|---|---|---|
| Material | : | CNAF |
| Thickness | : | 3 mm |
| Design | : | IS 2712 |
| Facing | : | Full Face |

5.0 **Bolts, Nuts**

| | | |
|---|---|---|
| Service | : | Fire Water |
| Material / IS Code | : | IS 1367 Cl. 4.6/4 |
| Test | : | Tensile test |
| Certificates | : | Chemical & tensile test |

6.0 **Sluice Valves / Gate Valves**

| | | |
|---|---|---|
| Material/ IS Code | : | Supply of Cast Iron Gate valve conforming to IS:210 Gr.FG220 for body & bonnet seat. |
| Manuf./Testing Std. | : | S:14846/2000/PN1.6 with ISI mark( Rising Spindle Type) |
| Rating | : | PN 1.6 |

7.0 **Globe Valves** (Sizes 40 NB and below)

| | | |
|---|---|---|
| Material | : | A 105 |
| Manuf./Testing Std. | : | BS 5352/BS 6755 |
| End Connection | : | socket welded |
| Rating | : | 800 # |

8.0 **Check Valves**

| | | |
|---|---|---|
| Material/ IS Code | : | IS 210 Gr. FG 220 |
| Mfg./Testing Std. | : | IS 5312 |
| Rating | : | Compatible with 10 kgs/cm$^2$ (g) working pressure |
| End connection | : | Flanged and drilled to ANSI B 16.5, 150# |
| Code / Standard | : | BS: 5153 |

9.0 **Hydrant Valve**

| | | |
|---|---|---|
| Manufacturer | : | Bidder to indicate |
| Type | : | Single headed, female oblique type |
| Code / Standard | : | IS: 5290, Type A |
| End connection | : | Flanged and drilled to ANSI B 16.5, 150# |
| Material of construction | : | SS |
| Testing | : | As per IS: 5290 |
| Test pressure | : | Body - 21 kg/cm$^2$<br>Seat - 14 kg/cm$^2$ |

10.0 **Water Monitor**

| | | |
|---|---|---|
| Manufacturer | : | Bidder to indicate |
| Type | : | Horizontal and vertical swivel type |
| Size | : | Refer Hydrant Schematic Layout. |
| Code / Standard | : | IS: 8442 |
| End connection | : | Flanged and drilled to ANSI B 16.5,150# |

Material construction

| | | |
|---|---|---|
| Water barrel | : | Seamless to ASTM A106 Sch. 40 |
| Nozzle | : | SS |
| Handle | : | MS to IS 2062 |
| Brass flange | : | MS IS 2062. Drilled to ANSI B 16.5, 150 # |
| Reducer & 90° Elbow | : | Seamless ANSI B 16.9 |
| Swivel joints (horizontal & vertical) | : | Bronze IS 318 LTB-2 |
| Rotation lock (Horizontal / vertical) | : | Brass IS 319 |
| Grease ripple | : | Brass |
| Drain cock | : | Bronze IS 318 LTB - 2. |
| Testing | : | As per IS : 8442 |
| Test pressure | : | 25 kg/cm$^2$ |
| Painting | : | Fire red as per IS-5 |
| Approval | : | ISI marked / TAC approved |

11.0 **Branch Pipe & Nozzle**

| | | |
|---|---|---|
| Manufacturer | : | Tata / Jindal |
| Size | : | Refer Hydrant Schematic Layout. |
| Code / standard | : | IS : 903-1995 |
| Material of construction | | |
| Branch pipe / nozzle | : | SS |

12.0 **Hose Coupling**

| | | |
|---|---|---|
| Manufacturer | : | Bidder to indicate |
| Type | : | Instantaneous male and female |
| Size | : | 63 NB |
| Code / standard | : | IS : 903 |
| Material of construction | : | SS |
| Testing | : | As per IS : 903 |

13.0 **Fire Hose**

| | | |
|---|---|---|
| Manufacture | : | Bidder to indicate |
| Type | : | Controlled Percolation |
| Size | : | 63 mm |
| Code / standard | : | IS : 8423 |
| Length | : | 15 m for internal and external hydrant |
| Approval | : | ISI marked / TAC approved |

14.0 **Hose Cabinet**

| | | |
|---|---|---|
| Type | : | Fabricated out of 16 Gr. MS sheet |
| Size | : | 750 x 600 x 250 |
| Mounting | : | Wall / column mounted |
| Painting | : | Two coats of zinc phosphate primer and two coats of finish paint to shade fire red of IS : 5 total DFT - 100 microns |

15.0 **Deluge Valve**

| | | |
|---|---|---|
| Manufacturer | : | Bidder to specify |
| Type | : | Quick release, diaphragm actuated |
| Size | : | Bidder to select |
| Type of operator | : | Hydraulic (wet pilot) pilot |
| Trim description | : | 1) Wet pilot trim<br>2) Electrical release trim<br>3) Test & Alarm trim<br>4) Drain valve<br>5) Priming connection<br>6) Drip check valve<br>7) Emergency release valve |

| | | | |
|---|---|---|---|
| | Accessories | : | All standard accessories |
| | Material of construction | | |
| | Housing | : | CI, IS 210 Gr. 200 |
| | Cover: | : | CI, IS 210 Gr. 200 |
| | Clapper | : | Cast bronze IS 318 LTB-2 |
| | Clamp ring | : | Cast bronze IS 318 LTB-2 |
| | Seat | : | Cast bronze IS 318 LTB-2 |
| | Diaphragm | : | Neoprene |
| | Seat rubber | : | Neoprene |
| | Bolts | : | Stainless (wet parts)<br>Hot dip galvanised MS (dry parts) |
| | Testing | : | As per UL |
| | Painting | : | Two coats of zinc phosphate primer after sand blasting of casting two coats of finish paint to shade fire red of IS: 5 total DFT - 100 microns. |

16.0 **Spray Nozzles (HVW)**

| | | | |
|---|---|---|---|
| | Manufacturer | : | Bidder to indicate |
| | Type | : | Open type<br>solid cone for HVW spray |
| | Material | : | Chrome Plated SS |
| | Accessories | : | Built in strainer |
| | End connector | : | Screwed, ½" or ¾" BSP |

17.0 **Quartzoid Bulb Detector**

| | | | |
|---|---|---|---|
| | Manufacturer | : | Bidder to indicate |
| | Material | : | Brass to IS : 319 chrome plated |
| | Sensitive element | : | Heat sensitive bulb |

18.0 **Local control Panel**

To be provided for deluge valves of cable galleries and transformers located near the equipment to be protected. Necessary interlocks with fire detection alarm panel for cable gallery shall be provided.

This panel shall have contact for remote annunciation in the annunciation panel in the fire water pump house.

Power for the local control panel shall be arranged from emergency bus.

**NOTE:**

EPC Contractor shall submit Fire detection & protection system description for the proposed power plant area, hydraulic analysis of hydrant lines, data sheet, list of drawings, testing procedure, performance guarantee, mandatory spares, Inspection & Test procedures, Quality Assurance plan, etc.

# VOLUME – III

# SECTION - 2

# DETAILED TECHNICAL SPECIFICATION - MECHANICAL

## SUB-SECTION - 2.10

## PIPING, VALVES AND FITTINGS

. **VOLUME - III**

**SUB-SECTION – 2.10**

**PIPING, VALVES AND FITTINGS**

## 1.0.0 GENERAL

This section is intended to provide the scope, design, constructional and functional requirements for all power plant piping, valves and fittings.

## 2.0.0 SCOPE OF SUPPLY

The scope of supply shall include but not limited to, the following:

**High pressure/ power cycle piping**

- High pressure piping covering complete main steam, hot reheat and cold reheat Piping between boiler and turbine nozzles, HP & LP bypass piping.
- Complete auxiliary PRDS and auxiliary steam piping system.
- All extraction steam piping.
- Complete feed water piping including booster pumps suction, inter connection between booster pumps and main pumps, boiler feed discharge piping up to economiser, recirculation, BFP warm up and leak off.
- Spray piping system for reheater/ superheater attemperation, HP & LP bypass system and auxiliary PRDS system.
- Condensate piping system.
- Condenser make up water system.
- Heater drains and vents piping including necessary flash tanks.
- Steam drains including necessary flash tanks.
- Valve gland sealing piping system.
- Miscellaneous line drains and vents including necessary flash tanks.
- Complete safety valve exhaust piping for safety valves on steam generator, HP piping, Aux. PRDS, heaters and deaerator etc.
- Start up vents, safety valves, and pneumatic relief valves (PRVs), flash tanks and all vents from the respective equipments and pipes upto a level of one meter above the boiler house/ TG building roof. Silencers shall be provided for start up vents, lowest safety valve and PRVs. All drains from respective equipments and pipelines shall be connected to the drain manifold of the flash tanks.
- Complete chemical dosing system piping.
- Any other piping system to make the power cycle piping complete.
- Complete steam blowing and chemical cleaning of piping including provision of temporary piping as required.

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- Piping systems shall be complete with fittings/accessories, specialities, blow-down valves, vent valves, drain valves and safety valves along with their escape piping, drain piping and steam traps, expansion joints, insulation, hangers, supports, restraints / guides, snubbers and auxiliary steel etc. The drain system shall be complete along with drain pipes, unit flash tank, drain valves, root valves, relief/safety valves, control valves, motorised valves, gate/ globe valves, non return valves, break-down orifices, steam traps etc.

**Low pressure piping and valves etc.**

The scope of low pressure piping including miscellaneous piping shall cover piping systems for the following services from the terminal points within the main plant area as specified elsewhere:-

- Condenser cooling water system, Auxiliary cooling water system, closed cooling water system.
- Condenser make up, boiler fill and deaerator fill systems.
- Closed cooling water system (DM water).
- Condensate polishing system (if applicable).
- Condenser on load tube cleaning system.
- Debris filter (applicable for water based CW system).
- Condenser air evacuation system.
- Drain water system.
- Chemical dosing system.
- Service water systems.
- Potable/ drinking water system.
- Fire water piping system.
- Oil storage and purification systems.
- Liquid effluent system.

All interconnection piping within and between the equipments and any other piping system.

Piping systems shall be complete with fittings/ accessories and specialities, expansion joints, all isolating and regulating/ control valves, hand operated and/or motorized/pneumatic/ hydraulic actuators, surface painting/ protection, hangers, supports, trestles, restraints/ guides, snubbers and auxiliary steel etc as required.

**Power cycle control valves**

All the control valves as required complete with pneumatic actuators and accessories, which shall include but not be limited to the following:

- Desuperheating spray water control valves for superheater, reheater and auxiliary steam supply.
- LP heaters normal and emergency level control valves.
- BFP recirculation control valves.
- Deaerator level control valves.
- Deaerator pressure control valves.

- Condensate recirculation flow control valves.
- Condenser normal make up control valves.
- Condenser emergency make up control valves.
- Feed water control valves (low load).
- Condensate recirculation control valve.
- Excess condensate dump control valve.
- Deaerator overflow control valve.
- Boiler continuous and intermittent blow down control valves.

The power cycle control valves shall be complete along with suitable type of bypass valves. Each control valve shall be provided with arrangement of upstream and downstream isolation valves (hand/ pneumatically/ electrically operated). All other control valves not specifically included above but required for completeness of the system shall also be in the scope of the Bidder.

All other valves shall be with the system / equipment / package.

## 3.0.0 DESIGN CRITERIA

The pipework shall be designed and erected in accordance with ANSI / ASME B31.1 'Power piping', and the relevant codes and standards of ASTM & AWWA or an expressively approved equivalent standard and Indian Boiler Regulations wherever applicable.

The present specification shall prevail against that of the code whenever the former is more restrictive.

The supply must be in accordance with the latest editions of the approved Standards as agreed by the Owner/Owner's Representative, incorporating any other features as required by this Specification and in accordance with the Piping Materials Specification. The requirement of Indian Boiler Regulation (IBR) shall be complied with as far as applicable.

All pipe components manufactured by the Bidder and parts on which he has worked, are to be marked clearly with an item number, specification number and material. This marking shall be permanent.

Sizes of pipelines shall be selected such that the velocity of fluid in pipes does not exceed the following limits under conditions of maximum possible volumetric flow:

**Steam:**

| | |
|---|---|
| Superheated steam | 75 m/s |
| Saturated Steam | 40 m/s |
| Wet steam / Exhaust steam | 30 m/s |

**Water and Condensate lines:**

| | |
|---|---|
| Pump suction lines (without feed water suction line) | 1.2 m/s |
| Water discharge lines | 2.2 m/s |
| Feed water discharge lines | 6.0 m/s |

| | |
|---|---|
| Feed water suction lines | 1.0 m/s |

**Air lines**:

| | |
|---|---|
| Delivery line for reciprocating compressors | 30 m/s |
| Suction line for reciprocating compressors | 20 m/s |
| Suction and delivery lines for rotary compressors | 15 m/s |

**Fuel gas and oil lines:**

| | |
|---|---|
| Lube and Control oil lines | 1.0 m/s |
| Fuel gas lines | 25 m/s |

All rules of the art considering technical and economic parameters shall be carefully followed, namely:

- Lower values of velocities that those stated above shall be used to determine line size if dictated by considerations of pressure drop, NPSH, surges, water hammer, etc.
- The design flows considered in line sizing shall not be less than the rated capacities of equipment to which the piping is connected such as pumps, blowers, compressors, valves, flow limiting orifices, etc., or, the system heat and/or mass balance diagrams.
- For lines conveying liquids, the design pressure must be equal to maximum operating pressure including the pressure reached during transients (water hammer.).
- The calculation of the pipework shall consider also the highest possible temperature that can occur during any mode of operation together with the highest corresponding pressure.
- For the design of safety valves installed downstream of reducing stations, H.P. bypass valves or equivalent control valves, the maximum throughput of the fully open reducing or bypass valve, including injection water quantity, is to be taken as the basis for calculation.
- Sizes of Boiler feed pump suction piping shall be selected to meet the NPSH requirements of the pumps under transient conditions prevailing on loss of steam supply to feed water tank. Similarly for all pumps, NPSH requirements shall be satisfied in line sizing.
- The calculation of wall thickness required for pipelines subject to internal and / or external pressure shall be based on the formulae and recommendations as given in the applicable codes. Adequate allowances shall be made towards thinning due to bending, weakening at branch connections, threading, commercial tolerances on pipe wall thickness, corrosion and erosion, etc. and the same shall be subject to approval by Owner/Owner's representative.

- In case of carbon steel materials, the nominal wall thickness of pipeline shall be not less than the minimum acceptable values given below :

| NB mm (inch) | 25 (1) | 32 (1 1/4) | 40 (1.5) | 50 (2) | 65 (2.5) | 80 (3) | 100 (4) | 125 (5) | 150 (6) |
|---|---|---|---|---|---|---|---|---|---|
| Min. thickness mm | 4.55 | 4.85 | 5.08 | 5.54 | 5.54 | 5.54 | 6.02 | 6.55 | 7.11 |
| NB mm (inch) | 200 (8) | 250 (10) | 300 (12) | 350 (14) | 400 (16) | 450 (18) | 500 (20) | 600 (24) | |
| Min. thickness mm | 8.18 | 9.27 | 9.53 | 9.53 | 9.53 | 9.53 | 9.53 | 9.53 | |

> NB 600 mm to NB 950 mm – 10.00 mm
> NB 950 mm to NB 1200 mm – 12.00 mm

Sizes of NB 32 (11/4"), NB 65 (21/2"), and NB 125 (5") shall not be used in the piping system. Minimum thickness for stainless steel pipes shall be Sch. 40S as per ANSI B 36.19.

- In addition to the required wall thickness in accordance with calculations, a corrosion allowance of 3.2 mm must be added for unprotected water lines where corrosion is to be expected.

- For vessels of carbon steel construction a corrosion allowance of 5 mm shall be considered.

- All pipes downstream of the final filter up to GT inlet shall be of stainless steel.

## 4.0.0 DESIGN AND CONSTRUCTION OF PIPEWORK AND ACCESSORIES

The pipework and its accessories shall be designed and arranged so that all parts can be mounted and replaced without difficulty. All important parts, such as valves must be accessible from the floors / platforms.

The platform must be able to withstand the weight of the valve removed as well as the weight of the appropriate number of persons handling the valve, and must be sized adequately providing both working space for the men and space for the valve.

For piping systems with a nominal pressure of more than 20 bar (g), drainage and venting facilities must be fitted with double valves.

The pipes with nominal diameter upto and including 40 mm can be arranged at site according to lengths and specification. The pipes with nominal diameter more than 40 mm can be installed according to the erection drawing designed. Pipe can be pre-fabricated or manufactured according to pipe length and specifications.

No tubes with nominal diameters less than 25 mm shall be used, except for impulse measuring lines, dosing pipelines and instrument piping.

All sampling pipes shall be of SS and shall be fabricated with welded joints.

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The nominal size of the takeoff connections for instruments shall not be less than 15 mm for service conditions not exceeding either 62 bar (g) or 425°C and 25 mm for service conditions which exceed either of these limits.

For all system parts subject to acceptance retests relevant provision shall be made so that they can be separated to allow for those retests.

None of the forces and moments transmitted by the pipes to adjacent machines, apparatus and platforms must exceed the maximum permissible values, given by the manufacturers of these items.

Trench piping shall not be used unless found unavoidable.

To the extent that steam or hot water can remain or flow in pipe sections isolated for repair purposes, dump pipes with hand operated shut-off valves capable of being locked open or closed shall be provided for the safety of personnel.

Piping systems shall be protected against excess pressure caused by thermal expansion of locked-in fluids.

Valve sizes for vents and drains shall be 25 NB minimum. Vent lines, which are normally operated, shall be terminated at a minimum height of 3.0 M above the highest service platform.

For vents, pipes and any upward facing atmospheric exhaust, weather hoods and silencers as necessary shall be provided.

For tanks and pressure vessels, piping material for drains and vents shall be the same as that of the vessel. Suitable drains shall be provided upstream and downstream of valves to facilitate maintenance in the circuit safely.

In addition, plugged drain and air release bosses shall be welded at appropriate places in the piping to facilitate hydrostatic testing.

Steam traps should be avoided as far as possible. If provided, steam trap installation shall include a permanent strainer, upstream and downstream isolation valves and a globe valve as free drain. Steam traps shall be of the bimetallic or thermodynamic type, selected to suit the service conditions.

The Bidder shall furnish and install suitable thimbles at all points where pipelines pass through building floors and walls.

The Bidder shall provide effective flashing rings with rain-tight hoods for all pipes passing through the roofs or exterior walls.

All piping shall be cleaned and kept clean and free from all foreign matter before and during erection. The Bidder shall submit a detailed description of proposed steam blowing and other cleaning procedures for all pipelines, and no part of this work shall be started until these procedures have been approved. The Bidder shall furnish, install and dismantle all temporary pipes, hangers, anchors, etc. required for cleaning of all piping systems.

As many welds as possible shall be carried out in the workshop. Supports for H.P piping systems shall also be welded in the workshop.

Pipes from water drains, air vents and safety valves shall be grouped together where possible and routed to easily observed points equipped with covered funnels or to flash tanks.

So far as practicable, hangers and supports shall be standardized and the number of types and component assemblies shall be reduced to the minimum. Each pipe hanger and support component shall be of a steel suitable for the maximum temperature that it shall attain during plant operation. Spring support assemblies shall be equipped with a means of locking the springs against movement. Rigid supports, clamps and restraints shall be used as far as possible.

The use of counterweights as a substitute for support spring assemblies shall not be permitted.

Sliding surfaces shall be constructed of non corrodible materials that do not rely on coatings such as paint, galvanizing, etc. for corrosion protection. Excessive friction shall be prevented.

After plant start-up, all supports shall be checked to confirm that spring load indicators have assumed the proper hot load position and that all hangers and supports which do not incorporate springs are in the correct position. After all required adjustments have been made, all threads shall be fully engaged and locked and all spring ties shall be disengaged.

In case of seawater intake and discharge piping, one of the following materials shall be provided.

a) MS pipe conforming to IS-3589 with “Pipecoat / Corrocoat” or equivalent coatings internally and externally.

b) Tentative design pressure of water pipe in 6 kg/cm²(g). Exact value shall be decided during detailed engineering stage.

4.1.0 **Piping Layout Considerations**

A minimum 2.2 meter headroom shall be maintained to the lowest point of all piping components or insulation in walking areas. At road crossings, minimum clearance below pipe rack shall be 7.5 meter for normal traffic and 11.0 meter for crane movement. A minimum passageway of 1.5 m shall be considered for access between and around all equipments and a 150 mm minimum clearance shall be provided between piping, including insulation if applied, and any point of adjacent equipment or piping including flanges and/or pipe supports.

Additional clearance shall be provided, where required, for pipe movement due to thermal expansion. All valves, instruments, strainers, orifices, valve motor drives and other piping accessories shall be provided with adequate space for access and removal of parts for maintenance.

All buried pipe in general shall be laid with the top of the pipe minimum 1.0m below the finished ground level. The buried pipe shall be factory made and spiral welded. It shall have wrapping and coating and lowered into trench after Holiday test and repair of all punchers/coat damage portion.

Bracket supports and other protruding attachments which constitute a hazard to operating personnel shall be elevated to a minimum of 2.2 m from the operator's access elevation.

All horizontal runs of outdoor piping shall be supported by pipe racks with a slope of 1:500 applicable for steam lines only. Steam lines inside building shall be laid with a slope of 1:100. All the gas lines shall be sloped to drain to a series of drain valves located at suitable points. These drain valves shall be lockable.

The instruments shall be positioned to allow easy observation. A 250 mm minimum clear space shall be provided from the bottom surface of pipe to trench bottom or finished grade.

All lines shall be provided with vent and drain connections at all high and low points, respectively, as per layout constraints with suitability for operation .All piping shall be arranged to permit complete

drainage when a particular unit or system is shutdown. Condensate & water lines shall also be provided with vent & drain lines for hydro test conditions. Drain points shall have a suitable isolating valve. All such drain connections shall be piped to a suitable collection point.

4.2.0 **Piping Flexibility Analysis**

Steam piping systems shall be designed and analysed using CAESAR II software (latest version) in such a way that no excessive stresses, forces, moments or deflections can take place. This static analysis shall be done for plant operating, shut down, hydro test and occasional loading (e.g. safety valves popping up & water / steam hammer conditions). As a general guidance a line shall be subjected to comprehensive stress analysis if it is fall under any of the following categories.

1. All lines at design temperature above 180 Deg.C.
2. 100 NB and larger with design temperature above 130 Deg.C.
3. 400 NB and larger with design temperature above 105 Deg.C.
4. All lines 100 NB and larger connected to sensitive rotating equipments.
5. All piping subjected to vibration.
6. All relief lines connected to pressure relief valves and rupture discs.
7. Other lines which in the option of Owner/r Owner's Representative requires a formal analysis.

Pipe sagging shall be restricted to 2.5 mm and piping rotation to less than 1degree.The calculations shall be based on design pressures, temperatures and weights of valves. In addition, the water weight for hydrostatic testing and the insulation weight shall also be taken into account.

The calculations shall determine the maximum combined pipe stresses and the forces, moments, and deflections at all points of support, anchors and restraints. In all calculations, the manufacturing tolerance (12.5% for OD pipes) shall be taken into account.

The design shall take into account possible maximum values, e.g. the maximum head of the pumps in the system as well as exceptional operating conditions, such as over pressures, vibrations and water hammer.

There shall be sufficient allowance for thermal expansion and displacement without excessive stresses. The thermal expansion of the pipe work shall be carefully analyzed and appropriate pipe routing and location of the supporting equipment to be decided to prevent the piping from causing excessive forces & moments at the anchoring points.

4.3.0 **Pipe Supports and Hangers**

Pipe supports shall be designed according to the layout requirements. Spring shall be used for pipe supports where restriction of vertical movement of pipe creates excessive stress in the piping system. Otherwise rigid supports like rod hangers, clamps, saddle supports etc. shall be used.

The supporting devices shall ensure that the finished system shall provide an uniform continuous slope for draining. Loads imposed on the building structure shall, in all instances, be subject to the approval of the Owner/Owner's representative.

All supports for piping, cables and fitting supplied under this Contract are to be clamped to building steelwork in preference to bolting, screwing or welding. Under no circumstances shall any part of the building steel work be drilled, cut welded without prior permission of the Owner/Owner's representative in writing. No point of passage of pipes through or walls is to be used as a point of support except with the approval of the Owner/Owner's representative .

Sling supports shall not be dependent for flexibility on the flexure of supporting rods or straps.

All outdoor installation supports and hangers shall be suitably coated to withstand the local environmental conditions.

All spring supports shall be designed and fabricated to forestall the complete release of the piping load in the case of spring failure.

Supports for horizontal piping shall be spaced to prevent excessive sag, bending and shear stress in the piping with special consideration given where components, such as flanges and valves, impose concentrated loads.

For standard and heavier wall thickness piping, the maximum spacing between supports on straight run of the piping shall be in accordance with ANSI B 31.1.

Vertical supports shall be spaced to prevent the pipe from being over stressed from the combination of all loading effects.

4.4.0 **Fabrication & Erection of Piping Systems**

The plant piping systems shall be fabricated, erected and tested in accordance with the requirements of ASME, ANSI and API Standards.

All piping to be adequately supported during construction so that excessive moments or loads are not placed on equipment or other piping. The piping is to be installed to permit free expansion and contraction without damage to joints or supports.

Piping bending, wherever required, is to be fabricated with a minimum of five (5) diameter radius. The joint spacing between bevelled ends of pipe shall be maintained between 1.5 and 2.5 mm. Butt welding & end preparation for pipe connections with pipe and flanges shall be as per ANSI B 16.25.

All joints in high pressure and low pressure piping shall be of the fully butt welded type except at points where flanged connections are essential to permit dismantling of pipework for maintenance purposes or for matching flanged item of plants.

Interconnecting joints in all pipes shall be made by butt-welding. Such joints shall be made without the use of backing rings. The welds shall be performed entirely in Gas Tungsten Arc. Welding (GTAW) Process but where this is not practicable, a combination of GTAW for the root run, and Shielded Metal Arc Welding (SMAW) for the subsequent runs, is acceptable. Consumable insert rings may be used where considered necessary.

All flanged joints shall meet the requirements of ANSI B 16.5 or the equivalent Approved Standard. All flanges shall be machined on the edge and spot faced at the back to receive bolts, washers and nuts. For high pressure services flange faces must be of serrated finish. Blank flanges are to be solid steel and machined all over. Flanges having pressure ratings less than 10 bar shall not be used. All flange jointing material unless specified, shall be subjected to the approval of the Owner / Owner's representative.

Socket welded connections shall be used on oil piping services less than 50 mm nominal size. The use of socket welded connections on other Piping services shall be subjected to the approval of the Owner/Owner's representative and restricted to the areas where the temperature or pressure cycling or severe vibration is not expected to occur or where the service may not accelerate crevice corrosion.

Screwed connections shall only be used on air services and only when the pipe is less than 50 mm nominal size. In case of threaded joints in piping, all screw threads shall be of the ISO metric form and the diameter and pitch of thread for all bolts, studs and nuts shall conform to the ISO standards. Threaded joints are used in galvanized steel pipes only. Threaded joints, which are to be seal-welded shall be made up without the use of any joint compound or sealing tape. Threaded joints, which are not to be seal- welded shall be made leak-tight by use of suitable joint compound. Backing off of the make-up threaded joints to facilitate fit-up to alignment is not permitted.

At all points where pipes pass through concrete floors or brick or other walls, suitable floor collars or wall boxes are to be provided and fixed. The floor collars shall have raised curbs of suitable height, which shall not be less than 75 mm. The wall boxes shall be flush fitting and be of neat design and approved finish.

The Contract shall include fixing of all necessary components for the protection against weather of such holes in an approved manner. Where pipes pass through roofs, the pipe collar shall up stand less than 200 mm above the top of the roof and hood shall shroud it to within 25 mm of the finished roof level. After the collars, boxes or other fittings been fixed in position, the floors, walls and structures shall be made good by the Bidder.

If service pipes run adjacent to each other, they are, wherever possible, to pass through a box. Where pipes of varying bore pass through a common box, a neat plate cover shall be provided between the pipes and the box. In the case of flanged pipework, boxes shall be large enough to permit the passage of the flange.

Where pipes are laid in covered trenches this Contract shall include for the supply and fixing of all the necessary pipe supports, clamps, packing and fixings, etc.

During erection the Bidder shall be responsible for providing temporary trench covers for the protection of the pipes in the trench and for the safety and convenience of his employees and those of other contractors working or having normal access in the vicinity of trench areas.

The Bidder shall be responsible for maintaining the trenches clean and dry, and shall hand over same to the Purchaser in clean and dry condition at the time of taking over of plant.

4.5.0 **Cleaning, Packing and Handling of Piping Systems**

The Bidder shall take all necessary precautions to ensure that the interior of all piping is kept clean during erection and free from any injurious matter.

All piping except water and air piping shall be chemically cleaned, pickled and purged with an air blast to clean the pipe inner surface. The outside of all pipes shall also be cleaned similarly. Carbon steel and ferritic alloys piping shall be cleaned after hot working or heat treatment. Cleaning shall be accomplished by either of the following methods.

a) Degreasing making use of alkalis.

b) Pickling in hot sulphuric acid along with suitable inhibitor, followed by washing in cold and hot water.

c) Cleaning by means of power driven wire brushes. The brushes shall be of the same material as the metal being cleaned. Both inside and outside surfaces shall be cleaned.

d) Grit-blasting the inner and outer surfaces using silicon carbide or steel shots. All grit shall be subsequently removed.

After cleaning (by any of the above methods), the pipes shall be protected by means of an outdoor preservative. All pipes shall be capped using plugs or plastic caps. All bevels, threads, flange faces and other sealing surfaces shall be suitably protected with wood or plastic to prevent damage to these surfaces.

Suitable connections shall be made, where necessary, on all pipe runs to facilitate the removal of dirt and debris and the cleaning of each pipe run in accordance with the requirements specified elsewhere.

All steam piping to turbines shall be blown through with steam in accordance with the Inspection and Testing Requirements. The Bidder shall install and subsequently remove any temporary piping, fittings, supports or instrumentation required to carry out the blowing through operation. The terminals of piping being blown through shall be adequately fixed in order to take the resultant thrusts. The anchor, whether temporary or permanent, shall be designed to take the thrust and any loads imposed on the building steelwork and shall receive the prior approval of the Owner/Owner's representative. Target plates shall be used to ascertain that the system is rid of impurities.

4.6.0 **Testing of Piping Systems**

The following tests shall be conducted in the piping systems to check for cracks and the welding joint quality.

**4.6.1 Hydro Test**

All pipework shall be tested hydraulically to at least 1.5 times the design pressure for at least 2 hours. After the hydraulic test, a leak test with air to 1.1 time the design pressure for at least 24 hours shall be performed.

The hydro test of the pipe work shall be carried out with skids isolated from the pipe work. Skids shall be tested separately before installation and connection to pipe work.

The hydro test pressure shall not be applied until the piping system and the testing medium have reached thermal equilibrium.

During the tests, hydraulic pressure shall be monitored and corrections shall be made to compensate for thermal expansion or contraction. By this procedure, the test pressure shall be kept within specified test pressure. All joints are visually examined for leakage during the test.

Tested systems shall be vented and drained immediately upon successful completion of the test.

All stainless steel lines are emptied and dried immediately after hydrostatic tests are completed. To avoid the possibility of pitting due to chlorine contents in water, demineralised or otherwise suitably treated water shall be used as the testing medium.

**4.6.2 Pneumatic Test**

Pneumatic testing of a piping system is done

i) When the piping system is so designed that it cannot be filled with water or other liquid testing medium.

ii) When the piping system is to be used in services where traces of the testing medium cannot be tolerated.

iii) When the piping system cannot be completely drained and dried out.

iv) When hydrostatic testing would contaminate, or adversely affect chemical handled during the process.

v) When the testing fluid would affect or damage internal lining.

Pneumatic tests shall meet the following requirements:

- Air test shall be performed with clean, dry air. The source shall be equipped with appropriate pressure relief valves and gauges. The pneumatic test pressure shall not be less than 1.2 or more than 1.5 times the design pressure of the piping system.
- No repair welding shall be performed on a pressurised system.

### 4.6.3 Radiographic Test

Radiographic inspection shall be carried out in accordance with the requirements of ANSI B 31.1 and ASME V for checking piping weld quality.

Random radiography shall be carried out in accordance with ASME V Article 2 for all full penetration butt welds. Weld repairs made as a result of radiographic examination shall be radiographed after welding. Repairing a particular area more than two times is not permitted and the component shall be rejected. Prior approval shall be obtained from the Owner/Owner's representative before taking up major weld repairs (When depth of repair exceeds 20% of thickness or 25 mm whichever is smaller). Mapping of major weld repairs is also required.

All butt welds of the gas fuel supply system shall be subject to 100% radiography test and all other welds shall be subject to 100% non destructive testing.

Radiography shall be carried out as follows:

i) For piping 65mm NB or smaller, a single elliptical exposure which encompasses the entire weld circumference.

ii) For piping 80mm NB or larger, the double-wall-single-image technique shall be used with at least three exposures at $120^{o}$ to each other.

The radiographic film recording shall be performed in accordance with the ASTM E94-77. The Radiographic Procedures and Standards of Acceptability shall be in accordance with ASME V and as specified in the appropriate design requirements:

- Gamma isotope double wall IR-192.
- Film used shall be fine-grained, a high contrast, direct type.
- Intensifying screen shall be `lead'.
- Image quality indicators shall be of the wire type (DIN 54109) selected to give the required level of sensitivity.

## 5.0.0 HDPE PIPING SYSTEM

This section covers the technical requirements and essential particulars for supply, fabrication, erection, testing, cleaning and commissioning of HDPE piping systems including design, fabrication and erection of pipe supports.

5.1.0 **CODES AND STANDARDS**

The piping system shall comply with the latest editions of the following codes and standards as applicable:

ASME B 31.1 - Code for Power Piping (applicable part)

IS 4984 - High Density Polyethylene Pipes for Potable Water Supplies

IS 7328 - High Density Polyethylene Materials for Moulding and Extrusion

All other applicable Indian Standards as well as International standards ASTM D3350 – Cl 345434C, FM (for Pipes, Fittings, Tees, Reducers, Caps, Couplings, etc.), DI, ASTM A536,ASME B16.42 (for Flanges), ASTM A307, Gr B with ASTM A 563, Gr A hex nuts (For Bolting).

5.2.0 **MATERIAL, SUPPLY AND ERECTION REQUIREMENTS**

5.2.1 MATERIAL REQUIREMENT

HDPE shall be provided with long term UV protection (2 – 3% carbon black). Flange adapters shall be provided with a serrated sealing surface. Stainless steel flat washers shall be used between the nut and backup ring in accordance with the manufacturer's recommendation.

5.2.2 SCOPE OF SUPPLY AND ERECTION

The Contractor shall supply and erect all piping materials like pipes, fittings, stub-ends and other items as required along with gaskets, fasteners and complete support assemblies including clamps, rods, etc.

5.2.3 MATERIAL SPECIFICATION

The Contractor shall furnish six (6) copies of certified physical and chemical test reports for the piping as called for in various standards. These certificates shall list the following as applicable:

- o Chemical composition.
- o Tensile properties
- o Certificate for internal creep rupture test
- o Dimensions
- o Hydrostatic tests.

5.2.4 FABRICATION

All HDPE piping fabrication procedures shall be submitted to the Owner/Owner's representative for review and approval before undertaking any fabrication and erection work.

The personnel to be deployed for fabrication/erection work shall have satisfactory previous experience. Details of such experience shall be furnished to the Owner/Owner's representative before commencement of work.

5.2.5 JOINING OF HDPE PIPES

Joining of HDPE pipes and fittings is accomplished by means of butt-welding using 'Mirror Technique'. The ends of pipes/fittings that are to be joined shall be cut to the desired angle. Then the metallic mirror is heated to a temperature of about 210 ±5°C. The mirror may be heated by means of a blow torch or inbuilt electrical coil. For detecting the temperature of the heated mirror, crayon-chalk can be used. The pipe ends to be joined are kept on either side of the heated mirror. When the rim of molten material is formed, the pipes are removed from the heating mirror and the joint is made by application of pressure.

In the case of smaller diameter pipes, manual holding and sufficient pressing of the two ends is adequate. However, for heavy duty pipes with large diameters, a suitable fixture may be used for holding and pressing the pipes. Then the pipes are allowed to cool to make a strong joint. The Contractor shall choose the correct method/equipment to establish a good and strong joint.

Whenever there are valves or equipment which require to be dismantled for maintenance, detachable joints by means of flanges shall be provided.

The bonding procedure and the bonder shall be qualified in accordance with Appendix-III of ASME B 31.1 code.

5.2.6 HANGERS AND SUPPORTS

HDPE pipes being flexible shall be supported with proper care. Supports for horizontal run, such as pipe clamp, brackets with rounded edges shall be used as per spacing indicated in drawings/documents. Normally mild steel supports are used. Standard pipe clips may also be used but care shall be taken not to over tighten and cause the clips to bite into the pipe. Pipe clips shall be correctly aligned and shall provide a smooth flat surface for contact with the pipe. All types of manual controls, and valves in particular, should be independently and firmly supported. This is to minimise the turning moment imparted to the pipe or equipment by the concentrated load, operation of the hand wheel or manual controls.

All piping supports along with auxiliary structural steel shall be furnished and erected by the Contractor. The Contractor's work shall include but not be limited to the location of all hangers, supports and the design of individual components. All supports designed by the Contractor shall be erected only after the support drawings are approved by the Owner/Owner's representative.

5.2.7 PROTECTION DURING TRANSIT

Effective precautions such as capping and sealing shall be used to protect all pipes and fittings, valves and specialities against ingress of dirt and damage during transit and/or storage.

5.3.0 **SHOP AND FIELD HYDROSTATIC TESTS**

5.3.1 SHOP TESTS

The following tests as mentioned below shall be carried out at the manufacturer's works before supply of pipes and fittings.

Reversion Test

This test shall be carried out as per the procedure given in Annexure-C of IS: 4984. The dimension of the test sample shall not change by more than 3% in the longitudinal direction.

Hydrostatic Test

The hydrostatic test shall be done as per the procedure given in Annexure-B of IS: 4984.

The samples shall not show signs of localised swelling or leakage and shall not burst during the pressurised test duration.

For other details the Contractor shall refer to IS 4984. If the above tests are already carried out by the pipe manufacturer, the Contractor shall only submit test certificates for the above tests.

5.3.2 HYDROSTATIC TEST AT SITE

After the fabrication and erection of pipes is complete, the complete piping system shall be subjected to hydrostatic test. The hydrostatic test pressure shall be 1.5 times the design pressure. The water temperature shall not exceed 40°C. In no case shall air be used for leak testing.

## 6.0.0 GUIDELINES FOR ERECTION OF VALVES

### 6.1.0 Scope of Specification

This specification covers the technical requirements for materials, installation and tests of general and special purpose valves, valve drives and related accessories. General-purpose valves include gate, globe, piston lift check, swing check, butterfly, plug, Ball and Diaphragm valves. Valve drives include pneumatic (diaphragm and cylinder), electric (motor and solenoid) actuators and hydraulic. All Service & potable water system pipelines are of HDPE composite pipes.

### 6.2.0 General Requirements

All regularly operated isolation valves and control valves shall be accessible from a permanent floor or access platform. For operator convenience, valves shall have 1.0 m clear approach space. The stems of all valves for outdoor service shall have weatherproof protection covers of approved construction.

Sufficient overhead access and clearance shall be provided to enable the valve internals to be withdrawn and also for the complete valve to be removed by means of lifting tackle if necessary. Pipe work systems shall be designed and supported so that valves can be isolated for maintenance purposes without shut down of the system whenever feasible and practical.

Unless otherwise specified, manually operated gate, globe, or butterfly valves shall be hand wheel operated and plug valves or ball valves shall be wrench-operated. Manual gear operators shall be provided, as required, depending on the size and pressure rating of the valve. All gear operators shall be of the totally enclosed type, self-locking, with position indicators. All valves shall be equipped with a locking facility, which permits locking in the open or closed position.

All valves shall be fitted with indicators such that it may be readily seen whether the valves are open or shut, and the extent of opening. In case, the valves fitted with extended stems, indicators shall be provided both on the valve and at the extended stem hand wheel. Where remote indication is required, the valves shall be equipped with limit switches mounted on the valves for electrical signal of valve positions "open" and "shut" or position 0 to 100% as required.

Valves and related accessories shall be subjected to hydrostatic testing and seat leak testing as per the requirement of the applicable codes and valve pressure classes as per B16.34 / API 598 / BS 5146. All motor actuators shall be supplied with type and routine test reports.

For gas service, all isolating valves shall be ball type with double block and bleed function. These valves shall be "fire safe" in accordance with API - 607 or BS-5146 and of anti-static design in accordance with BS-5351.

The shut off valves in the vent line from the safety valves shall be locked open by a approved master key system.

All isolation valves shall be designed to withstand differential pressure across them when closed.

The drains from each filter separator and other liquid drainage points shall be fitted with a non-return valve and manual isolating valve. The drains shall be grouped and connected to a common drain header leading to the condensate tank.

Vents and thermal reliefs shall discharge to the vent system. The capacity and the design of the vent system shall be as per the recommendations of API standards.

Whenever there is a risk of pressure above design point safety valves shall be provided.

6.3.0 **General Purpose Valves**

a) Gate and Globe Valves

All gate and globe valves, except bronze body valves, shall be screwed outside and yoke designed with rising stems. Bronze body valves shall have union type bonnets & rising stems.

Bonnets joints shall be of the bolted, flanged type for class rating upto 600#. Pressure seal bonnets shall be provided for class rating above 600#. The bypass shall be integral with the main valve and shall be of welded connection.

Valves shall be provided with back-seating construction and shall be suitable for re-packing at full pressure with the valve in the open position. Gate valves for pressure above 40 bar shall have double wedge type discs. Globe valves shall have plug type discs. All valves shall have replaceable seat rings.

b) Check valve

Check valves shall be designed for mounting in horizontal or vertical piping runs. Check valve shall be of a non slam type with a swing disc and, in special cases, of the tilting disc type or guided piston lift type used upto 2". Check valves are placed in line with a gate valve or a globe valve where guaranteed tightness is required. All check valves shall be horizontally mounted.

c) Butterfly valves

Butterfly Valves shall be used in place of gate or globe valves for low-pressure liquid or gas service. Valves are to be designed for minimum pressure loss when open and capable to withstand the full pressure of the line when closed and cause minimum vibration when used for throttling of flow.

All manually operated valves of 150 mm and larger shall be of the gear type with totally enclosed gearing, and smaller shall have multi-position lever operators.

d) Ball Valves

Ball valves may be used for low pressure liquid / air service. Each ball valve shall be provided with an operating lever.

e) Instrument Root Valves

Instrument shut-off valves shall be Globe type construction, no bonnet, outside screw, rising stem, with vent plugs and flanged or socket weld ends.

6.4.0 **Special Purpose Valves**

Special purpose valves include valves operated with motor, pneumatic and solenoid actuators. These valves are mainly meant for remote operation in critical controls of fluid pressure, flow and temperature. The special valves shall have provision for hand operating gear.

a) Motor operated valves:

Electrically operated valves are preferred for non-safeguarding service. Local operation shall be provided on all valves. Every selector switch shall be lockable in "local" or "remote" or "hand" positions and each shall be provided with a padlock and two keys. Valve motors shall be supplied from the 400 V, 3-phase system.

Electric actuators shall have torque-limiting devices effective throughout full travel, the torque at which these operate being readily adjusted, and travel limit switches for controls and also for the operation of remote indicating lights.

The speed of operation of all power-operated valves is to be selected to suit the operating conditions of the system and to minimise pressure surges. Actuators shall have adequate power and control systems to operate the valves accurately under all system operating conditions.

All motorized valves shall be equipped with four limit switches, for automatic control and position indication purposes. Two torque switches are equipped, one for acting in the opening direction and the other in the closing direction. Limit switches shall not be used as mechanical stops. The materials of the limit switches shall be corrosion resistant to gases and chemicals present in the plant environment by hermetically sealed snap acting single pole double throw type, able to switch faultlessly 125 V DC / 24V DC / 230V AC.

b) Pneumatic actuated valves:

Pneumatic actuators may be of the following types:

- Spring opposed diaphragm motor type
- Spring less opposed diaphragm motor type
- Piston operated type

Air actuators shall be designed to produce the required stem forces with supply air pressures of 5.5 - 7 bar (g). Piston actuators shall be used where stem forces dictate their use.

Diaphragms shall be of moulded rubber, neoprene or other suitable materials and diaphragm housings shall be of pressed steel construction.

Piston actuators use cast pistons and cylinders with O-ring seals. Air cylinders are manufactured in accordance with BS 4862 or approved equivalent.

The cylinders, unless otherwise specified, shall be required to be supplied with protective gaiters - bellows type to protect the piston rod seals. Cylinder seal materials are to be selected by considering higher ambient temperatures.

c) Solenoid Operated Valves, SOV:

Solenoid coils are rated at 110 V DC for continuous energizing and designed to operate satisfactorily within 0.80 to 1.1 of rated DC voltage and in 55°C ambient temperature.

Solenoid valves shall operate on the "ON-OFF" principle. The use of economy resistors is not allowed. Solenoids shall be installed in a vertical orientation.

d) Safety and relief valves:

Safety & safety relief valves are provided to relieve the pressure in excess of the design pressure building up in the system.

All relief valves are direct spring loaded, angle body types of a design suitable for their respective operating conditions. Relief valves for compressed air, steam services shall be of the "safety" type. Relief valves for water or oil shall be of the liquid relief type having a slow opening and closing action. All relief valves shall be arranged for field adjustment of the set pressure and provided with lifting levers.

e) Control valves:

Control valves are meant for regulating pressure, temperature & flow parameters in the system. Control valve stations are generally designed with a gate valve at its upstream and downstream with a globe vent valve and a globe type bypass valve. Manual bypass valve is provided where manipulation can provide satisfactory control or where it is required for the safe plant shutdown following failure of the control valve. Bypass valves are not provided in cases where manual control cannot sensibly be achieved.

Trim of control valves shall be designed to avoid erosion, excessive noise and vibration while handling flashing condensate.

Control valves shall have stainless steel stems, guide bushing, inner valves, seat rings, stem lock pins and stuffing box parts hardened with stellite or other equivalent seating surfaces.

Flow control valves shall be especially designed to meet high pressure drop applications with stainless steel stems, stellited, or other equivalent hardening, seats and discs.

Control valves shall be fitted with approved indicators, showing accurately the amount of valve opening, and shall have electric position transmitters with 4-20 mA output equivalents to 0-100% opening. All valve seats & faces shall be renewable and be made from materials that are corrosion & wear resistant. Noise levels for control valves shall be restricted to 85 dBA at 1 m.

f) Pressure reducing valves:

Pressure reducing valves shall be designed for perfectly stable, quiet and non-vibratory operation over its full range and shall be suitable for continuous duty at the operating temperature.

In case of electrical or hydraulic valve operator is provided, on failure of the operating mechanism, the valve shall not close automatically and the valve opening shall be readily adjustable by hand. A pressure relief valve shall be provided at the discharge of each reducing valve, capable of discharging the maximum flow of the reducing valve without build-up of pressure.

Pressure & Temperature gauges shall be provided upstream and downstream of each reducing valve and this valve is operated by sensing the downstream pressure with the set pressure.

6.5.0 **Valve Selection Criteria**

The valve selection criterion is generally as below:

For reasons of plant standardization the Bidder shall standardize the valves, to reduce number of types and manufacturers to a minimum. Installation and testing of the valves shall be in accordance with the applicable standards. The requirement of this clause shall apply if they are more stringent than the approved standards.

All valves shall be suitable for the media and for the service conditions and those performing similar duties shall be interchangeable. All valves must meet maximum design demands for pressure and temperature of the piping system.

If the media handled are polluted, the shut off devices used in discharge lines (e.g. drains on vessels) and possibly also in vent lines should consist of gate valves.

The maximum permissible forces for actuation hand wheels are 300 N for wheels with diameter up to 400 mm and 600 N for larger diameters. Differential pressures requiring higher forces for actuation of hand wheels shall entail fitting the valve with gears. For calculation of the gears or all other actuators the design pressures shall be taken as differential pressures. Large valves that are frequently operated or hard to operate manually shall be motorized.

Valves that are required to be motor operated shall be provided with hand operated equipment for closing and opening of the valves during power failure and shall have a suitable arrangement for de-coupling when the valves are being motor operated.

Gear operator shall be of totally enclosed. Bevel gear in grease case with grease nipples for gate and globe valves and totally enclosed helical worm gear in grease case with grease nipples for ball, plug and butterfly valves.

Where required, valve spindles shall be lengthened so that the hand-wheel is at a minimum height of one metre above the level of the floor. Where necessary they shall be provided with headstocks and pedestals of rigid construction. The actuation of valves by means of chain drives is not permissible.

On all valves where the hand wheels are liable to be dangerously hot to touch thermal insulation shall be provided on the ring and spokes.

All valves shall be closed by rotating the handwheel in clock wise direction when looking at the face of the hand wheel. The face of each handwheel shall be clearly marked 'open and 'shut', with arrows indicating the direction of rotation to which each term refers.

Plastic or bakelite valve handwheels shall not be accepted. Valves with solid handwheels are not acceptable since all valves must be capable of being locked by means of a chain and padlock in the open and closed position.

All valves must be suitable for outdoor installation with due consideration of the special climate and environmental conditions at the site.
Unless otherwise agreed, all valves shall be fitted with the spindle in the vertical position. Eye bolts shall be provided where necessary to facilitate handling heavy valves or parts of valves.

Valves of sizes 50 NB and above shall be provided with position indications.

Fire safe valves shall be supplied with antistatic devices.

Materials used must confirm to the applicable standards. Materials for screws, bolts and nuts must have the operating temperature limits closely observed.

All valves of the relevant pipework systems must be suitable for pickling.

Cast Iron, C.I. material shall not be used for Valve MOC. Valve material shall be of Carbon steel (CS), Stainless steel (SS) or Alloy steel (AS) based on fluid system operational requirement of the power plant.

Unless otherwise required by virtue of the valve's function, bodies shall have an internal cross section corresponding to the nominal diameter of the connection.

Integral bypass arrangement for gate valves shall be provided wherever necessary. In that case, bypass valve shall be a globe valve and bypass attachment to main valve body shall not be screwed. The integral bypass valve shall also be motorised if the connected main valve is provided with motor actuator.

Gate valves and swing check valves of the H.P. piping systems shall be equipped with self-sealing lid covers. Gate valves with self-sealing lid covers shall be equipped with a safety device at the body. If discs are used they must be capable of being dismantled and changed under operating conditions.

Connecting flanges shall be in accordance with the applicable standards with regard to both the connection dimensions and the minimum thickness of the material.

The transition from the flat rear surface of the flange (nut contact faces) to where the welding begins must have no sharp-edged machined grooves.

The spindle must be made in one piece: the length of thread must be such that the threaded bush is fully engaged in any position of the moving part. The connection between the spindle and the cone must be sufficiently flexible. For H.P. globe valves and globe valves for throttling purposes of NB 50 or less the spindle and cone must be made in one piece.

In case of metallic sealing elements there must be difference in hardness between the body seat and the sealing element, the sealing element having the higher hardness values.

All globe valves shall be equipped with throttling cones with parabolic characteristics.

Each valves shall be marked on the body with the material diameter, the nominal pressure, type of valve and an arrow showing the flow direction whenever only one is possible.

No traps which incorporates internal screens or check valves shall be used unless specifically required by the specifications or approved by the Owner/Owner’s representative.

Condensate drainers shall be of the ball-float type.

For safety valves, pressure relief valves, bursting discs and other safety devices against excess pressure the directives of appendix II of the code ANSI B31. 1: 'New Mandatory Rules for the design of Safety Valve Installations' shall apply as well as requirements of Indian Boiler Regulations (IBR) wherever applicable.

## 7.0.0 MATERIAL REQUIREMENTS FOR PIPING COMPONENTS AND VALVES

The main materials and special requirements specified under this title shall be seen as the minimum requirement.

The following guideline represents minimum requirements. In case of intended deviations 'Deviation from Enquiry Documents' applies.

### PIPING MATERIAL SPECIFICATIONS:

| SL. NO. | SERVICE | SIZE | PIPE | FITTINGS | FLANGES | GASKETS | END JOINT |
|---|---|---|---|---|---|---|---|
| 1 | HP steam system – HP Steam to steam turbine, HP steam upto PRDS | All | ASTM A335 P91 | ASTM A234 WP91 | - | - | Butt welded |
| 2 | Steam Temperature above 540º C | All | ASTM A335 P91 | ASTM A234 WP91 | - | - | Butt welded |
| 3 | Steam Temperature above 500 and upto 540º C | All | ASTM A335 P22 | ASTM A234 WP22 | - | - | Butt welded |
| 4 | Steam Temperature above 400 and upto 499º C | <= 50 NB | ASTM A335 P11 | ASTM A182 F11 | ASTM A182 F11 | Spiral Wound SS316 | Socket Welded |
| | | > 50 NB | ASTM A335 P11 | ASTM A234 WP11 | ASTM A182 F11 | Spiral Wound SS316 | Butt welded |
| 5 | Temperature below 400º C (LP steam system, Auxiliary steam system, Fuel oil, Hot water supply & return, CEP suction, Nitrogen Filling and Effluent system) | <= 50 NB | ASTM A106 Gr B | ASTM A105 | ASTM A105 | Spiral Wound SS316 | Socket Welded |
| | | > 50 NB | ASTM A106 Gr B | ASTM A234 WPB | ASTM A105 | Spiral Wound SS316 | Butt welded |

| SL. NO. | SERVICE | SIZE | PIPE | FITTINGS | FLANGES | GASKETS | END JOINT |
|---|---|---|---|---|---|---|---|
| 6 | Condensate system | <= 50 NB | ASTM A106 Gr B/C | ASTM A 105 | ASTM A105 | Spiral Wound SS316 | Socket Welded |
| | | > 50 NB | ASTM A106 Gr B/C | ASTM A234 WPB/WPC | ASTM A105 | Spiral Wound SS316 | Butt welded |
| 7 | DM water distribution system & LP chemical dosing system | <= 50 NB | ASTM A312 TP 304L | ASTM A182 Gr F304L | ASTM A182 Gr F304L | EPDM/ Teflon | Socket Welded |
| | | > 50 NB | ASTM A312 TP 304L | A 403 Gr WP304L | ASTM A105 | EPDM/ Teflon | Butt welded |
| 8 | Closed cycle cooling water system | <= 50 NB | ASTM A53 Gr B ERW. | ASTM A105 | ASTM A105 | EPDM/ Teflon | Socket Welded |
| | | Above 50 NB and upto 450 NB | ASTM A 53 Gr B ERW. | ASTM A234 WPB | ASTM A105 | EPDM/ Teflon | Butt welded |
| | | Above 450 NB | ASTM A134-A283 Gr C ERW | ASTM A105 | ASTM A105 | EPDM/ Teflon | Butt welded |
| 9 | Instrument Air system, Service & Portable water system. | <= 50 NB | ASTM A53 Gr. B (ERW) Galvanised | ASTM A105 Galvanised | ASTM A105 Galvanised | EPDM/ Teflon | Threaded |
| | | > 50 NB | ASTM A53 Gr. B (ERW) Galvanised | ASTM A234 WPB Galvanised | ASTM A105 Galvanised | EPDM/ Teflon | Threaded |
| 10 | Service air | <= 50 NB | ASTM A53 Gr B ERW. | ASTM A105 | ASTM A105 | EPDM/ Teflon | Socket Welded |
| | | > 50 NB & Upto 450 NB | ASTM A53 Gr B ERW. | ASTM A234 WPB | ASTM A105 | EPDM/ Teflon | Butt welded |
| | | 450 NB & Above | ASTM A134-A283 Gr C ERW | ASTM A234 WPB | ASTM A105 | EPDM/ Teflon | Butt welded |

| SL. NO. | SERVICE | SIZE | PIPE | FITTINGS | FLANGES | GASKETS | END JOINT |
|---|---|---|---|---|---|---|---|
| 11 | HP Chemical dosing system | <= 50 NB | ASTM A312 TP 304L | ASTM A182 Gr F304L | ASTM A182 Gr F304L | Soft Iron 'O' Ring | Socket Welded |
| | | > 50 NB | ASTM A312 TP 304L | ASTM A403 Gr WP304L | ASTM A182 Gr F304L | Soft Iron 'O' Ring | Butt welded |
| 12 | Natural Gas, LNG Lines, Lube Oil, Waste oil and Control / Hydraulic Oil (Upstream of Filter) | <= 50 NB | ASTM A106 Gr B | ASTM A105 | ASTM A105 | Spiral Wound SS316 | Socket Welded |
| | | > 50 NB | ASTM A106 Gr B | ASTM A234 WPB | ASTM A105 | Spiral Wound SS316 | Butt welded |
| 13 | Natural Gas, LNG Lines, Lube Oil, Waste oil and Control / Hydraulic Oil (Downstream of Filter) | <= 50 NB | ASTM A312 TP316 | ASTM A182 Gr F316L | ASTM A105 | Spiral Wound SS316 | Socket Welded |
| | | > 50 NB | ASTM A312 TP316 | ASTM A403 GRWP316 | ASTM A105 | Spiral Wound SS316 | Butt welded |

**VALVE MATERIAL SPECIFICATIONS:**

| GATE / GLOBE VALVES | | | | | | | |
|---|---|---|---|---|---|---|---|
| SL. NO. | SERVICE | SIZE | BODY / BONNET | DISC | STEM | SEAT | END JOINT |
| 1 | Steam Temperature above 510º C | All | A 217 Gr C12A | A 217 Gr C12A stellite faced | 13% Cr Steel, forged and machined | Alloy steel + Stellited | Butt welded |
| 2 | Steam Temperature above 420º C and below 510ºC | All | A 217 Gr WC6 | A 217 Gr WC6 | 13% Cr Steel, forged and machined | Stellited | Butt welded |
| 3 | Steam Temperature less than 420ºC and Feed Water, Condensate, | <= 50 NB | A 105 | 13% Cr Steel | 13% Cr Steel, forged | Carbon steel, 13% Cr faced (Stellited for class 900 and above). | Socket Welded |
| | | > 50 NB | A 216 Gr WCB | 13% Cr Steel | 13% Cr Steel, | Carbon steel, 13% | Flanged upto Class |

| GATE / GLOBE VALVES | | | | | | | |
|---|---|---|---|---|---|---|---|
| **SL. NO.** | **SERVICE** | **SIZE** | **BODY / BONNET** | **DISC** | **STEM** | **SEAT** | **END JOINT** |
| | Closed Cycle cooling water system, Nitrogen Filling | | | | forged | Cr faced (Stellited for class 900 and above). | 600 #, Butt welded for class 900 and above |
| 4 | Service water | <= 50 NB | A 105 (Galvanised) | 13% Cr Steel | 13% Cr Steel, forged | Carbon steel, 13% Cr faced | Threaded |
| | | > 50 NB | A 216 Gr WCB (Galvanised) | 13% Cr Steel | 13% Cr Steel, forged | Carbon steel, 13% Cr faced | Flanged |
| 5 | Instrument Air | <= 50 NB | A 105 (Galvanised) | A181 | Carbon steel | Carbon steel, hardened | Threaded |
| | | > 50 NB | A 216 Gr WCB (Galvanised) | A181 | Carbon steel | Carbon steel, hardened | Flanged |
| 6 | Service Air | <= 50 NB | A 105 | A181 | Carbon steel | Carbon steel, hardened | Socket Welded |
| | | > 50 NB | A 216 Gr WCB | A181 | Carbon steel | Carbon steel, hardened | Flanged upto Class 600 #, Butt welded for class 900 and above |
| 7 | DM Water Distribution, Chemical Dosing | <= 50 NB | A 182 F 304L | SS 304 | Stainless steel | Teflon | Socket Welded |
| | | > 50 NB | A351 CF8 | SS 304 | Stainless steel | Teflon | Flanged upto Class 600 #, Butt welded for class 900 and above |
| 8 | Effluent | <= 50 NB | A 105 | 13% Cr Steel | 13 % Cr. Steel, Forged | Carbon steel, 13 % Cr faced | Socket Welded |
| | | > 50 NB | A 216 Gr WCB | 13% Cr Steel | 13 % Cr. Steel, Forged | Carbon steel, 13 % Cr faced | Flanged |
| 9 | Natural Gas, LNG | <= 50 NB | ASTM A105 | ASTM A479 TP410-2 | ASTM A479 TP410 | Carbon steel, 13% Cr faced | Socket Welded |

| GATE / GLOBE VALVES | | | | | | | |
|---|---|---|---|---|---|---|---|
| **SL. NO.** | **SERVICE** | **SIZE** | **BODY / BONNET** | **DISC** | **STEM** | **SEAT** | **END JOINT** |
| | Lines, Lube Oil, Waste oil and Control / Hydraulic Oil , LDO, Furnace Oil (Upstream of Filter) | > 50 NB | ASTM A216 Gr WCB | ASTM A216 Gr WCB | ASTM A479 TP410 | Carbon steel, 13% Cr faced | Butt welded |
| 10 | Natural Gas, LNG Lines, Lube Oil, Waste oil and Control / Hydraulic Oil, LDO, Furnace Oil (Downstream of Filter) | <= 50 NB | SS410 | SS410 | SS410 | Carbon steel, 13% Cr faced | Socket Welded |
| | | > 50 NB | SS410 | SS410 | SS410 | Carbon steel, 13% Cr faced | Butt welded |
| 11 | Brackish Water | <= 50 NB | A182 F316L | SS 410 | SS 410 | SS 410 | Threaded |
| | | > 50 NB | ASTM A439 Gr.2 Ni resist | 13% Cr | 13% Cr | CS+13%Cr.Faced | Flanged |

| CHECK VALVES | | | | | | | |
|---|---|---|---|---|---|---|---|
| **SL. NO.** | **SERVICE** | **SIZE** | **TYPE** | **BODY** | **DISC** | **SEAT RING** | **END JOINT** |
| 1 | Steam Temperature above 510º C | All | SWING CHECK | A 217 Gr C12A | A 217 Gr C12A stellite faced | Stellited | Butt welded |
| 2 | Steam Temperature above 420º C and below 510 ºC | All | SWING CHECK | A 217 Gr WC6 | A 217 Gr WC6 | Stellited | Butt welded |
| 3 | Steam Temperature less than 420º C and Feed Water | <= 50 NB | SWING CHECK | A 105 | 13% Cr Steel | Carbon steel, 13% Cr. Faced | Socket Welded |
| | | > 50 NB | SWING CHECK | A 216 Gr WCB | 13% Cr Steel | Carbon steel, 13% Cr. Faced | Flanged upto Class 600 #, Butt welded for class 900 and above |
| 4 | Condensate, Closed cycle cooling water, Nitrogen Filling | <= 50 NB | SWING OR PISTON | A 105 | A 105 | Carbon steel, 13% Cr. Faced | Socket Welded |
| | | > 50 NB | SWING CHECK | A 216 Gr WCB | A 216 Gr WCB | Carbon steel, 13% Cr. Faced | Flanged upto Class 600 #, Butt welded for class 900 and above |
| 5 | Service and Potable water | <= 50 NB | SWING OR PISTON | A 105 (Galvanised) | A 105 (Galvanised) | Carbon steel, 13% Cr faced | Flanged |
| | | > 50 NB | SWING CHECK | A 216 Gr WCB (Galvanised) | A 216 Gr WCB (Galvanised) | Carbon steel, 13% Cr faced | Flanged |
| 6 | Instrument Air | <= 50 NB | SWING OR PISTON | A181/ A 105 (Galvanised) | A181/ A 105 (Galvanised) | Carbon steel, hardened | Threaded |
| | | > 50 NB | SWING CHECK | A 216 Gr WCB (Galvanised | A 216 Gr WCB (Galvanis | Carbon steel, hardened | Flanged |

| CHECK VALVES | | | | | | | |
|---|---|---|---|---|---|---|---|
| **SL. NO.** | **SERVICE** | **SIZE** | **TYPE** | **BODY** | **DISC** | **SEAT RING** | **END JOINT** |
| | | | | ) | ed) | | |
| 7 | Service Air, Lube Oil and Waste Oil | <= 50 NB | SWING OR PISTON | A181/ A 105 | A181/ A 105 | Carbon steel, hardened | Socket Welded |
| | | > 50 NB | SWING CHECK | A 216 Gr WCB | A 216 Gr WCB | Carbon steel, hardened | Flanged upto Class 600 #, Butt welded for class 900 and above |
| 8 | DM Water Distribution, Chemical Dosing | <= 50 NB | SWING OR PISTON | A 182 F 304L | A 182 F 304L | Carbon steel faced with 13% Cr | Socket Welded |
| | | > 50 NB | SWING CHECK | A351 CF8 | A351 CF8 | Carbon steel faced with 13% Cr | Flanged upto Class 600 #, Butt welded for class 900 and above |
| 9 | Effluent | <= 50 NB | SWING OR PISTON | A 105 | A 105 | Carbon steel, 13 % Cr faced | Flanged |
| | | > 50 NB | SWING CHECK | A 216 Gr WCB | A 216 Gr WCB | Carbon steel, 13 % Cr faced | Flanged |

| BUTTERFLY VALVES | | | | | | | |
|---|---|---|---|---|---|---|---|
| **SL. NO.** | **SERVICE** | **SIZE** | **BODY** | **DISC** | **SHAFT** | **SEAT** | **END JOINT** |
| 1 | Closed cycle cooling water, Service water, | <= 300 NB | A 216WCB | A 216 WCB | SS 410. | Nitrile rubber/Teflon | Wafer Type |
| | | > 300 NB and upto 500 NB | A 216WCB / CI-IS 210 FG-260 | A 216WCB / CI-IS 210 FG-260 | SS 410. | Nitrile rubber/Teflon | Lug Type |
| | | Above 500 NB | Fabricated steel as per IS-2062 or equivalent | Fabricated steel as per IS-2062 or equivalent | SS 410. | Nitrile rubber/Teflon | Body Flanged |
| 2 | Brackish water and Effluent | >100 NB and upto 600 NB | ASTM A 439 Gr. D2 NI Resist | ASTM A 439 Gr. D2 NI Resist | Stainless steel AISI : 316 L / Duplex SS / | Nitrile rubber | Body Flanged |
| | | > 600 NB | Fabricated steel as per IS-2062 or equivalent (fully ebonite lined of cured thickness 4.5 mm) | Fabricated steel as per IS-2062 or equivalent (fully ebonite lined of cured thickness 4.5 mm) | Stainless steel AISI : 316 L / Duplex SS / | Nitrile rubber | Body Flanged |

| DIAPHRAGM VALVES | | | | | | | |
|---|---|---|---|---|---|---|---|
| **SL. NO.** | **SERVICE** | **SIZE** | **TYPE** | **BODY** | **BONNET** | **DIAPHRAGM** | **END JOINT** |
| 1 | DM Water Distribution | > 50 NB | WEIR | A 216 WCB, Rubber lined | A 216 WCB | Nitrile Butadiene Rubber (NIBR) | Flanged |

| BALL VALVES | | | | | | | |
|---|---|---|---|---|---|---|---|
| **SL. NO.** | **SERVICE** | **SIZE** | **TYPE** | **BODY** | **SEAT** | **BALL** | **END JOINT** |
| 1 | Nitrogen filling | <= 50 NB | Single/Two piece body | A 105 | Teflon | SS316 | Socket Welded |
| | | > 50 NB | Two/three piece body | A216 Gr WCB | Teflon | SS316 | Flanged upto Class 600 #, Butt welded for class 900 and above |

| PLUG VALVES | | | | | | |
|---|---|---|---|---|---|---|
| **SL. NO.** | **SERVICE** | **SIZE** | **TYPE** | **BODY** | **DISC** | **END JOINT** |
| 1 | Instrument Air | <= 50 NB | Two / Three Piece | A 181/A 105 (Galvanised) | A 181/A 105 (Galvanised) | Threaded |
| | | > 50 NB | Two / Three Piece | A216 Gr WCB (Galvanised) | A216 Gr WCB (Galvanised) | Flanged |
| 2 | Service Air, Lube Oil and Waste Oil | <= 50 NB | Two / Three Piece | A 181/A 105 | A 181/A 105 | Socket Welded |
| | | > 50 NB | Two / Three Piece | A216 Gr WCB | A216 Gr WCB | Flanged upto Class 600 #, Butt welded for class 900 and above |

## 8.0.0 BURIED PIPING

### 8.1.0 Excavation for Pipe Trenches

The trench shall be cut true to the line levelled with the help of sight rails provided at every 30 m, at change of direction, gradient and at any suitable distance as directed by the Owner/Owner's representative.

If the trench is excavated below the required level indicated in the drawing, the extra depth shall be filled with concrete or approved equivalent material as directed by the Owner/Owner's representative at no extra cost to the Owner/Owner's representative.

The trench shall be excavated so as to provide an average cover of 1000 mm or equal to the diameter of the largest pipe to be laid in the trench unless otherwise shown in drawings. The average cover shall be reckoned from top of the pipe of the largest diameter to be laid in the trench, to the finished grade. The width of the trench shall be sufficient to give free working space on each side of the pipe. The free working space shall conform to IS:783. Generally it shall not be less than 150 mm on either side or 1/3rd of diameter of pipe whichever is greater.

No excavated material shall be deposited within 1.5 meters from the excavated trench.

In case of road cutting, all material i.e. metal, bricks, etc. shall be taken out carefully and kept separately for reuse and road work shall be redone upto the original level prior to cutting the road with the excavated road materials after laying & testing of the pipeline within 10 days from the date of starting the work at the cost of the Bidder. The Bidder shall provide suitable signs and barricades to prevent accidents. He shall also provide reasonable bypass at his own cost when a road is cut for laying pipeline. The dykes etc. affected due to laying of the pipes, shall be redone conforming to the original specifications by the Bidder at his own cost. Hume pipes shall be used at all road crossings for pipes and cables.

During excavation if some obstacle is met with, same shall be reported to the Owner/Owner's representative and dealt with as instructed by him.

The Bidder shall dewater, shore or do whatever might be required to excavate the trench, install the pipe in it and backfill the trench, in accordance with the specifications at no extra cost to the Owner/Owner's representative. Dewatering shall be done in advance of the laying of the pipe to allow adequate inspection of padding of the bottom if required and dewatering shall be continued throughout during laying of the pipe and backfilling of the trench.

In muddy / slushy ground, the bed shall be provided with a layer of a sand or lean concrete as directed by the Owner/Owner's representative.

The trench shall follow the gradient of pipeline as specified in the drawing. The Bidder shall keep the trench in good condition, until the pipe is laid and tested. No extra claim shall be entertained due to its caving or setting down either before or after the pipe is laid. All materials to shore the trench in order to prevent caving are to be furnished and removed by the Bidder at no extra cost to the Owner/Owner's representative.

In case pipe is lowered in caved trench and back-filled before being inspected by the Owner/Owner's representative, the Bidder shall re-excavate the trench for inspection and backfill it at his own cost.

8.2.0 **Corrosion Protection Tape coating**

**Materials**

All underground steel pipes shall be protected with external corrosion Protection Tape Coating shall be coal tar based tape coating materials confirming to AWWA C203. Tape shall be coal tar component supported on fabric of organic / inorganic fibres. The fibre shall be thoroughly coated and completely covered on both sides with coal tar component. The tape shall be supplied in standard width and rolls shall be wound on hollow cores of standard diameter. The material shall have enough mechanical strength and dimension stability. As far as possible the fabric shall be thin, flexible, uniform and composed of glass fibres in an open structure bonded with a suitable inert material compatible with coal tar.

The primer shall be a coal-tar or suitable resin product. The primer shall consist of chlorinated rubber synthetic plasticizer and solvents. These primers shall be suitably compounded to produce a liquid coating which may be applied by brushing or spraying and which shall produce effective bond between the metal and subsequent coating of coal tar tape. Primer should not contain benzol or other toxic and/or highly volatile solvents, added pigments or inert fillers or other substances and shall show no tendency to settle out in containers.

Where the soil is corrosive in nature, Cathodic protection shall be given. If soil resistivity is greater than 5000 ohm-cm, Cathodic protection is not required.

**Application Procedure**

**Cleaning, blasting and protection after blasting**

Before the metal is blast cleaned, all oil and grease on the surfaces shall be thoroughly removed by flushing with a suitable solvent (such as xylene or 1,1,1 trichloroethane) and wiping with clean rags. The use of dirty or oily rags or dirty solvent shall not be permitted. All foreign matter not removable by blast cleaning shall be removed by suitable means. Blast cleaning operations shall remove all rust, scale and other impurities from the surface, exposing base material, presenting a greyish matte appearance. Slight shadows, strata or discoloration caused by rust stains or mill scale oxides need not be removed. Blasted surfaces that rust before a priming coat has been applied shall be cleaned of all rust by buffing or wire brushing, or shall be re-blasted. Adequate air separators shall be used to effectively remove all oil and free moisture from the air supply to the blaster.

After being cleaned, the pipe shall be protected from and be maintained free of oil, grease and dirt that might fall on the pipe before it has received its coal tar tape. During blast cleaning, any pipe found to show pits shall be set aside immediately, pending examination by the Owner/Owner's representative for acceptance, reconditioning or rejection.

**Priming and Application of coal tar tape**

All blasted surfaces shall be primed immediately following blasting and cleaning. The surfaces be dry at the time the primer is applied and no primer shall be applied during rain unless the pipe to be primed is protected from the weather by suitable housing.

The use of coal tar primer that has become fouled with foreign substance or has thickened through evaporation of the solvent oil shall not be permitted. The application of primer shall be hand brushing, spraying or other suitable means and shall be in accordance with instructions for application, as supplied by the manufacturer. The apparatus to be used for application of the primer shall be acceptable to the Owner/Owner's representative. Spray gun apparatus to be used shall include a mechanically agitated pressure pot and an air separator that shall remove all oil and free moisture from the air supply.

After application, the primer coat shall be uniform and free from floods, runs, sags, drips, holidays or bare spots. Any bare spots or holidays shall be recoated with an additional application of primer. All runs, sags, floods or drips shall be removed by scraping and cleaning, and the cleaned area shall be retouched or remedied by re-blasting and re-priming. Suitable measures shall be taken to protect the wet primer from contact with rain, fog, mist, spray, dust or other foreign matter until completely hardened and tape applied.

The minimum and maximum drying times of the primer or the period between application of primer and application of coal tar tape, shall be in accordance with instructions issued by the manufacturer.

If the coal tar tape is not applied within the allowed maximum time after priming, the pipe shall be re-primed with an additional light coat of primer or the entire prime coat shall be removed by re-blasting and the pipe re-primed.

The cleaning and priming operation may be carried out in the Bidder's workshop or on site. The entire pipe length shall be cleaned but the ends of the pipes shall be left without coating for a distance of 230 mm for joints, which shall be coated and wrapped manually on site after laying, welding and testing the pipes.

Tape application should fallow as soon as the primed surface is tacky. Tape shall be wraped in accordance with the manufacturer's recommendation in a manner that shall meet the adhesion and

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holiday detection requirement. In no case the overlap per single wrap is less than 12.5 mm. Two coats of coal tar tape coating shall be applied. A suitable primer as per manufacturer's recommendation shall be applied between the wraps. Air pockets or bubbles between the pipe and tapes or between tapes are to be avoided and tape shall be in perfect contact with the primed steel.

8.3.0 **Laying of Underground Piping**

**General**

After prefabrication, coating and trenching, the Bidder shall lay the underground piping in accordance with the following clauses and as per the approved piping arrangement drawings. The Bidder shall be responsible for correct layout and gradient of the line. Errors, if any, shall be rectified by the Bidder at his own cost.

**Lowering & Laying**

The pipes shall be lowered either by mechanical methods or by hand when the trench is ready and bottom of the trench is graded as per required pipe laying conditions and specifications.

**By machine**

The shop coated pipe, already transported to the pipe laying site/convenient length of pipe assembly coated and wrapped near the trench after hydrostatic testing shall be placed on clean square cut skids suitably spaced so as to keep the pipe away from touching the ground. The pipe may be lowered down in the trench by the launcher cranes, with sufficient care to protect the coating of the pipeline. Bare cables, chains hooks etc. shall not be permitted to come in contact with the coating. At tie in welds and other places, the Bidder shall clean, prime, coat and wrap manually. Also short sections of pipelines which are impracticable to shop treat may be hand treated but only on the prior written approval of the Owner/Owner's representative.

**By Hand**

The pipe may be lowered with the help of tripods and chain pulleys blocks into the trench immediately after the coating. However if in the opinion of the Owner/Owner's representative that the temperature condition do not allow direct lowering, then the pipe shall be set down on clean square cut skids. The skids shall be so spaced as to keep the pipe away from touching the ground.

**Method & Time of lowering pipe**

Under favourable temperature, conditions and using methods which shall not damage coating, the pipe may be lowered into the trench.

Pipe previously set on skids, because of unfavourable temperature conditions shall be lowered into the trench normally in the cool of the morning and only when the temperature of the pipe is below the softening point of the coating materials.

All skid marks and other places of damages shall be thoroughly examined to ensure proper patching where necessary, before the pipe is finally lowered into the trench.

**Handling of Coated Pipes**

Coated pipes shall not be placed in trench until cave in plugs, hard clods, stones, skids, welding rods etc. have been removed there from. Where the trench has a hard or jagged bottom, sufficient fine dirt or sand shall be placed therein, before the pipe is lowered.

Coated pipe shall not be handled or moved by means of cable or chains or by prying with skids or bars. It shall be tied and lowered by using lowering belts of a standard width and designs for the size of pipe being handled.

Coated pipe shall not be dragged along the ground or otherwise handled in a manner that shall be detrimental to the coating.

**Lining up & Welding**

The ends of the pipe line shall be kept securely closed to prevent entry of any foreign material/ moisture after lowering into the trench.

Before making joints the pipe shall be carefully laid so as to be perfectly aligned in both plan and profile and the end closures provided shall be removed.

Tie-in shall be made in the coolness of the morning or when the ambient temperature is not exceeding 29 $^{0}$C or softening temperature of the coating material whichever is less. All bevelling, aligning and welding shall be in accordance with the welding specifications.

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

8.4.0 **Draining**

All lines and equipment shall be completely drained after the hydrostatic test of a system has been completed. High point vents shall be open to prevent excessive vacuum and permit complete draining.

If it becomes necessary to leave a system filled with the testing medium for any abnormal length of time, suitable arrangement such as venting shall be made to provide for possible liquid expansion with change in ambient temperature.

8.5.0 **Backfilling**

After testing and inspection of the pipeline to the entire satisfaction of the Owner/Owner's representative, the trench shall be backfilled with the same material as the pipe bed above the top of the pipe. No trench shall be backfilled without the approval of Owner/Owner's representative.

Backfilling with the excavated material shall be done in layers of 200 mm, well watered and rammed to avoid any settling afterwards.

The Bidder shall place soil over the trench to such a height as to provide adequately for future settlement of the trench backfill.

If due to exigencies of the work, some portion of the pipeline is backfilled without approval of the Owner/Owner's representative, the Owner/Owner's representative shall have the right to order uncovering of the pipe for examination and the cost of such uncovering shall be borne by the Bidder.

The backfill material shall be free from stone pieces.

Surplus excavated soil or rubbish material shall be removed by the Bidder at his own cost to a place designated by the Owner/Owner's representative.

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When the trench has been dug through roads all backfill shall be thoroughly compacted. In certain cases, special compaction methods may be required by the Owner/Owner's representative. This shall be done by the Bidder at no extra cost to the Owner/Owner's representative.

When the trench has been dug through unlined ditches the backfill shall be thoroughly compacted in 150 mm layers for a distance of 1.50 m beyond the outside banks of the ditch on either side. The banks of the ditch shall also be compacted in 150 mm layers at no extra cost to the Owner/Owner's representative.

After the roads have been already graded, if they are trenched or otherwise disturbed by the Bidder during laying of the pipelines. The Bidder shall restore the road to its original level and condition. In the event, the Bidder is required to place extra fill, gravel, or other special material it shall be borne by him without any extra cost to the Owner/Owner's representative.

8.6.0 **Clean up of Surroundings**

As soon as the backfill is completed, the Bidder shall immediately clean up the adjoining area by removing all surplus and defective material and dispose of all refuse such as spurs, sheet iron, broken skids etc. to the complete satisfaction of the Owner/Owner's representative.

# VOLUME - III

# SECTION - 2

# DETAILED TECHNICAL SPECIFICATION – MECHANICAL

# SUB-SECTION – 2.11

# THERMAL INSULATION

**VOLUME - III**

**SUB-SECTION - 2.11**

**THERMAL INSULATION**

## 1.0.0 GENERAL

This section is intended to provide the scope, design, constructional and functional requirements of thermal insulation for piping, valves, fittings and equipments for the purpose of heat conservation, temperature maintenance, process stabilization, personnel protection.

## 2.0.0 SCOPE OF SUPPLY

Thermal insulation

Marine grade aluminium Cladding material & Other Accessories materials.

Cladding sheet, all other ancillary materials i.e. Wires, Straps, Zinc coated Screws, Wire netting, Joint sealing compound, Ceramic mill boards, MS flats, Lugs, Bolts & Nuts etc. shall be of commercial quality.

## 3.0.0 DESIGN REQUIREMENTS

### 3.1.0 Insulation Material

Thermal insulation shall be required for all hot piping and equipment with fluid temperature greater than 60$^{o}$C.and for piping and equipment for the following cases:

- Conservation Energy and thereby increase system thermal efficiency.
- Maintaining the process temperature.
- Personnel protection
- Prevention of condensation.

Piping and equipment shall be insulated with Bonded Mineral (Rock) wool mattresses conforming as per the relevant code & provided as below:

Lightly Bonded Mineral (Rock) Wool Mattresses of density 150 kg/m$^3$ shall be provided for piping where hot face temperature is more than 400 $^{o}$C and Lightly Bonded mineral (Rock) wool Mattresses of density 100 kg /m$^3$ shall be provided where temperature is less than and equal to 400 $^{o}$C.

All equipment shall be insulated with Bonded Mineral (Rock) Wool Mattresses of density 100 kg /$m^3$.

Insulation mattresses shall be finally covered with cladding, conforming to IS: 737.

### 3.2.0 Cladding material & Other Accessories materials

Cladding of Marine grade aluminium shall be required for piping and equipment for the following purpose:

- Cladding over hot thermal insulation to protect insulation surface against moisture in air or rain, to prevent physical damages etc.

Mattresses shall have backup stainless steel hexagonal wire netting for interface temperature greater than 400 $^oC$ & galvanised steel for interface temperatures less than & equal to 400 $^oC$. The insulation shall be backed with hexagonal wire mesh on one side.

Mattresses shall be wrapped and held in place using binding and lacing wires. The binding and lacing wires shall be of stainless steel material for interface temperature greater than 400 $^oC$ & galvanised steel for interface temperatures less than & equal to 400 $^oC$.

Insulation supporting arrangements for vertical piping and equipments shall be provided.

The straps for securing Aluminium cladding sheet shall be of Aluminium material.

## 4.0.0 CONSTRCTION REQUIREMENT

### 4.1.0 Construction requirement of Insulation

Insulation work on piping and equipment shall be done after the system has been completely tested, cleared and cleaned of loose scale, rust, grease etc. and after application of primer.

Insulation materials shall be dry. If the materials become wet after application, they shall be dried or replaced before weather proofing work.

When applying cold insulating materials, care shall be taken to ensure that the material is applied at the recommended applied density.

When applying multi-layer material for cold insulation all joints shall be staggered and each layer shall be separately secured in place. Unless otherwise specified, at least the final two layers shall be provided with a suitable vapour barrier where the operating temperatures are above 0 °C.

For cold insulation, the lugs or other insulation supports used shall not be more than 75 percent of the total insulation thickness used in order not to puncture the vapour barrier.

Sampling lines shall be insulated. Controllers and instruments which are located indoors, together with tubing connected there shall not be insulated.

### 4.1.1 Piping

The blankets shall be properly butted to each other so that the fibres are interlocked at all longitudinal and horizontal joints.

All joints, gaps shall be densely filled with loose mineral wool. The mattresses shall be securely laced together at all joints with GI tie wires.

Where pipe work is being insulated, the valves and flanges shall be covered with removable box type insulation and a separate width of aluminium jacket shall be used over the insulation. The removable covers shall be secured in place by means of bands with quick release clips.

A small hole to act as a leakage indicator shall be formed in flange lagging.

Steam traced lines shall be insulated with a provision to accommodate one 15 NB steam trace line. Tracing union loops located outside the insulation shall be wrapped with 25 mm width, 3mm thick standard insulation tape and weather proofed.

For horizontal surface the longitudinal joints shall always be either at the bottom or on sides. When more than one layer of insulation is required the circumferential joints shall be staggered by at least 50 mm.

Bends shall be insulated in the same manner as straight pipe except that the insulation shall be applied in mitred segments to conform to the contour of the bend.

Expansion joints properly filled with loose mineral wool shall be included to allow movement and expansion of the pipe without producing random tracking of insulation.

In the case of the greater insulation thickness (atleast from 60 mm upwards) spacer shall be provided to ensure a uniform insulating thickness on all sides and a perfect circular shape of the sheet metal jacket.

### 4.1.2 Equipment

For vertical surfaces of vessels and equipment, the insulation material shall be laced together along all joints and to the support rings immediately above them. This shall be further secured by 20 mm wide 20 SWG, horizontal aluminium bands at about max 1 meter pitch. For dished ends of vessels, the insulation shall be secured by readily tensioned 20 mm wide 20 SWG marine grade aluminium bands fixed centrally to a wire ring at the outer ends to band round the body of vessel.

For insulation of equipment, supports of same metal as vessel, projecting to a point not more than half the thickness of the insulating materials shall be welded to the vessel to support the vertical insulation. The support shall be uniformly pitched at 500 mm. A support shall be located above each vessel flange at a sufficient distance above the flange bolts to allow for their easy removal.

Small cylindrical surfaces are insulated with preformed slabs or blankets section. The edges of each mattress shall be butt jointed closely together, in order to eliminate gaps and secured with GI strap bands of 15 mm wide, 0.5 mm at intervals of 250 mm. The mats to be stitched together at the horizontal joint using 0.7 mm thick GI wire.

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If the insulation is in several layers, joints shall be staggered. Each layer must be secured separately.

For Equipment / Pressure vessel nozzles including man holes, hand holes and their covers, line flanges, valves and other fittings, if any, shall be insulated with removable metal jacketed sections. The jackets shall permit removal and replacement of these parts without causing damage to the insulation.

### 4.2.0 Construction of Cladding

All joints of the cladding shall be bent true to shape, properly grooved &overlapped (min 25 mm) & neatly screwed with self-tapping rust proof screw size M4 x 12 mm. The self tapping screws shall be cadmium plated and shall be flat or round headed. In addition, to these screws the sheet metal joints shall be sealed with bituminous mastic or equivalent joining compound.

The application of the cladding such that the vapour barrier of the cold insulation shall be effective and prevent moisture migration into the body of the insulation which will cause deterioration in the insulation value, physical damage to the insulation and corrosion of the cold surface.

During application of the vapour seal over cold insulation, special care is to be taken that it shall be carried down over all exposed edges of the insulation.

### 5.0.0 SPECIFIED DESIGN DATA SHEET

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| **1.0.0** | **General** | | |
| 1.1.0 | Ambient temperature | °C | Refer site condition |
| 1.2.0 | Surface Velocity | | 0.5 m/sec. |
| 1.3.0 | Emissivity | | 0.2 |
| 1.4.0 | Insulation surface temperature | °C | 60 |
| 1.5.0 | Operating temperature fore Pipe / Equipment | °C | MCR condition |
| 1.6.0 | Thermal conductivity | W/mk | As per standard. |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| **2.0.0** | **Insulation** | | |
| 2.1.0 | Material | | Lightly bonded Mineral (Rock) wool mattresses |
| 2.2.0 | Type | | |
| 2.2.1 | Preformed pipe sections | | Shall be used for pipes & fittings diameter less than and including 400 mm |
| 2.2.2 | Preformed slabs or blankets section | | Shall be used for diameter greater than 400mm and all equipment. |
| 2.3.0 | Density | kg/m³ | 100 (up to 400°C) |
| | | kg/m³ | 150 (more than 400°C) |
| **3.0.0** | **Cladding** | | |
| | Type of material | | Marine grade aluminium |
| 3.1.0 | For piping having outside diameter over insulation below 450 mm | SWG | 22 SWG (0.71 mm) |
| 3.2.0 | For piping having outside diameter over insulation above 450 mm | SWG | 20 SWG (0.91 mm) |
| 3.3.0 | Equipment | SWG | 20 SWG (0.91 mm) |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| **4.0.0** | **Finishing Cement** | | |
| 4.1.0 | Type of material | | Lightly bonded Mineral wool |
| 4.2.0 | Density | $kg/m^3$ | 1100 |

**VOLUME - III**

**SECTION - 2**

**DETAILED TECHNICAL SPECIFICATION - MECHANICAL**

**SUB-SECTION - 2.12**

**LABORATORY AND LABORATORY EQUIPMENT**

**VOLUME - III**

**SUB-SECTION - 2.12**

**LABORATORY AND LABORATORY EQUIPMENT**

## 1.0.0 GENERAL

The main function of the laboratory is to support the operation and maintenance of the Power Plant.

Mainly standard chemical and physical analysis will be carried out on lube oil, steam, condensate, demineralised water, cooling water, wastewater, etc.

## 2.0.0 SCOPE OF SUPPLY

The Contractor shall provide the laboratory and laboratory instruments, which shall comprise, but not be limited to, the following fixtures, apparatus and other necessary devices.

- Fixtures as specified.
- Equipment/Instruments as specified.
- Apparatus as required. Bidder to submit list.
- Reagents as required. Bidder to submit list.
- The Contractor shall furnish and install the items mentioned above, and shall design the laboratory room which shall serve as the steam/water analysis room, gas cylinder storage room.
- All the required testing equipment for analysis of water, lubricating oil and different materials etc., shall be included in the scope of the Contractor.
- The equipment quoted by the Bidder shall be complete in all respects to enable the specified tests to be carried out without the necessity of getting remaining items from other sources. In case of incomplete equipment quoted by the Contractor, he shall state clearly the items or parts omitted by him and the specification of such parts giving the dimensions, material of construction etc., and also possible source of procurement.
- The Contractor, while quoting the complete equipment, shall also give a list of components and parts, comprising the whole equipment and indicate separate prices for such parts and individual detailed specifications of each part.
- All items quoted by the Bidder shall be described in detail with respect to ratings, characteristics, accuracy, ranges etc. Fully illustrated leaflets, descriptive catalogues, line diagrams and dimensional drawings giving a complete picture of the equipment shall be submitted in his Tender.
- All equipment supplied requiring electrical operation shall generally be suitable as per power supply stipulated under his responsibility. Wherever the equipment requires different power than above, the Contractor shall also provide necessary equipment/ accessories with the testing equipment to put the instrument for useful operation under the laboratory power supply as above.
- The Contractor shall also supply all necessary tools and tackles required for operation and maintenance of the equipment.

- Facilities of dark room and air conditioning shall be provided in each of the laboratories where found necessary. The Contractor shall also provide any specific furnishing of laboratory rooms to accommodate testing equipment for suitable useful operation. This shall include foundation structure of equipment, providing water and electricity for laboratories, laboratory tables, sinks reagent store cabinets, fume hoods, office furniture, water taps including eye wash and safety showers and laboratory cleaning equipment wherever found necessary.
- The equipment/instrument shall have to be installed, tested, calibrated and further commissioned at site by the Contractor, to the satisfaction of the Employer.
- The Contractor shall also supply all necessary glassware items and testing chemicals required for one-year operation. All glassware items shall be of corning/Pyrex or equivalent make and the testing chemicals shall be of analytical/guaranteed reagent grade/highest order of purity grade. Suitable racks/shelves/tools shall also be provided by the Contractor to store the glassware and chemicals and their handling.
- After the incoming cable, all electrical installations including 415 / 240 V switchgear, AC / DC Boards, Control switches, push buttons, all electrical points, cables etc., shall be in the scope of the Contractor.
- All associated civil/structural works of all the laboratories including foundations of equipment, water connections, skins, drain channels, cable trenches, acid/alkali proof lining of drain channels/pipe etc., shall be in the scope of the Contractor. Drains from different laboratories shall finally be led to the neutralization pit, the work for which shall be in the scope of the Contractor.
- The Contractor shall, also take care of, any other item not specifically mentioned but required by the system.
- The Contractor shall supply design, layout and location of each laboratory including storing facilities for glassware, chemicals, safety equipment and other necessary equipment.
- All necessary piping including pressure reducing valves, regulatory valves of gas piping, gas cylinders for all analytical instruments, demineralised water piping, filter water piping to be used for utility of analysis works shall be supplied by the Contractor and furnished gas cylinder room shall be provided.
- The Contractor shall design, supply and erect all necessary facilities for Laboratory rooms including.

  a) Complete water supply of service water and drinking water.

  b) Complete water supply of demineralised water from demineralised water main pipe up to laboratory rooms.

  c) Complete drainage system from fixtures up to wastewater disposal system.

### 3.0.0 DESIGN REQUIREMENTS

Though the types and names of fixtures, apparatus and instruments described herein are specified, equivalent which can meet the specifications shall be acceptable, providing the proposed manufacturer's equipment is equal or superior in quality, function, etc.

The water analysis instruments and apparatus shall be supplied, and shall have a minimum capacity required in view of steam power plant water control.

Oil analysis instruments and apparatus corresponding to JIS or ASTM shall be provided, and shall be capable of analysing the following items.

- Specific gravity (L.O.)
- Viscosity (L.O.)
- Water content (L.O.)
- Total acid value (L.O.)
- Oil sludge (L.O.)
- Color phase (L.O.)
- Conradson carbon residue (L.O.)

Note: L.O. indicates lubricating oil use.

In case of analysing instruments, a complete set of glass, reagent and articles of consumption shall be included in the said instruments.

All accessories required for measurement shall be supplied.

The Contractor shall also be responsible to identify all equipment, which requires controlled environmental conditions for their proper functioning.

The Contractor shall design, furnish and install the respective laboratory rooms

Plug sockets for DC 110 volt and AC 415/240 volt electric power sources, as required shall be installed on walls and tables through the electric distribution panel, which shall be installed in the respective laboratory rooms.

Material such as drainage pipes (corrosion proof), gas piping service water pipes demineralised water pipes (stainless steel), piping for hot water shall be supplied by the Contractor.

Ventilation system for respective laboratory rooms shall have sufficient capacity so as to ensure personnel safety and prevent environmental pollution.

One (1) set each of draft chamber for water analysis room shall be installed with all necessary pertinent.

Materials to be used for floor of laboratory room shall be of the antalkali and acid proof type.

Drainage water discharged from respective laboratory rooms shall be sent to wastewater storage panel by submerged pump through the sump pit. The Contractor shall install the sump pit with discharge pump.

The Contractor shall execute the required site training of the Employer’s Personnel for testing method of all laboratory instruments in accordance with applicable standards, and shall provide ASTM testing method textbooks for steam, water, wastewater and lube oil analysis.

The Contractor shall supply and install complete ventilation and exhaust system including ductwork, power supply and control devices.

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The Contractor shall provide draft chamber as draft system including exhaust fan and dust work for the following room.

Water analysis room x 1 set.

The general specification of draft chamber shall be as follow:

| | | |
|---|---|---|
| Material: | Exterior | Spec antichemical backing finish |
| | Interior | Hent proof anti chemical<br>Inner lighting reinstalled |
| Buffule dumper: | Hard chloroethylene | |
| Buffule duct: | Hard chloroethylene, drain trap reinstalled | |
| Inspection door: | Tempered glass (6 mm), balance weight type | |
| Washing table: | Epoxy module | |
| Water outlet:<br>Drainage: | One (1) set : Swan neck type<br>Drum trap | |
| Gas outlet: | Two (2) set : antichemical backing finish | |
| Plug socket: | AC 240 V 15 A twin outlet | |
| Air intake: | Air intake unit and fan with air intake stop censer | |
| Exhaust fan: | Not less than 18 $m^3$/min. | |

The Contractor shall supply and install grounding for each equipment. Plug wochets shall also be grounded to comzed grounding wire.

### 4.0.0 FIXTURES LIST

All fixtures of the best quality shall be procured and provided by the Contractor.

### 4.1.0 Water Analysis Room

| Item | Dimension (L x W x H) | Quantity |
|---|---|---|
| Drawer cupboard | 1500x750x800 | One (1) set |
| Sink unit | 1500x750x(800+160) | One (1) set |
| Center table (with two sink unit and drawer cupboard) | 3000x1500x800 | One (1) set |
| Storage cupboard | 1760x400x970 | Two (2) sets |
| Wall table | 1800x750x800 | One (1) set |
| Corner unit | 1100x1100x800 | One (1) set |
| Vibration proof balance table | 900x750x750 | One (1) set |
| Office desk and chair | | One (1) set |

### 4.2.0 Storage Room and Dark Room Oil Analysis Room

| Item | Dimension (L x W x H) | Quantity |
|---|---|---|
| Storage cupboard | 1760x400x970 | Two (2) sets |
| Storage cupboard | 1800x500x1800 | Two (2) sets |
| Wooden shelf | 1000x610x1830 | Two (2) sets |
| Corner unit | 1100x1100x800 | One (1) set |
| Wall table | 1500x750x800 | One (1) set |

### 4.3.0 Oil Analysis Room

| Item | Dimension (L x W x H) | Quantity |
|---|---|---|
| Storage cupboard | 1800x500x1800 | One set |
| Bottle cabinet | 680x620x750 | Two set |
| Wall table | 2400x750x800 | Two set |
| Wall table | 1800x750x800 | Two set |
| Drawer cupboard | 1800x750x800 | One set |
| Corner unit | 1100x1100x800 | One set |
| Sink unit | 1500x750x(800+160) | One set |
| Center table (sink unit and drawer board) | 3000x1500x(800+700 | One set |
| Vibration proof balance table | 900x750x750 | One set |

## 5.0.0 LIST OF EQUIPMENT

### 5.1.0 Water Analysis Equipment

### 5.1.1 PH Meter

PH meters shall be provided, and shall be complete with cells, automatic temperature compensation and spare electrodes.

The general specifications of pH meter shall be as follows:

1) Number — Two sets (Digital display)

| | |
|---|---|
| Measuring range | 0 - 14 pH, 0 to 1999 mV |
| Minimum scale | 0.01 pH mv 1mV |
| Accuracy | PH:0.01 PH $\pm$1 digit<br>mV:0.1% of rdg = 1 digit |
| Power | AC 240V |
| Temperature compensation | $0^{o}$C to $60^{o}$C |

The following accessories shall be supplied.

a) Spare electrodes
   (a) Glass Two (2) sets
   (b) Reference Two (2) sets
   (c) Combination Two (2) sets

b) Standard accessories

### 5.1.2 Conductivity Meter

Conductivity meters shall be provided to measure the conductivity of town water, service water, feed water, boiler water, demineralised water and condensate water. The meters shall be direct reading digital type instruments.

The general specification of meter shall be as follows.

| | | |
|---|---|---|
| Measuring range: | | 0.1 us/cm to 1000 ms/cm<br>1.00 us/cm - 100.0 ms/cm<br>0.100 us/cm - 10.00 ms/m<br>10.0 us/cm - 1000 ms/cm |
| Accuracy | 10us-10mv range :<br>100mv range | 0.2% rdg ± 2 digit<br>0.5% of rdg ± 2 digit |
| Temperature compensation | | $0^{o}$C to $60^{o}$C |
| Compensation accuracy | | ± $1.5^{o}$C |
| Power | | AC 240V, 50 Hz |

The following accessories shall be supplied.

| | | | |
|---|---|---|---|
| 1) | Standard cells with constant | K=1.0 | 2 pieces |
| 2) | Special cells with constant | K=0.1 | 2 pieces |
| 3) | Special cells with constant | K=10 | 2 pieces |
| 4) | Standard accessories | | |

### 5.1.3 Drying Oven

The drying oven shall be provided to enable water determination of substances.

The general specification shall be as follows:

| | |
|---|---|
| Number | One set |
| Operating temperature range | $40^{o}$C to $250^{o}$C |
| Temperature control accuracy | ± $1.0^{o}$C |
| Time to reach max. temperature | 80 minutes |
| Inner wall | Stainless steel SUS-304 |
| Inner capacity | 150 l |
| Power | AC 240V, 50 Hz |
| Power consumption | 1.5 kW |
| Accessories | Standard accessories |

**One (1) set**

### 5.1.4 Muffle Furnace

The electricity heated muffle furnace shall be provided, and shall have an adequate zone, which can be maintained, at a uniform temperature of 1150 $^{o}$C.

The general specification shall be as follows.

| | |
|---|---|
| Number | One (1) set |
| Operating temperature range | 100 $^{o}$C to 1150 $^{o}$C |
| Temperature control accuracy | ± 10 $^{o}$C |
| Temperature controller | Indicating controller (0 $^{o}$C to 1200 $^{o}$C 2 position control system, with thermocouple use) |
| Power | Single phase<br>AC 240V, 50 Hz 2 KVA |

The muffle furnaces shall be complete with accessories including thermocouple, lead wire, power supply cord, grounding wire, connecting cord, etc.

### 5.1.5 Magnetic Stirrer

The magnetic stirrer shall be supplied, and shall be capable of handling up to six sample containers at one time to efficiently stir and mix samples.
Six (6) built-in motors shall be provided and shall operate individually.

The general specification shall be as follows.

| | |
|---|---|
| Number | One set |
| Stirring speed | Approx. 300 - 2500 rpm. |
| Stirring capacity | 100 ml - 1000 ml |
| **Motor, S shading coil type** | **2 pole** |

The following accessories shall be provided.

| | |
|---|---|
| Stirring bar | Two pieces |
| Grounding wire | One piece |
| Rubber sheets | Two pieces |

### 5.1.6 Water bath

The constant temperature water bath shall be provided. The general specifications shall be as follows.

| | |
|---|---|
| Number | One set |
| Operating temperature range | Room temperature +5$^{o}$C to boiling point |
| Temperature control accuracy | ± 0.6 $^{o}$C |
| Temperature distribution accuracy | ± 1 $^{o}$C |
| Number of openings | 6, 82 mm in diameter each |
| Inside capacity | approx. 6.5 lit. |

The water bath shall be complete with accessories including thermometer, stand, and clamp.

### 5.1.7 Direct Reading Balance

The analytical electronic balance shall be provided and shall have a capacity of 200 g maximum load.

| | |
|---|---|
| Number | One set |
| Capacity | 200 g/max load |
| Indication | Fully digital |
| Readability | 0.1 mg |
| One division of 10 mg projection scale | AC 240 V, 50 Hz |
| Standard accessories | One set |

One set of top loading electronic balance with vibration proof desk shall be provided.

| | |
|---|---|
| **Number** | **One (1) set** |
| Capacity | 1 kg load (max.) |
| Indication | Digital |
| Readability | 0.1 g |
| Standard accessories | One (1) set |
| Power | AC 240 V, 50 Hz |

### 5.1.8 Electric Refrigerator

One set of electric refrigerator to be used for storage of reagents and samples shall be supplied.

| | |
|---|---|
| Number | One set |
| Total capacity | 225 lit. (Freezer cap: 52 lit.) |
| Temperature range | (at 30$^{o}$C ambient) |
| Freezing room | -18$^{o}$C |
| Refrigerating room | 3$^{o}$C |

### 5.1.9 Shaker

The shaker to be used for agitating, mixing and extracting of samples shall be supplied. The shaking speed shall be operated by freely selecting speeds from low to high (40 to 300 times/min.).

| | |
|---|---|
| Number | One set |
| Number of sample | 3 pieces (1000 mlit.) |
| Horizontal shaking | Approx. 40-280 times/min. |
| **Vertical shaking** | **Approx. 40-300 times/min.** |
| Timer range | 0 to 60 mm (minimum 5 min.) |
| **Power** | **AC 240 V 50 Hz** |

All accessories for this equipment shall be supplied.

### 5.1.10 Hot plate

One set of hot plate with complete accessories shall be supplied.

The general specification shall be as follows.

| | |
|---|---|
| Number | One set |
| Range of temperature | 300$^{o}$C to 400$^{o}$C |
| Power | AC 240 V, 1 kW |
| Size 350 L x 300 W (mm), minimum requirement | |

### 5.1.11 Demineraliser

The portable demineraliser shall be provided and installed in water analysis room.

The general specification shall be as follows.

Number One set

**Capacity 25 litre/hour**

| | |
|---|---|
| Total pure water produced in one cycle | 400 litres |
| Resin volume | Cation resin 0.6 litre<br>Anion resin 1.2 litre |

All required standard accessories for this equipment shall be supplied.

### 5.1.12 Jar Test Apparatus (Laboratory Flocculate)

The flocculate shall comprise a multiple stirring machine equipped with variable speed drive. Four stainless steel stirrer paddles with arrangement to vary the speed for each independently from 0 rpm to 200 rpm shall be provided.

The flocculate shall be fitted with a fractional horsepower motor, and shall accommodate jars and beakers of 100 ml capacity having 130 mm diameter. The lighting arrangement shall be provided under the base.

The general specifications for this apparatus shall be as follows.

| | |
|---|---|
| Number | One set |
| Speed | 0 rpm to 200 rpm |
| Size | 500(W) x 220(D) x 480(H) mm |

### 5.1.13 Filtration equipment

Filtration equipment to be used for filtering of testing water shall be provided.

The general specifications shall be as follows.

1) Mini pump

| | |
|---|---|
| Number | Two sets |
| Type | Oilless, diaphragm |
| Capacity | 15 l/min. (minimum) |
| **Accessories** | **One set** |

2) Filter holder

Three sets of filter holder shall be provided.

| | |
|---|---|
| Number | Three sets |
| Type | Glass |
| Size | Filter holder 47 mm<br>- Standard 2 sets |

Milipore filter 0.45 micron cellulose acetate filter discs.

### 5.1.14 Indigo Carmine Apparatus

Indigo carmine apparatus shall be provided for easy measurement of dissolved oxygen contained in the condensate water and feed water.

| | |
|---|---|
| Number | One set |
| Measuring range | 0 ppb to 170 ppb |
| Accessories | Indigo carmine reagent |

### 5.1.15 Free Chlorine Tester

Free chlorine tester shall be provided for measuring free chlorine in drinking water and service water. This testing method shall comprise the ortho-trigine method.

Number Two sets

The equipment shall be provided with all standard accessories.

### 5.2.0 OIL TESTING EQUIPMENT

The oil testing equipment shall be provided in the oil analysis room in the building.

### 5.2.1 Flash Point Tester

Pensky-Martens Flash Point Testers of JIS-K2265 or ASTM, complete with electrical heaters, electrical stirrer and igniter's shall be provided.

The general specification shall be as follows.

| | |
|---|---|
| Number | One set |
| Type | Motor agitator 90 rpm to 120 rpm |
| Power | AC 240 V, 50 Hz |

All required accessories for this equipment shall be provided.

### 5.2.2 Gravity Hydrometers

The Contractor shall provide long type hydrometers having an overall length 335 (max) with torpedo shaped bulbs 25 (max) SP.Gr, in maximum scale length of 125 mm, with a maximum permissible error of 0.0005$^{o}$SP.Gr. Adjustable for use at 15$^{o}$C.

The gravity hydrometers shall be installed in the automatic water bath for measuring the specific gravity at constant temperature.

| | |
|---|---|
| Range (in degrees) | 0.600 - 0.650, 0.650 - 0.700 |
| | 0.700 - 0.750, 0.750 - 0.800 |
| | 0.800 - 0.850, 0.850 - 0.900 |
| | 1.0 - 1.050, 1050 – 1.100 |

Hydrometer jars made of glass with foot and lip shall be provided. The general specification shall be as follows.

| | |
|---|---|
| Overall height | 360 mm ± 10 |
| Indicated diameter | 55 mm ± 3 |
| Number | Three (3) sets |

The following hydrometers and thermometers with accessories shall be provided.

| | | | |
|---|---|---|---|
| 1) | Hydrometer | 0.750 - 0.800 | Five sets |
| | | 0.800 - 0.850 | Five sets |
| | | 0.850 - 0.950 | Five sets |
| | | 0.950 - 1.000 | Five sets |
| 2) | Thermometer | 0$^{o}$C - 100$^{o}$C | Ten sets |
| | | (Mercury, 0.02$^{o}$C divisions) | |

### 5.2.3 Viscosity Water Bath

One set of viscosity water bath with complete accessories shall be provided.

| | |
|---|---|
| Number | One set |
| Measuring range | Room temperature to 100$^{o}$C |
| Temperature accuracy | ± 0.01$^{o}$C |
| Agitating method | Forced circulating (Induction motor) |
| Temperature control Accessories | One touch, automatic control |

1) Standard — One set

2) **Standard set for Cannon method of JISK2283**

| | |
|---|---|
| Range 50 - 400 cst at 50 $^{o}$C | Five sets each |
| 2.2 - 50 cst at 30 $^{o}$C | Five sets each |

3) **Stop watch**

30 sec/cycle, 0.1 sec division
Four (4) sets, 1 min./cycle
0.2 sec division (2) sets

### 5.2.4 VOID

### 5.2.5 Water Content Measuring Apparatus

The Contractor shall supply the water content measuring apparatus for determining water content in oil. This apparatus shall be furnished complete with distillation vessel condenser and two receivers of 10 ml and 25 ml each.

| | |
|---|---|
| Number | One set |
| Accessories | (a) Flask heater two sets |
| | (b) 1 set of all instruments including condenser, flask (500 ml), etc. |
| | (c) Standard One set |

### 5.2.6 Pour Point Tester

The Contractor shall provide the pour point tester for measuring the pour point of oil. This equipment shall be furnished complete with all required standard accessories.

| | |
|---|---|
| Number | One set |
| Measuring range | -12 $^{o}$C |
| Vessel | Metal bath |

### 5.2.7 Centrifuges

Small laboratory centrifuges of 240 V, 50 Hz single phase with adjustable control of motor speed between 1000 rpm to 4000 rpm shall be provided.

The equipment shall be of angle rotor self-balancing type having buckets, which accept 15 ml centrifuge tubes.

The motor and rotor shall be completely enclosed.

The general specification shall be as follows.

| | |
|---|---|
| Number | One set |
| Speed | 4000 rpm |
| Capacity | 100 ml x 4 |
| Size | 850(W) x 850(D) x 950(H) mm |

All required standard accessories shall be provided.

### 5.2.8 Hot Plate

One set of hot plate with complete accessories shall be supplied.

The general specification shall be as follows.

| | |
|---|---|
| Number | One set |
| Temperature range | 300 $^{o}$C to 400 $^{o}$C |
| Power | AC 110 V, 1 kW |
| Size | 350 L x 300 W (mm) minimum requirement |

# VOLUME - III

# SECTION - 2

# DETAILED TECHNICAL SPECIFICATION – MECHANICAL

# SUB-SECTION - 2.13

# INSPECTION AND TESTING AT MANUFACTURER'S WORKS

**VOLUME - III**

**SUB-SECTION - 2.13**

**INSPECTION AND TESTING AT MANUFACTURER'S WORKS**

## 1.0.0 GENERAL

This section is intended to provide the scope, design, constructional and functional requirements for Inspection and Testing of various mechanical equipment, material, parts, and workmanship of the Plant during manufacture, to demonstrate compliance with specification, codes and standards and to ensure overall reliability of plant operation and performance.

## 2.0.0 INSPECTION AND TESTING REQUIREMENTS

The equipment to be supplied under this Contract shall be subject to works' inspections and workshop tests.

Bidder shall issue a quality assurance programme, indicating the kind and extent of inspections and tests to be carried out on plant components. These inspections and tests shall prove whether the equipment fulfils the requirements of the Contract in view of:

- safety conditions
- consideration of the applied standards and regulations
- execution of workmanship
- Conformity with the present state of modern technology.

### 2.1.0 Material tests

Test specimens shall be taken from all important forgings, castings, tubing, etc., in accordance with the relevant standards and codes. Dimensions shall be adequate for the purpose intended and the test specimen shall accompany the component through all phases of the heat treatment. Before cutting or otherwise removing the test specimens, these shall be permanently banded together with the forgings, castings or components which they represent and, if requested, in the presence of the Owner/Owner's representative. Except where expressively otherwise approved, all test specimens shall be machined to the dimensions specified in the relevant standards find codes. Steel castings and forgings, in all cases; be annealed before the test specimens are withdrawn.

Chemical analysis and mechanical properties of the material concerned shall also be submitted.

All casting components shall be tested for compliance with the relevant standards and codes and shall be suitable for the purpose for which the castings are to be used. The chemical analysis and mechanical properties of the material tested shall be provided by the Bidder. The results obtained from these material tests shall be in compliance with the values contained in the relevant standards and codes and with the figures quoted in the relevant sections of the Contract, if any X-ray examination and ultrasonic examination of circumferential, longitudinal, nozzle welded joints, stiffening rings, etc., shall be carried out by the Bidder in compliance with the standards under which the relevant equipment will be designed.

All castings and forgings shall be subjected to X-ray and / or ultrasonic tests before the start of machining procedures, in order to detect defects as early as possible and to replace in time defective parts, thus avoiding undue delay in the manufacture and delivery of plant components. After partial machining in the Bidder's workshop, further tests may be performed. No repair welding machining of castings and forgings of major components shall be carried out without prior

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inspection and confirmation by the Owner/Owner's representative. In case of a rejection, written and certified notice must be given to the Owner/Owner's representative, indicating also measures undertaken by the Bidder in order to cope with the requirements of the Contract.

**Major steel forgings**

Purchase specifications shall clearly state the quality and inspection requirements and should include, but not be limited to:

a) chemical composition range

b) heat treatment

c) mechanical test specimen locations

d) mechanical properties

e) magnetic properties (when applicable)

f) non-destructive testing
   - methods and procedures
   - stage and extent of application
   - recordable indication size
   - allowable indication size

g) thermal stability test (HP and reheat turbine shafts only)

Each forging shall be suitably marked with an identification number which shall transferred throughout all machining stages. The identification number shall be indicated on all documents relating to the forging.

Repair welding will not be permitted on rotating parts and on other components the proposal will be subject to approval by the Owner/Owner's representative.

**Rotor forgings**

The profile of forgings at the stage of final ultrasonic Inspection should be such as to minimize the regions where complete coverage is not possible.

Ultrasonic indications should be measured by the equivalent flat bottomed hole or AVG (DGS) method.

The toughness of rim and core (where applicable) material shall be evaluated by testing charpy V- impact specimens over a range of temperatures and thus determining the 50% fibrosity fracture appearance temperature.

Allowable indication size and material toughness are interdependent design related criteria and the Bidder must be prepared, if requested by the Owner/Owner's representative, to justify his proposals by reference to fracture mechanics calculations.

Bores, when provided, shall be magnetic particle inspected and a suitable intrascope used for examination.

**Major steel castings**

Purchase specifications shall clearly state the quality and inspection requirements and should include:

a) chemical composition range
b) heat treatment
c) mechanical test specimen locations
d) mechanical properties
e) non-destructive testing
   - methods and procedures
   - stage and extent of application
   - recordable indication size
   - allowable indication size
f) other tests
g) standard weld repair procedure

Each casting shall be identified by hand stamped or cast-on reference numbers which shall be Indicated on all documents relating to the casting.

**Non-destructive testing**

Minimum requirements are as follows:

a) Crack detection of critical areas of castings which in the case of castings to operate at high temperature or high pressure shall consist of 100% of all accessible areas. Magnetic particle inspection shall be used for ferritic steel castings.
b) Ultrasonic inspection of all surfaces of castings to operate at high temperature or high pressure.
c) Ultrasonic thickness check of critical areas.
d) Radiographic examination adjacent to future butt weld regions (Acceptance Standard Level 1 of ASTM E446 or E186 as appropriate).
e) Radiographic examination shall also be used to assist in defining defects indicated by ultrasonic inspection.

In addition to being applied as necessary quality control on as cast items, inspections outlined in a) and b) above shall be applied to the finally heat treated casting.

Prior to non-destructive testing all surfaces shall be satisfactorily prepared and visually examined.

**Repair welding**

Unacceptable defects observed by visual examination or indicated by non-destructive testing shall be excavated by chipping or thermal gauging and grinding and their complete removal proved by crack detection.

In the case of excavations which penetrate more than 25 mm or 50% of the wall thickness or cover more than 10,000 $mm^2$ area the Owner/Owner's representative's written approval of the proposed repair must be obtained.

Only welders qualified by performance tests on similar cast materials shall be used.

On completion of repair welded areas shall be ground smooth and carefully blended into the surrounding material. The repaired areas shall be surface crack detected, magnetic particle inspection being used for ferritic steel castings and in addition ultrasonic inspection shall be used on castings to operate at high temperature or high pressure.

**Steel plates and sections**

The following requirements, which may be supplementary to the applicable material standards, shall be considered when selecting material grades:

- impact testing of plate or sections over 50 mm thick (impact requirements to be dependent on application)
- ultrasonic testing of plate where the presence of non-metallics may interfere with the interpretation of ultrasonic testing of future welds
- ultrasonic testing and through thickness ductility measurement, where the application involves the risk of lamellar tearing in the material at regions of high restraint (e. g. at set-on nozzle locations or cruciform joints)
- ultrasonic testing clad materials to detect lack of bonding (proposed rectification procedures shall be submitted for the approval of the Owner/Owner's representative.

**Reinforced thermosetting resin pipes**

Checks shall be made on all raw materials to ensure that they comply with the relevant ASTM Standard.

All deliveries of resin shall be checked for consistency by viscosity and reactivity. Any resins deviating from the manufacturer's published figures shall not be used.

Testing of reinforced thermosetting resin pipes:

- Long term hoop strength (type test for pressure pipes only)

  In accordance with ASTM D2992 Procedure B with the exception that the test results shall be extrapolated to determine the stress which the pipe can withstand for a period of 60 years without failure. The lower 95% confidence limit at 60 years shall also be calculated.

- Hydraulic test

  100% of the pipes shall be subjected to an internal hydraulic pressure test at the manufacturer's works prior to delivery. The test shall be applied to a pressure equal to 1.5 times the maximum working pressure stated for each classification of pipe. The test pressure shall be applied for a minimum period of 5 minutes without signs of leakage.

- In addition to the above the first pipe and every thirtieth thereafter of each class and diameter shall be maintained at test pressure for a minimum of 4 hours without signs of leakage.

  Each pipe and fitting shall be subjected to an internal low pressure air test at the manufacturer's works prior to delivery. The test pressure shall be an overpressure of 0.1 bar and this shall be applied for a minimum period of 5 minutes without signs of leakage or distress. Fittings which are of mitred construction shall be manufactured from pipes which have successfully passed the tests defined above.

- Dimensions

  The dimensions and tolerances of all pipes shall be determined in accordance with ASTM-D 2122 Stiffness.

  A minimum of one pipe for every 30 pipes manufactured shall be tested for stiffness in accordance with ASTM-D 2412 "Method of Test for External Loading Properties of Plastic Pipe by Parallel Plate Loading". A minimum of one pipe of each class and diameter of pipe shall be tested.

  Longitudinal and hoop tensile strength. The tensile strength properties of a minimum of one pipe for every 100 pipes manufactured shall be measured in accordance with ASTM-D 638. A minimum of one pipe of each class and diameter of pipe shall be tested.

- Cure

  Curing, to be tested by the Barcol Hardness test determined in accordance with ASTM-D 2583 standard: 100 % of the produced pieces. Minimum acceptable hardness is 90% of the value recommended by the resin manufacturer of the particular resin used, when non-reinforced. The sample pipe shall also withstand a commercial acetone test on the internal portion of the laminate.

- Loss on ignition

  A minimum of one pipe for every 30 pipes manufactured shall be tested in accordance with ASTM-D 2584 "Standard Method of Test for Ignition Loss of Cured Reinforced Resins".

- Joint tests

  A minimum of two pipes in every 100 pipes manufactured shall be jointed and tested in accordance with the requirements of section 7.2 of ASTM-D 3262.

- Visual inspection

  Each pipe and fitting shall be subjected to a complete visual inspection before shipment in accordance with ASTM-D 2563.

- Vacuum test

  Vacuum test of pipe shall be carried out for each diameter once at beginning of production. The vacuum to be applied shall be equivalent to the condition which occurs during full vacuum. The corresponding derated vacuum for this test shall be proved by the pipe manufacturer.

- Failure of tests on completed pipes.

  In the event of a specimen not fulfilling the minimum requirements for strain corrosion resistance, all pipes of that class and diameter which have been manufactured shall be rejected and shall be replaced entirely.

  Any pipe or fitting which fails any of the quality control tests which are to be carried out on each and every pipe or fitting shall be rejected. In the event of any pipe failing any of the remaining tests outlined above that pipe shall be rejected and the relevant test shall be carried out on a further ten pipes of that class and diameter. If any one of these ten pipes fails than the manufacture of pipes of that class and diameter shall cease and the Owner/Owner's representative reserves the right to reject all the pipes of that class and diameter.

- Thermal insulating materials

  Materials shall be tested for bulk density, specific heat, compressive strength, fire resistance under pressure, service temperature limit in accordance with VDI 2055 or equivalent standards.

- Workshop manufacturing and pre-assembly

  All workshop fabricated components and parts of the plant shall, to the fullest practical extent, be formed, machined, fitted, welded, stress-relieved. X-rayed, adjusted, tested, cleaned and painted. The equipment shall be pre-assembled in the workshop of the Bidder or his sub-supplier to the maximum possible extent, then dismantled only as far as required for safe and proper shipment, in order to keep erection work on site to a minimum. Equipment and parts shall be marked, labelled or otherwise identified to facilitate assembly and erection on site. Marks and labels shall be fixed in such a manner so that deformation or obliteration shall not 'occur during shipment, storage and erection on site.

### 2.2.0 Manufacturing tests

### 2.2.1 Welding

Welding procedures shall be qualified in accordance with the requirements of the construction code/specification for the item of plant concerned and in the case of critical plant items the tests shall be witnessed by an internationally recognised inspection authority.

Welders shall be qualified in accordance with the requirements of the construction code/specification for the item of plant concerned for all types/positions of welding he may perform.

A system of positively identifying the work of each welder shall be maintained and any welder whose work is the subject of multiple rejections shall be required to undergo a requalification test. Any welder failing the retest may, at the discretion of the Owner/Owner's representative be disqualified from further welding on items under this contract.

Welded fabrications shall be stress relieved when specified by the applicable standard or for dimensional stabilisation prior to machining.

Copies of temperature charts referenced with load items shall be included in the test certification supplied for the relevant items.

All welds shall be visually examined and shall be of smooth contour, free from cracks, undercut and other significant defects. Wherever possible the interior of tubes etc. shall be examined using a suitable optical device where necessary.

Fillet welds shall be checked for size using suitable gauges which shall be available for use on request by the Owner/Owner's representative during an inspection visit.

**Non-destructive examination of pressure and vacuum containment welds**

Welds shall be non-destructively tested in accordance with the construction standard applicable to the item of plant. In addition the requirements of the **following Table 2.15.1** shall be observed. This table shall also apply in cases where the standards used for design and construction of an item of plant does not specify the quality requirements for welds. Fault limitations to be subject of agreement with the Owner/Owner's representative prior to fabrication.

**Table 2.15.1 : Non-Destructive Testing**

| Type of Steel | Design Factor (shell) | Wall thickness (mm) | Inside diam. (mm) | Type and Extent of Non-Destructive Testing | | | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | Butt | Nozzle | Fillet | |
| C and C-Mn steels with C content not exceeding 0.25% | ≤ 0.85 | ≤ 10 | all | - | - | - | Only applicable to: Atmospheric systems (excluded systems, which handle chemicals, toxics or flammable media). |
| | | ≤ | all | 10% R | - | - | |
| | | > 40 | all | 100% R | 10% M | 10% M | |
| | > 0.85 | ≤ 40 | ≤ 100 | 10% R | - | - | |
| | | | > 100 | 100% R | 10% M | 10% M | |
| | | > 40 | all | 100% R | 100% M | 100% M | Test after stress relief |
| C-Mn steels with C content 0.25 to 0.35% and C 1/2 Mo steels | | ≤ 30 | all | 10% R | 10% M | 10% M | Applicable below 50 bar |
| | all | > 30 | all | 100% R | 100% M | 100% M | Test after stress relief |
| Low alloy steels except CrMoV and 2 CrMo | all | all | all | 100% R | 100% U | 100% M | Test after stress relief |
| CrMoV and 2CrMo steels and 12% Cr ferritic/ martensitic steels | all | all | ≤ 100<br>> 100 | 100% R<br>100% R*<br>100% U | 100% M<br>100% M<br>100% U | 100% M<br>100% M | Test after stress relief<br>Test after stress relief |
| * Radiographic examination may be omitted if done on as-welded joint | | | | | | | |

| Type of Steel | Design Factor (shell) | Wall thickness (mm) | Inside diam. (mm) | Type and Extent of Non-Destructive Testing | | | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | Butt | Nozzle | Fillet | |
| Austentic Stainless Steels | ≤ 0.85 | ≤ 15 | all | - | - | - | Not applicable to: Butt welds made from one side only Operating temperatures exceeding 200 °C |
| | | ≤ 30 | all | 10% R | - | - | |
| | | > 30 | all | 10% R | 10% D | 10% D | |
| | | | ≤ 100 | 10% R | - | - | |
| | > 0.85 | ≤ 30 | | | | | |
| | | | > 100 | 100% R | 10% D | 10% D | |
| | | > 30 | all | 100% R | 100% D | 100% D | |

Legend: R = Radiographic examination
U = Ultrasonic examination
M = Magnetic particle examination
D = Dye penetrant examination

**Note:**

1. Where 10% examinations are shown for pipe work under 100 mm diameter bore this shall be the circumference of 10% of the welds by each welder selected at random with a minimum of one per welder.
2. Where 10% examinations are shown for vessels or large diameter pipework this shall be 10% of each weld length and must include all intersections of longitudinal and circumferential welds.
3. Where partial examinations reveal rejectable defects, adjacent welds or areas of weld shall be examined. In the event of rejectable defects being found welds shall be subject to 100% examination.
4. Welds in clad materials shall be tested in accordance with the requirements of the base material and the surface of the overlaid welds shall be dye penetrant tested throughout their length.

**Non-destructive examination of structural welds**

Welds shall be non-destructively tested in accordance with the construction standard applicable to the item of plant. Where appropriate, the following requirements shall also be observed:

Magnetic particle testing of the tension side welds In major fabricated girders and sections.

Ultrasonic examination of heavily restrained welds (e. g. cruciform joints) where there is a risk of lamellar tearing in the parent material.

**Weld repairs**

Unacceptable defects observed by visual examination or indicated by non-destructive testing shall be completely removed by chipping or thermal gouging and grinding. The resulting excavation shall be crack detected prior to re-welding.

Details of the original defects and repair shall be recorded.

Repaired welds shall be subjected as a minimum requirement to the same inspection requirements as the original welds and test records should indicate that a repaired weld is referred to.

### 2.2.2 Pressure testing

All items subjected in service to internal pressure or vacuum shall, unless otherwise agreed, be pressure tested in the manufacturer's works and prior to any internal or external coating.

**Hydrostatic testing**

All pressure vessels, inserts or other parts of such vessels, which are subject to an internal pressure or vacuum during operation shall undergo a hydraulic or other approved test. Unless otherwise stated in the specification, the test pressure shall be maintained for a sufficient period to permit complete examination by the inspector.

Should it be necessary to carry out repair welding on stress-relieved equipment, it must undergo a stress-relieving process again. In all such cases, the hydraulic test must be repeated.

Particular attention must be paid to the temperature of water used for hydraulic testing which shall not be less than 20°C. Prior to testing, metal temperatures shall also not be less than 20°C. Where pressure parts 600 mm in diameter and above are being tested, the hydraulic pressure shall be raised to the test pressure in stages, during which the item shall be examined and all defects rectified before the full test pressure is reached.

Suitable water shall be used as the test media unless otherwise agreed and test pressures shall be in accordance with the applicable construction standard but if none is specified then the test pressure shall be 1.5 times the design pressure but not less than an overpressure of 3.5 bar. Test pressure of vacuum containment items shall be agreed with the Owner/Owner’s representative.

The test pressure shall be maintained for sufficient time to permit complete visual examination of all surfaces and joints and in no cases less than specified in the applicable construction standard.

The chloride content of water used for testing austenitic stainless steel items shall not exceed 30 ppm unless immediate flushing with water of this quality is done after the test.

**Pneumatic testing**

The Bidder shall apply pneumatic testing in cases where hydrostatic testing is impractical or undesirable. Safety precautions, test pressures/ duration and degree of prior non-destructive examination of the subject items shall be agreed with the Owner/Owner’s representative.

Pneumatic or gas leak testing supplementary to hydraulic testing shall be applied in appropriate cases where specified by the applicable construction standard.

### 2.2.3 Testing of corrosion protection

**Surface coatings**

Following tests have to be performed before, during and after coating:

- visual inspection of blasted surfaces according to DIN 55928 part 4, annex 1
- checking of coating material

- measurement of air humidity, air temperature and coating area temperature (determination of dew point)
- visual inspection of coating
- checking of dry film thickness (DFT)
- checking of adhesion.

**Galvanised zinc coatings**

Surfaces shall be visually inspected. Bare patches, lumps blisters or inclusions of foreign matter shall be cause for rejection.

Zinc coating thickness shall be determined non-destructively in accordance with DIN 50981 or coulometrically in accordance with DIN 50932. For coatings with a weight exceeding 900 g/m$^2$ the coulometric test method specified in DIN 50932 shall be used.

**Hard rubber linings**

Surfaces shall be visually inspected. Uneven surfaces, splits, blisters or inclusion of foreign matter shall be cause for rejection.

The thickness of linings shall be measured in accordance with VDI Standard 2539 or equivalent. A tolerance of + 10% is permitted for rubber coatings of 3 mm nominal thickness.

Hardness tests shall prove compliance with the rubber manufacturers standards.

The absence of pores shall be proved by the induction sparking test method. The potential used shall be 5,000 Volts for each mm of thickness plus an additional 5,000 Volts (i.e. potential of 20,000 Volts for 3 mm thick lining).

## 2.3.0 Mechanical equipment

### 2.3.1 Rotating units

**Balance testing of rotating units**

Each rotating unit shall be first statically balanced and then dynamically balanced (in the case of impellers this shall be done before and after mounting of the service rotor shaft). A check balance of items that have undergone overspeed test shall also be made.

**Vibration testing of rotating units**

The vibration characteristics of rotating units shall be measured during performance tests. Locations of measurement and standards to be achieved shall, on request, be subject to agreement by the Owner/Owner's representative.

### 2.3.2 Gas turbine

All equipment and components of gas turbine generator shall be works tested in accordance with the manufacturer's standard methods and procedures as necessary to ensure high quality materials and equipment, reliable and safe operation, and long life. Copies of the manufacturer's quality assurance programme, manufacturing test description and pre-shipment operating test descriptions shall be submitted in advance of the start of fabrication, along with a listing of the test reports to be provided to the Owner/Owner's representative and a schedule of each test. Example copies of representative key test reports shall also be provided.

All major components namely the gas turbine, auxiliary components, generator and other major and critical systems included in the gas turbine package shall be required to undergo acceptance test-run at the manufacturers works prior to delivery at site. The Owner/Owner's representative will witness the acceptance test for all major components.

A no-load operational test shall be made for the turbine, using Natural Gas fuel. All control and safety devices shall be checked for proper operation during this test.

The GT compressor rotor is to be statically and dynamically balanced and over speed tested at the factory.

The following items shall be checked during no-load operation of the turbine :

- Bearing oil temperature rise.
- Vibration levels over the operating speed range.
- Exhaust temperature.
- Wheel space temperatures.
- Fuel system operating characteristics.
- Overspeed trip.
- Coolant system.
- Air flow & pressure ratio.
- AOP cut-in and cut-out pressures.
- Individual accessories, including heat exchangers for lube oil and water, solenoid valves, stop valves, control valves, pumps, motors, ignition system, gauges, thermocouples, heaters and electric switches.
- Check for assembly clearance after the test.

Prior to the no-load test, all pressure containing parts shall be hydrostatically tested at 1.5 times the design pressure. The turbine and compressor rotors shall be precision balanced before being fitted into the turbine stator and the turbine and generator rotor shall also be tested for a minimum of 120% rated speed for about five (5) minutes.

### 2.3.3 Steam turbine

The turbines shall be completely assembled with their control, stop and governing valves on a suitable erection rig at the manufacturer's works and shall be carefully inspected and measured for manufacture and assembly tolerances. Functional tests shall be performed on the safety equipment (running with steam is not requested).

Important items of turbine control equipment which cannot be adequately tested during the main tests shall be separately bench tested.

Furthermore testing shall comprise:

- Balancing and overspeed test of the assembled rotor.
- Measurement of radial clearances.
- Assembling inspection.
- Bearing oil temperature rise.
- Vibration levels over the operating speed range.
- AOP cut-in and cut-out pressures.
- Check for assembly clearance after the test.

### 2.3.4 HRSG

As per the requirement of IBR / ASME.

### 2.3.5 Pumps

Running tests and performance tests shall be conducted on all pumps:

Performance tests shall be conducted through the full operation range of the pump to closed valve conditions. Graphs indicating flow/head, flow/power absorbed, flow/efficiency, flow/NPSH and speed shall be produced.

The lubricating oil used in the test shall be of the same brand and grade as that recommended by the manufacturer for service use.

Bearing oil temperature rise and Vibration levels over the operating speed range shall be measured and shall be as per the standard.

Dismantling of the pump for visual examination of parts for damage following test shall be done when required by the inspection standard, when considered necessary by the manufacturer, or when requested by the Owner/Owner's representative's witnessing the running or performance tests. Replacement of parts following test shall necessitate repeat testing.

Job motor shall be used for testing the BFP, CEP CW, ACW and CCW pumps.

NPSH test shall be performed for BFP and CEP pumps. For vertical pumps minimum submergence test shall be conducted.

For all the pumps in the plant, the Testing and acceptance std. shall be IS 5120 / HIS / PTC code. However no negative tolerance is allowed for Flow, Head, Shut off head & Efficiency at Guarantee point. However positive tolerance of 3% on Heat at Guarantee point and 5% on shut off head is permitted.

### 2.3.6 Fan

All fans shall be tested in accordance with the BS 848 part 1 and other applicable standards.

The particular test procedure to be applied to each type of fan shall be agreed with the Owner/Owner's representative. The tests shall be conducted strictly to the requirements of the agreed test procedure so that all points on the performance curves are within agreed tolerances.

### 2.3.7 Fuel Gas compressor and conditioning System

- Running tests and performance tests as per API and ASME
- balancing test of the assembled rotor
- measurement of radial clearances
- assembling inspection.
- Bearing oil temperature rise
- Vibration levels over the operating speed range

### 2.3.8 Deaerator, Condenser and Plate Heat Exchanger

- Hydro Test as per IBR/ASME sec VIII , Div 1
- Air test of tube to tube sheet joints for condenser

### 2.3.9 Gate, Globe, Regulating and Check valves

- As per IBR / ASME
- Shell Hydro test
- Seat leakage test as per BS 6755 part 1 Rate A with Air test & Hydro test.

### 2.3.10 Control Valve, Pneumatic block valve and PRDS

- As per IBR / ASME.
- Shell hydro test as per ASME 16.34.
- Seat leakage test , Actuator chamber leakage test, as per ASME 16.104.
- Operation test ( calibration , Hysteresis ).
- Flow characteristics test.

### 2.3.11 Butterfly valves

- Shell hydro test & Disc strength test as per BS 5155.
- Seat leakage test BS 5155.
- Open & close operation check for more than 14“ valve.
- Flow characteristics test.

### 2.3.12 Air compressors

Air compressors shall be tested in accordance with the requirements of BS 1571, class C.1 part 1, ISO 1217, ASME PTC-9 or similar standards. Any request for deviation from the test conditions shall be accompanied by the manufacturers' proposals for the adjustment of the correction factors contained in the standard.

No Tolerance on guaranteed values of energy consumption, volumetric efficiency, air drier capacity, dew point of air, is allowed.

### 2.3.13 Air Drying Plant

Leakage test, Auto sequential test, operating time for regeneration cycle, Dew point test

Performance test for the air dryer shall be conducted at site to prove the following parameters:

a) Rated dew point temperature.

b) No spikes in the dew point temperature during changeover from one tower to the other in the dryer.

### 2.3.14 Cranes and hoists

Where size permits cranes and hoists shall be completely assembled at the manufacturers works and functional tests without load conducted.

### 2.3.15 Fire fighting system

All testing requirement as per TAC / NFPA.

**Hydrant Valves and stand post assembly**

The stand post assembly along with the hydrant valve (valve being open and outlet closed) shall be pressure tested at a hydrostatic pressure of 21 Kg/cm$^2$ to detect any leakage through defects of casting.

Flow test shall be conducted on the hydrant valves. The flow through valves shall not be less than 900 Litres/min.

Leak tightness test of the valve seat shall be conducted at hydrostatic test pressure of 14 kg/cm$^2$(g).

### 2.3.16 HVAC

a) All Building area of the power plant shall be ventilated.

b) Air Handling Unit

Visual and dimensional check shall be done for quality workmanship and completeness of each section and component and their assembly. The cooling coils shall be pressure tested (hydraulic for chilled water, pneumatic for direct expansion type) for minimum 1.5 times the design pressure.

Performance Tests

All Air handling units shall be performance tested at the manufacturer's work. During the test reading shall be taken for various parameters like:

- Air flow rate and static pressure developed by the air handling fan.
- Cooling capacity of the cooling coil.
- Noise level at specified distance form the unit and Vibration.
- Power consumption.
- Leak tightness for the assembled unit.
- Smooth operation and responsiveness of the face and bypass damper.

c) Cooling Tower

Following test shall be carried out as shop test

- Visual check on hub for fan, FRP components, FRP casing, drift eliminators, nozzles and fills.
- Visual dimensional and leakage test of the basin, visual dimensional and profile test on the fan blade.
- Static balancing of the fan assembly.
- Thickness of zinc coating for GI components.
- Vibration.

Performance Tests

Cooling towers shall be performance tested at the manufacturer's work. During the test reading shall be taken for various parameters like;

- Noise and vibration level of the equipment shall be measured.
- Power consumption.
- Leak tightness for the assembled unit.

### 2.3.17 Water system

Functional tests on completed individual equipment shall include:

- Pumps.
- Interlock and protection panels.

# VOLUME - III

# SECTION - 2

# DETAILED TECHNICAL SPECIFICATION - MECHANICAL

# SUB-SECTION - 2.14

# WATER SYSTEM

**VOLUME - III**

**SUB-SECTION - 2.14**

**WATER SYSTEM**


| CLAUSE NO. | DESCRIPTION | SHEET NO. |
|---|---|---|
| 1.0.0 | GENERAL | 314 |
| 2.0.0 | PLANT DESCRIPTION | 314 |
| 3.0.0 | SPECIFIC REQUIREMENTS | 316 |
| 4.0.0 | PERFORMANCE TEST REQUIREMENTS & GUARANTEES | 317 |
| 5.0.0 | SUBMISSION OF TEST PROCEDURES | 318 |
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| 7.0.0 | TECHNICAL SPECIFICATION FOR VALVES | 320 |
| 8.0.0 | BOLTS AND NUTS | 321 |
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| 13.0.0 | SPECFIED DATASHEETS | 325 |

## SUB-SECTION – 2.14

## WATER TREATMENT PLANT

1.0.0 **GENERAL**

1.1.0 This section is intended to provide within the scope which includes design, constructional and functional requirements for water system for Gas Based Combined Cycle Captive power plant (CCCPP).

1.2.0 The bidders are requested to note that only the major equipments are mentioned below. Any other equipment / system not specifically mentioned below but mentioned elsewhere in the specifications and any other equipment / system essential for smooth and efficient functioning of the system shall be considered in the scope of the bidder at no extra cost. Also bidder shall ensure the adequacy of extension from existing filtered water, DM water, service water and potable water lines from locations as marked in the plot plan.

1.3.0 This section covers the technical aspects of design, manufacture, testing at works and transportation to site, supervision of erection, testing and commissioning of Water system. Capacity shall be decided by EPC bidder as per the design basis given elsewhere.

1.4.0 Supply and services shall be rendered in conformity with proven design principles, taking into account the current technology. The requirements of the contract must be fulfilled in its entirety.

1.5.0 The supply and services shall be rendered inclusive of all appliances and interconnecting arrangements with other supplies needed for proper and reliable continuous operation and for satisfactory maintenance and repair.

2.0.0 **PLANT DESCRIPTION**

2.1.0 **Description of existing Facilities**

2.1.1 **Pre-treatment Plant**

Raw water from river is pumped to the raw water reservoir. From raw water reservoir, water is treated through clarifier and gravity sand filter. This filtered water is pumped into the complex with help of filtered water transfer pump located near raw water reservoir, through 14" & 30"filtered water line. Bidder shall identify the tapping point either in 14 "or 30"line based on the availability of adequate flow and pressure

Bidder shall start their scope from counter flange and extend the piping up to cooling tower as well as overhead service water storage tank of proposed power plant with fittings, pipe rack, supports etc. However, bidder to ensure the adequacy of the flow and head at the tap off point.

2.1.2 **DM Plant**

There are 3 x 100 % (2w+1s) each of 100 $m^3$/hr is available in the existing HRSG area. Bidder to check the adequacy of the existing plant in terms of capacity requirement of DM water for proposed CCCPP.

2.1.3 **Potable water**

There is existing potable water running near to the proposed power plant as marked in the attached plot plan.

Bidder shall start there scope by taking tapping from existing potable water piping and extend the same up to overhead potable water storage tank located at the highest elevation in the proposed power plant (Over Control room building). However bidder to ensure the adequacy of the flow and head at the tap off point.

2.2.0 **Description of Proposed water system**

2.2.1 Scope of proposed DM plant for HRSG make up purpose is as below,

- Checking adequacy of existing DM plant for make - up water requirement for steam generation of proposed power plant.
- Tapping from the existing DM water line shall be taken by bidder
- 2 x 100 % (1w+1s) Mixed Bed
- 1 x 100% Acid dosing tank
- 1 x 100 % of caustic dosing tank
- 1 no. Intermediate DM water tank of 30 minutes Retention.
- 2 x 100 % DM water storage tank fill pumps of suitable capacity.
- 1 no. DM water storage tank of (1000 $m^3$)
- 2 x 100 % DM water transfer pumps for HRSG make - up.
- 1 x 100% HRSG Initial fill pump.
- 1 x 100 % pH correction dosing system with 1 no. of pH Correction dosing tank and 2 nos. of pH correction dosing pumps.
- DM water piping after Mixed Bed to DMWST in CCCPP area along with pipe fittings, pipe rack.

2.2.2 Scope of proposed Filtered water distribution for cooling tower make - up and service water purpose is as below:

- Checking adequacy of existing Pre-treatment plant for make - up water requirement for cooling tower.
- Tapping from existing filtered water line shall be taken by bidder.
- 1 no. CW makeup water storage tank.
- Extension of piping along with pipe fittings and pipe rack.

2.2.3 Scope of proposed Potable water system:

- Tapping from the existing potable water network shall be taken by bidder.
- 1 no. potable water overhead tank.
- Extension of piping along with pipe fittings and pipe rack. Distribution of potable water in the proposed CCCPP.
- “UV sterilizers” shall be used to disinfect the potable water near the potable water outlets.

2.2.4 Scope of proposed Service water system:

- Tapping from filtered water line shall be taken for service water purpose
- 1 no. Service water overhead tank
- Extension of piping along with pipe fittings and pipe rack.
- Distribution of service water in the proposed CCPP.

2.2.5 Scope of proposed Effluent disposal system:

Effluent generated from HRSG blow down along with oily waste shall be collected in the HRSG blow down tank, and pumped with HRSG blow down transfer pump to the existing PWS drain pit. SSF backwash water shall be collected in the SSF backwash storage tank and with the help of SSF backwash water transfer pump; it shall be transferred to the OWS drain pit. Cooling tower blow down, shall be routed to the existing OWS drain pit. MB regeneration waste shall be neutralised in the existing N-Pit, Bidder to check the adequacy of existing N-Pit in terms of capacity so as to accommodate the additional regeneration effluent generated by Mixed Bed unit for proposed CCCPP.

Contractor to check the adequacy of the existing effluent treatment system such as OWS & PWS, so as to handle the additional flows from the proposed CCCPP

3.0.0 **SPECIFIC REQUIREMENTS**

a) Gross capacity of the plant shall be sized corresponding to net requirement indicated including regeneration.

b) Piping of Mixed Bed Unit shall be done in such a way that there shall be interchangability of the streams shall be done.

c) Contractor to check the adequacy of extending the existing acid/alkali lines, for MB regeneration.

d) 1 X 100% CW make-up water storage tank of 1000 $m^3$ capacity shall be provided near CW forebay.

e) Minimum thickness of pressure vessels shall be 6 mm.

f) For unlined pressure vessels a minimum of 2 mm corrosion allowance shall be provided.

g) Chemical dosing pumps shall be provided with SS 316 strainer.

h) Contractor to furnish all necessary instruments including level indicators for all tanks.

i) Mixed Bed shall be designed to provide minimum chemical consumption for the specified outlet water quality.

j) The maximum allowable noise level shall be 85 dBa at 1 m from the outline of respective equipment.

k) Approved quality assurance plan of Owner/Owner's representative shall be followed by Contractor.

l) Erection and Commissioning.

m) All Electrical Equipment.

n) Complete Instrumentation & control.

o) Contractor to consider adequacy of flow, pressure & also recheck the location of hook up points at site before ordering / commercial negotiation, any change in the hook up points shall be done by Bidder without any cost implications, Also if isolation of the system is not possible at hook up points, then Bidder shall take the hot tapping at the interface points

## 4.0.0 PERFORMANCE TEST REQUIREMENTS & GUARANTEES

### 4.1.0 Guarantee Requirements

All chemicals & consumables shall be given by Supplier for 72 hours availability period from commissioning.

In addition to compliance with the requirements of the Specification, Supplier shall meet the specific guarantees of performance as required and as stated in the Schedule of Guaranteed Data. All tests shall be carried out in accordance with the relevant international standards, unless otherwise specified or approved by Owner/Owner's representative.

a) The Complete Water treatment plant & its auxiliaries shall operate safely, reliably, and without undue maintenance or operator attention/intervention. Guarantees shall be such as can be met in everyday operation under all specified operating conditions. All guarantee figures shall be realisable in everyday operation under all anticipated operating conditions.

b) Supplier shall note the provisions of the clauses on tests as outlined in the specification for "Inspection and Testing".

c) Performance test will be carried out within the appropriate time period as specified. The performance test result of the water treatment plant & its auxiliaries shall be corrected to the design conditions to establish an "as new and clean" performance.

d) **Guarantee Test Procedure**

In conducting the plant performance tests, the plant shall be operated by Owner/Owner's representative's staff under the direction and responsibility of Supplier's representative and to the mutual satisfaction of the parties concerned, but under the general supervision of Supplier.

e) **Water treatment plant**

i. Supplier shall submit the design calculations for arriving at the required quantity of resin for each exchanger, supported by resin characteristic data used in the calculations, inline with manufacturer's / best engineering practices. Supplier shall take into account derating factor of 10% while deciding the useful quantity of resin. A derating factor of 30% shall be considered for resin used for MB unit. After including the above margins and other additions such as minimum resin quantity, the chemical consumption shall be calculated. The quantity of resin and regeneration chemical consumption shall be as per the "Guaranteed Data".

ii. Before commencement of tests, Supplier may if so desired by him, bring the MB resins to the fully regenerated condition by carrying out double regeneration, that is, two consecutive regenerations. No other double regeneration will be permitted during the capacity test period.

iii. Minimum six (6) runs shall be carried out for establishing the guaranteed values of treated water with regard to quality (stage wise) and capacity as well as for establishing the guaranteed values for chemical consumption, continuous power consumption etc. Of these six test runs, a minimum of three (3) consecutive test results shall meet the guaranteed values. For Mixed Bed, a minimum of (3) three test runs shall be conducted and all the results shall meet the guaranteed values.

## 5.0.0 SUBMISSION OF TEST PROCEDURES

The Supplier shall submit for approval **one month** prior to testing, detailed test procedures for equipment, sub-systems and complete systems covered under this Order. These procedures shall include details of all performance tests either conducted in the manufacturer's works or at site. Detailed lists shall be provided which shall specify applicable codes, functional and other tests to be carried out on each item of equipment, each sub-system and each complete system. The lists shall be supplemented with logic diagram to show the correct plant functioning requirements together with system flow diagrams showing all points of measurement for both functional and performance tests.

The procedures, lists, logic diagrams and flow diagrams together with test results shall be correlated and presented as a single bound document to form a comprehensive set of test procedures and records of the tests conducted on the plant.

## 6.0.0 DESIGN AND CONSTRUCTION FEATURES

### 6.1.1 Mixed Bed

The Mixed bed Ion exchange units are provided for removal of TDS and to achieve desired DM water quality to produce Dematerialized water of required quality and quantity for steam cycle.

The Mixed Bed Exchanger contains both Strong Acid Cation and Strong Base Anion resins. Hydrochloric Acid and Sodium Hydroxide are used for regenerating cation and Anion Resins respectively. The Dematerialized water thus generated will be led and stored in DM water storage tanks. MB is designed for regeneration every 7 days. The MB will be constructed of vulcanized rubber lined Carbon steel. Resin Traps are provided in rinse outlet and process outlet of the Mixed Bed unit.

**Design**

Mixed bed shall have Shells and Dished ends both constructed of IS:2062 and shall be designed as per IS 2825. Vessels shall be designed to contain resins, filter media, distribution system and under drain system. All the vessels shall be supplied with frontal pipe work with valves and fittings.

Mixed bed shall be provided with a group of individual pneumatic operated valves designed for manual operation. The Material of construction of all valves and piping shall be as per specification. All internal material shall be of Stainless steel (SS - 316) for pipe size less than 50 NB and more than 50 NB shall be MSRL unless otherwise specified elsewhere.

All the vessels shall be provided with Cat Ladder and Platform.

The interior of all vessels and all parts, which come into contact with corrosive liquid, shall be lined with natural rubber.

Wherever rubber lining is required, the same shall confirm to IS 4682 Part I.

**All vessels shall be furnished with a manhole, hand hole, view glass, vent and drain valves, resin traps, flanged connections for the piping system and structural steel leg support.**

MB units shall be equipped with three (3) nos. of sight glass, one (1) at upper resin level, one (1) in upper section of exchanger vessel & one (1) at resin interface level.

**Construction**

The Mixed Bed shall be of vertical, cylindrical type. It shall have shells and dished shall be designed as per IS 2825. The filters shall be designed to contain filter media, distribution system and under drain system. All internal material such as nuts bolts & washers shall be of Stainless steel (SS 316) unless otherwise specified elsewhere.

The Ion exchangers shall be supplied with frontal pipe work with valves and fittings. Instrument and accessories shall be supplied as per specified in relevant clause.

6.1.2 **DM Water Storage Tank**

One number of DM water storage tank shall be located in the proposed HRSG area. The tank will be vertical, cylindrical, field erected tanks of Carbon steel construction with protective interior coating. The tank roof will be of the self-supported type. The tank will be provided with a vent, stub type overflow, etc.

6.1.3 **General**

All piping shall be designed, fabricated and tested in accordance with the Approved Standards, Piping Materials Specification as per the specification.

All pipes subject to corrosion which are unwrapped, unlagged and external to the building, in addition to the normal designed wall thickness, shall have an additional corrosion allowance sufficient to ensure a minimum service life of 20 years.

The velocity of flow in pipes shall not generally exceed the following values unless otherwise specifically mentioned.

| **Water lines** | **m/s** |
|---|---|
| Water Discharge lines | 1.0 to 2.2 |
| Water suction lines | 0.6 to 0.9 |

6.1.4 **Pipe Materials**

Instrument tubing shall be of stainless steel 316 for all pressures. Pipe connections after the isolating valves can be compression type couplings to the approval of the Owner/Owner's representative. Steels made by Acid Bessemer process are not acceptable. Fittings made from block forgings and machined to required dimensions are not acceptable.

| | | |
|---|---|---|
| Chemical Lines | : | GRP/CPVC. |
| DM water | : | SS 316 |
| Filtered water piping | : | MSEP |

6.1.5 **Bends and Fittings**

Wherever possible, pipe fittings such as bends and tees, shall be to standard dimensions.

All flanged joints shall meet the requirements of **ANSI B 16.5**. All fasteners shall be in mm size only.

All flanges shall be machined on the edge and spot faced at the back to receive bolts, washers and nuts.

For high-pressure services, flange faces must be of serrated finish. Blank flanges are to be solid steel and machined all over.

Flanges having pressure ratings less than 10 bar (g) shall not be used. All flange jointing material unless specified shall be approved quality.

7.0.0 **TECHNICAL SPECIFICATION FOR VALVES**

7.1.0 **Intent of Specification**

7.1.1 This section of the specification covers the requirements of valves for various system of the plant.

7.2.0 **Codes & Standards**

7.2.1 The supply manufacture, inspection, testing and performance of valves shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. The equipment shall also conform the latest applicable standards. Nothing in this specification shall be construed to relieve the Supplier of this responsibility.

7.2.2 Latest edition of design codes and standards shall be considered as minimum requirements**.**

7.3.0 **Design and Construction Features**

7.3.1 Supplier shall select valves and accessories, which are suitable for the operating conditions of the systems.

7.3.2 Valves and accessories which are of a similar make, size and type shall be interchangeable with one another.

7.3.3 All valve bodies shall be of the same nominal size as the adjacent piping, unless otherwise required.

7.3.4 Hand wheels shall be of painted normal standard type and of spoked construction with smooth finished spokes and rims.

7.3.5 Spindles for all valves located outdoors shall have weather-proof protection on spindle bearings and guards. Valve stem shall be forged or from a forged rolled bar. Casting for stem is not acceptable.

7.3.6 All valves shall be designed to withstand a hydrostatic pressure test for tightness and mechanical strength as per applicable standards.

7.3.7 For handling heavy valves (or part of valves), eye bolts, lugs etc. shall be provided.

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7.3.8 All valves shall be designed so that the hand wheel moves in a clockwise direction to close the valve. The face of each hand wheel shall be clearly marked with the words 'OPEN' and 'CLOSE' and shall be provided with an arrow to indicate the direction for opening.

7.3.9 Valves of sizes 50 NB and above shall be provided with position indicators.

7.3.10 All flanged valves shall have flanges integral with the valve body.

7.3.11 All the valves shall be of CI diaphragm type. All the valves for corrosive service shall be rubber lined / ebonite lined to a thickness of minimum 3mm.

The material of construction of diaphragm shall be as follows:

a. Reinforced natural rubber for water service.

b. Reinforced neoprene rubber for handling weak chemicals

c. Teflon with backing for severe chemicals and solvents.

Needle valves shall be used in sampling lines and for instrument isolation.

7.4.0 **Tests and Inspection**

7.4.1 All valves shall be subjected to tests. Tests shall be conducted at Supplier/ Sub Supplier's works witnessed by the Owner/Owner's representative and conforming to the relevant standards and all test certificates shall be submitted for approval of Owner/Owner's representative before despatch of material. All valves shall be tested hydrostatically for strength, tightness of seats and tightness of backseating at pressure specified in the standards.

7.4.2 Procedure for testing the tightness of seats of valves shall be as follows. The valves shall be subjected to city water pressure to or a minimum of 2.812 Kg/cm² (40 psig). The pressure shall then be increased to the specified seat test pressure. Valves shall then be cracked open at this pressure to determine the tightness of the seat ring in the body. Gate valves shall be tested on both sides of the disc and globe valves shall be tested under the disc.

8.0.0 **BOLTS AND NUTS**

All bolts and nuts shall conform dimensionally and be threaded in accordance with the Approved Standards and shall be in mm size only.

Where there is a risk of corrosion, studs and bolts are to be finished flush with the surface of the nuts otherwise a maximum of 1.5 complete threads shall protrude.

The use of slotted screws shall be avoided, hexagon socket screws of recess type heads being preferred.

When connecting pipe work to fittings studs shall not be used. Where fitted bolts are used they shall be adequately marked to ensure correct assembly and the fitted portion shall be not less than 4 mm in diameter larger than the threaded diameter. They shall be driving fit in the reamed holes they occupy.

All washers shall be included in the scope, including locking devices and anti vibration arrangements, which shall be subject to the approval of the Owner/Owner's representative. Taper washers shall be fitted where necessary.

If bolts are to be tightened under heat or by mechanical extension, one set of the necessary equipment shall be provided under this Order and retained at site for each unit.

9.0.0 **WELDING**

9.1.0 **General**

All welding performed in pursuance of this Order shall conform to the Approved Standards.

The Supplier shall show that the proposed welding specifications and standards conform to the requirements of the design codes adopted for the relevant portion of the work.

Wherever there is conflict between Codes and Standards the Owner/Owner's representative shall decide which shall prevail.

9.2.0 **Welding Techniques**

Single sided butt weld joints (in low alloy steel and high yield steel) shall be designed to have the root run made by the Gas Tungsten Arc Welding process.

For butt welded joints the following techniques are acceptable.

i. Shielded Metal arc welding with argon root-run.

ii. Shielded Metal arc welding with consumable insert in root fused by argon arc.

iii. Semi-automatic or automatic welding with argon root-run.

Weld joint preparations shall be in accordance with ASME Sec. VIII Div.1 as applicable or an equivalent or superior approved standard and to the Owner/Owner's representative's approval. Welding symbols shall be to any Approved Standard.

10.0.0 **INSTRUMENT LIST FOR WTP**

| **A)** | **DM PLANT** | |
|---|---|---|
| 1 | Mixed Bed | Conductivity transmitter at the outlet (common for each MB) |
| | | Pressure gauge at the I/L& O/L |
| | | pH transmitter (Ultra Pure Water) at the outlet (common for MB) |
| | | Dual Channel Silica analyzer at the common outlet of MB |
| | | FT at the I/L & O/L |
| 2 | DM Water Tank | Float and Board type level indicator |
| | | Level switch low low and Level switch high |
| | | Differential pressure/Ultrasonic type level Transmitter |
| 3 | DM water transfer pump/HRSG Initial fill pump | Pressure Gauge on the discharge of each Pump. |
| | | Pressure switch on the common discharge header |
| | | pH transmitter at the discharge of pumps. |
| 4 | CW makeup storage tank | Level gauge |
| | | Level low switch |
| 5 | Acid dosing system | Level gauge |

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| | | |
|---|---|---|
| | | Level low switch |
| 6 | Caustic dosing system | Level gauge |
| | | Level low switch |
| 7 | HRSG Blow down Pit | Level switch low low and Level switch high |
| 8 | HRSG Blow down transfer pumps | Pressure Gauge on the discharge of each Pump. |
| | | Pressure switch on the common discharge header |
| | | Temperature gauge |
| 9 | SSF backwash water storage tank | Level switch low low and Level switch high |
| 10 | SSF backwash water transfer pump | Pressure Gauge on the discharge of each Pump. |
| | | Pressure switch on the common discharge header |
| 11 | Overhead Service water storage tank | Float and board level gauge |
| 12 | Overhead potable water storage tank | Float and board level gauge |

## 11.0.0 DESIGN CRITERIA - TREATMENT SCHEME

11.1.0 Filtered Water

i. Raw water source / storage : Filtered water

ii. Design Filtered water analysis : Refer 12.1.0 below.

11.2.0 DM Plant

i. Feed water source : DM water from existing DM plant.

ii. Design DM water analysis : Refer 12.2.0 below.

iii. Net output capacity of DM plant : 2 x 100 %

iv. Operation / location : Manual / Outdoor

v. Stream configuration : Refer flow scheme and scope of supply

Note : There shall be interconnection between two MB streams in such a way that, during regeneration of one mixed bed, second mixed bed can be possible. Also in case of emergency 2 mixed bed shall run together

11.3.0 Effluent Treatment Plant

i. Effluent water source : Effluent from Cooling tower blow down, HRSG blow down, SSF backwash, MB. Regeneration waste, Oily waste water.

## 12.0.0 WATER ANALYSIS (TYPICAL)

### 12.1.0 Filtered Water Analysis (Typical)

| Sr. No. | Characters | Unit | Filtered water Analysis |
|---|---|---|---|
| 1 | pH | | 8.3 |
| 2 | Total Hardness | Mg/l as CaCO3 | 115 |
| 3 | Ca Hardness | Mg/l as CaCO3 | 60 |
| 4 | Sodium | Mg/l as CaCO3 | 78 |
| 5 | Iron | As Fe | Traces |
| 6 | Total Cation | Mg/l as CaCO3 | 193 |
| 7 | Turbidity | NTU | <2 |
| 8 | Total Alkalinity | Mg/l as CaCO3 | 130 |
| 9 | Sulphate | Mg/l as CaCO3 | 6 |
| 10 | Chloride | Mg/l as CaCO3 | 57 |
| 11 | EMA | Mg/l as CaCO3 | 63 |
| 12 | Total Anion | Mg/l as CaCO3 | 193 |
| 13 | Silica | Mg/l as SiO2 | 20 |
| 14 | KMnO4 Value | Mg/l as CaCO3 | 15 |

Note : Bidder shall consider 20% deterioration in the above values while considering the same for Cooling tower make up purpose as well as service water purpose.

### 12.2.0 DM water analysis at the outlet of existing DM plant (Typical)

| Sr. No. | Characters | Unit | Filtered water Analysis |
|---|---|---|---|
| 1 | pH | | 6.5 - 7 |
| 2 | Conductivity | µ/cm | 1.0 |
| 3 | SiO2 | mg/l | 0.05 |
| 4 | Hardness | mg/l | Nil |
| 5 | Fe | mg/l | < 0.03 |
| 6 | Cu | mg/l | < 0.005 |

Note: Bidder shall consider 20% deterioration in the above values while designing of the Mixed Bed unit.

## 13.0.0 SPECFIED DATASHEETS

| | | | |
|---|---|---|---|
| **A** | **DM PLANT** | | |
| **1.1.0** | **Mixed bed exchanger-** | | |
| 1.1.1 | Design standard | | IS:2825 |
| 1.1.2 | Type | | Vertical, dished ended, Rubber lined, Steel, welded vessel. |
| 1.1.3 | No. of units | | 2 x 100% – MB |
| 1.1.4 | Design pressure | | Shut-off head of upstream pump |
| 1.1.5 | Hydrostatic test pressure | | 1.5 times design pressure |
| 1.1.6 | Maximum flow rate | | 45 $m^3/hr/m^2$ |
| 1.1.7 | Rubber lining | | 4.5 mm thick (min.)to IS:4682 Part-I |
| 1.1.8 | Free board | | 100 % of bed depth |
| 1.1.9 | Gross output of each exchanger per cycle | | As per requirement indicated in Section-1 of this specification. |
| 1.1.10 | Minimum resin bed depth | | 1000 mm |
| 1.1.11 | Material of construction | | IS:2062 |
| 1.1.12 | Minimum shell / dishend thickness | | 6 / 8 mm thick |
| 1.1.13 | Tolerance | | 0.2 mm mill tolerance for dished end, 2 mm thinning allowance. |
| 1.1.14 | Resin type | | High capacity strongly acidic, polystyrene based cation exchanger resin and Strongly basic anion exchange resins. |
| 1.1.15 | Method of regeneration | | Co current (Simultaneous air blower) |
| 1.1.16 | Under drain system | | Strainer on plate. |
| 1.1.17 | Accessories / Instrumentation | | Refer control and instrumentation for details. |
| **1.2.0** | **Air scouring blowers (For MB units)** | | |
| 1.2.1 | Type | | Rotary, twin lobe |
| 1.2.2 | No. of units | | 2 x 100% (1w+1s) |
| 1.2.3 | Capacity & Head | | As per requirement of MB units. |
| 1.2.4 | Material of construction | | CI Gr. 25-with EN8 shaft with SS sleeving, damper and filters in CS, Base plate in M.S. |
| 1.2.5 | Medium handled | | Air |
| 1.2.6 | Design temperature | | Refer project information. |
| 1.2.7 | Painting | | As per painting specification |
| **1.3.0** | **DM Water Storage Tank** | | |
| 1.3.1 | Design standard | | IS:803 |
| 1.3.2 | No. of tanks | | 1 No – DM water |
| 1.3.3 | Material of construction | | MSEP- DM water |
| 1.3.4 | Working capacity of each tank | | 1000 $m^3$ – DM Water |

| | | | |
|---|---|---|---|
| 1.3.5 | Type | | Conical roof type, Vertical atmospheric steel tank. Tank shall have 3 layers of PP balls of 50 mm dia. Also it shall be provided with CO2 absorbers. |
| 1.3.6 | Accessories / instruments | | As per control & instrumentation requirements. |
| **1.4.0** | **pH Correction Dosing Station** | | |
| 1.4.1 | PH Correction Solution tank | | |
| 1.4.2 | No. of tank | No. | One (1W) |
| 1.4.3 | Capacity of tank | Litres | To suit process requirement. |
| 1.4.4 | Material of construction | | MSRL / FRP |
| 1.4.5 | pH Correction Dosing Pump | | |
| 1.4.6 | No. of pumps | Nos. | 2(1w + 1s) |
| 1.4.7 | Capacity of pump | | To suit process requirement. |
| 1.4.8 | head of pump | | To suit process requirement. |
| 1.4.9 | Type | | Positive displacement |
| 1.4.10 | Material of construction | | PP |
| 1.4.11 | Motorised Agitator for above tank | | |
| 1.4.12 | Quantity | | One |
| 1.4.13 | Material of construction | | SS316 |
| **1.5.0** | **DM water transfer Pump for Hotwell make up / HRSG Initial fill pump** | | |
| 1.5.1 | Type | | Centrifugal, horizontal. |
| 1.5.2 | Design standard | | IS :1520 / IS: 5120 |
| 1.5.3 | No. of pumps | Nos. | 2(1w + 1s) |
| 1.5.4 | Medium handled | | DM water |
| 1.5.5 | Design temperature | | Ambient |
| 1.5.6 | Capacity of each pump | | 2 x 100% (for Hot well makeup) / 1 x 100 % (for HRSG Initial fill) |
| 1.5.7 | Head required | | Suitable. |
| 1.5.8 | Material of construction | | |
| | i. Casing / impeller / shaft | | SS 316 |
| | ii. Base plate | | MS |
| 1.5.9 | Shaft sealing arrangement | | Mechanical sealing |
| **1.6.0** | **Acid measuring tank** | | |
| 1.6.1 | Design standard | | BS 4994 |
| 1.6.2 | Material of construction | | FRP |
| 1.6.3 | No. of tanks | | i) 1 no. 100% capacity for MB. |
| 1.6.4 | Fluid handled | | 32 % HCl diluted to required concentration |

| | | | |
|---|---|---|---|
| 1.6.5 | Capacity | | One regeneration requirement with 20% margin |
| 1.6.6 | Accessories / instruments | | Refer control and instrumentation |
| **1.7.0** | **Caustic dilution tank** | | |
| 1.7.1 | Design standard | | IS 803 |
| 1.7.2 | Material of construction | | MSEP / FRP |
| 1.7.3 | Nos. | | i) 1 no. 100% capacity for MB. |
| 1.7.4 | Fluid handled | | 48 % NaOH diluted to 10% solution |
| 1.7.5 | Capacity | | One regeneration requirement with 20% margin |
| 1.7.6 | Accessories / instruments | | Refer control and instrumentation |
| **1.8.0** | **Agitators for caustic dilution tanks** | | |
| 1.8.1 | Quantity | | 1 no. per tank |
| 1.8.2 | Type | | Turbine type |
| 1.8.3 | Material of construction | | |
| 1.8.4 | Impeller / shaft | | SS - 316 |
| 1.8.5 | Mounting | | Clamped / flanged |
| 1.8.6 | Impeller type | | Propeller |
| 1.8.7 | Transmission | | Direct coupled |
| **1.9.0** | **Ejectors** | | |
| 1.9.1 | Nature of fluid | | Acid/ Caustic |
| 1.9.2 | No. of ejectors | | 2 Nos. |
| 1.9.3 | Location | | i) 1 no. at the outlet of AMT<br>ii) 1 no. at the outlet of CDT |
| 1.9.4 | Injection fluid | | HCl / NaOH |
| 1.9.5 | Material of construction | | Ebonite lined CI |
| **2.0.0** | **CW Makeup Water Storage Tank** | | |
| | Design standard | | IS:803 |
| | Quantity | No | 1 – Filtered water |
| | Material of construction | | MSEP |
| | Working capacity | $m^3$ | 1000 |
| | Free board | Mm | 300 |
| | Type | | Conical roof type, Vertical atmospheric steel tank. |
| **B** | **POTABLE WATER SYSTEM** | | |
| **1.1.0** | Potable water overhead tank | | |
| 1.1.1 | No. of tank | No. | One (1) |
| 1.1.2 | Capacity of each tank | Litres | To suit drinking water requirement. |
| 1.1.3 | Material of construction | | HDPE / FRP |

| | | | |
|---|---|---|---|
| **C** | **SERVICE WATER SYSTEM** | | |
| **1.1.0** | Service water overhead tank | | |
| 1.1.1 | No. of tank | No. | One (1) |
| 1.1.2 | Capacity of each tank | Litres | To suit process requirement. |
| 1.1.3 | Material of construction | | HDPE / FRP |
| **D** | **EFFLUENT DISPOSAL SYSTEM** | | |
| **1.1.0** | **HRSG Blow down pit** | | |
| 1.1.1 | No. of tank | No. | One (1) |
| 1.1.2 | Capacity | $m^3$ | Suitable to store the HRSG Blow down for 2 hrs |
| 1.1.3 | Location | | Underground (u/g) |
| 1.1.4 | Material of construction | | RCC |
| **1.2.0** | **HRSG Blow down transfer Pump** | | |
| 1.2.1 | No. of pumps | Nos. | 2(1w + 1s) |
| 1.2.2 | Design capacity of pumps | $m^3$/hr | As per System requirement |
| 1.2.3 | Head of the pumps | bar (g) | As per System requirement |
| 1.2.4 | Material of construction | | |
| | i. Casing / impeller / shaft | | SS : 316 |
| | ii. Base plate | | MSEP |
| 1.2.5 | Shaft sealing arrangement | | Gland packing |
| 1.2.6 | Design temperature | Deg. C | 80 to 90 |
| **1.3.0** | **SSF backwash water storage tank** | | |
| 1.3.1 | No. of tank | Nos. | One |
| 1.3.2 | Capacity | $m^3$ | Suitable to store the SSF backwash for 20 minutes. |
| 1.3.3 | Location | | Underground |
| 1.3.4 | Material of construction | | RCC |
| **1.4.0** | **SSF backwash water transfer pump** | | |
| 1.4.1 | No. of pumps | Nos. | 2(1w + 1s) |
| 1.4.2 | Design capacity of pumps | $m^3$/hr | As per System requirement |
| 1.4.3 | Head of the pumps | bar (g) | As per System requirement |
| 1.4.4 | Material of construction | | |
| | i. Casing / impeller / shaft | | SS : 316 |
| | ii. Base plate | | MSEP |
| 1.4.5 | Shaft sealing arrangement | | Gland packing |
| 1.4.6 | Design temperature | Deg. C | Atmospheric |

# VOLUME - III

# SECTION - 2

# DETAILED TECHNICAL SPECIFICATION - MECHANICAL

## SUB-SECTION – 2.15

## SURFACE PREPARATION AND PAINTING

# SUB-SECTION – 2.15

# SURFACE PREPARATION AND PAINTING

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## SUB-SECTION – 2.15

## SURFACE PREPARATION AND PAINTING

### 1.0.0 SURFACE PREPARATION

### 1.1.0 General

This specification covers the general requirements related to the cleaning protective coating and painting of equipment, component and system. The components and/or equipment shall be mechanically and / or chemically cleaned during the following stages of the Contract.

- Cleaning in workshop.
- Cleaning before painting and / or corrosion protection (application of prime coat).
- Cleaning before erection and during installation.

Cleaning of fabricated component items shall be carried out after fabrication and final heat treatment of welding at manufacturer's work or at site, as appropriate.

For cleaning in workshop and before painting mechanical cleaning as opposed to alternative chemical cleaning is the preferred method of for works cleaning except where this is precluded by design or access considerations.

Mechanical surfaces shall be protected during the cleaning operations.

In the event of the surfaces not being cleaned to the purchaser's satisfaction, such parts of the cleaning procedures or agreed alternatives as are deemed necessary to overcome the deficiencies shall be carried out at the supplier's sole expense.

For reclining small areas, hand cleaning by wire brushing may be permitted wire brushless used on austenitic steel bristles.

Austenitic stainless steels, copper and aluminium alloys, cast iron, bimetallic and metallic / plastic items, and components fabricated by spot welding or riveting shall not be chemically cleaned. All weld areas shall be suitably stress relieved before chemical cleaning.

various international standards equivalent to Swedish standard for surface preparation are given in Table-1.

The contractor shall arrange at his own cost, to keep a set of latest edition of the above standards and codes at site.

The paint manufacturer's instruction shall be followed as afar as practicable at all times. Particular attention shall be paid to the following.

a) Proper storage to avoid exposure as well as extremes of temperature.
b) Surface preparation prior to painting.
c) Mixing and thinning.
d) Application of paints and the recommended limit on the intervals between coats.
e) Shelf life for storage.

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Any painting work (including surface preparation) on piping or equipment shall be commenced only after the system tests have been completed and clearance for taking up painting work is given by the Engineer, who may, however, at his discretion authorise in writing, the taking up of surface preparation of painting work in any specific location, even prior to completion of system test.

1.2.0 **Tools & Tackles**

All tools, brushes, rollers, spray guns, blast material, hand power tools for cleaning and all equipment, scaffolding materials, shot/sand blasting equipment and air compressor etc. shall be arranged by the contractor at the site in sufficient quantity at his own cost. He shall arrange to his own cost, for suitable paint thickness measuring instrument like Elkometers acceptable to the Engineer (with calibration facilities).

Mechanical mixing shall be used for paint mixing operation in case of two pack systems except that the Engineer may allow the hand mixing of small quantities at his discretion.

1.3.0 **Mechanical Cleaning at Manufacturer's Works**

Mechanical cleaning shall preferably be carried out by abrasive blasting. The Purchaser is prepared to consider alternative methods provided they achieve the necessary surface condition.

1.3.1 **Surface condition**

The Metal surfaces shall be clean and free of mill scale, rust dirt, grease and any other deleterious matter.

Where metal surfaces are to be painted the surface profiles shall conform with the painting specification requirements.

Where this does not apply surfaces shall have a surface texture not coarser than Grade 80 abrasive paper.

1.3.2 **Abrasives**

Abrasives containing silica, silicates of slag, residues shall not be used for water/steam side surfaces of plant except for cleaning sand castings, where hydro blasting with sand may be used.

For austenitic materials only abrasives containing 98% or more of aluminia, $Al_2 O_3$, shall be used.

1.3.3 **Removal of abrasive and debris**:

After cleaning abrasive and debris shall be thoroughly removed from components.

1.3.4 **Alternative Chemical Cleaning at Manufacturer's Works**

The procedure shall comprise of Pre-treatment and Acid treatment.

To achieve cleanliness equivalent to that specified for mechanical cleaning. The procedure to be adopted must meet with the purchaser's approval.

1.3.5 **Protection at Manufacturer's Works**

As soon as all items have been cleaned and within four hours of the subsequent drying, they shall be given suitable anti-corrosion protection.

All water, air and steam side surfaces shall be protected by the application of approved water soluble corrosion inhibitors, or vapour phase inhibitors that can be subsequently removed by site water washing or steam blowing.

The rate of application of volatile corrosion inhibitors shall be at least 10 grams per square metre or 35 grams per cubic metre, whichever is the greater, except for pipes up to 300 mm diameter for which the minimum application rates shall be 5 grams per square metre.

Immediately after the protective treatment has been applied all vessels and pipes shall be suitably sealed off by discs or caps or approved alternatives to prevent ingress from the surrounds Cylindrical plugs shall not be drive into the ends of pipes. These protective covers shall not be removed until immediately before final connection is made to the associated equipment.

1.4.0 **Weather Conditions**

Painting shall be done only when the surface temperature is above $5^{o}$C surface temperature must be at least $3^{o}$C above dewpoint to ensure that condensation does not occur on the surface.

Reasonable protection against precipitation, corrosive fumes and vapours shall be exercised for the painting of outdoor parts.

Precautions shall also be taken against solar radiation to ensure that the specified dry film thickness of priming of finish coats is obtained.

Any prime coat exposed to excess humidity, rain, dust etc. before drying, shall be permitted to dry & the damaged area of primer shall be removed and the surface prepared & primed again.

Sheltered or unventilated horizontal surfaces on which dew may collect require more protection, and to achieve this an additional top coat of paint shall be applied.

1.5.0 **Surface Preparation**

In preparing any surface to be coated, all loose paint, dirt, grease, rust, scale, weld slag or spatter or any other extraneous material shall be removed and defects repaired so as to obtain a clean, dry, even surface to receive the priming or finishing coat(s) as called for in the painting schedules. Sharp adges should be rounded especially when tank linings have to be applied.

All machined surfaces, including flange faces, shall be suitably covered to prevent damage during surface preparation.
All surface should be blast cleaned whenever possible.

1.5.1 **Surface preparation methods.**

Bare steel surfaces should be prepared by one of the methods described below in order of preference and in accordance with Swedish Standard SIS 05 5900 or Steel Structures Painting Council, SSPC, Vis1,or DIN 55928, section 4.

1.5.1.1 **White metal blast cleaning**: Sa 3 or SSPC - SP 5

Sa 3 Blast cleaning to bare metal, Mill scale, rust and foreign matter must be removed completely. Subsequently, the surface is cleaned with vacuum cleaner, clean dry compressed air or a clean brush. It must then have a uniform metallic colour & correspond in appearance to the prints designated Sa 3.

1.5.1.2 **Near white metal blast cleaning** Sa 2 1/2 or SSPC - SP 10

Sa 2 1/2. Very thorough blast cleaning. Mill scale, rust and foreign matter shall be removed to the extent that the only traces remaining are slight imperfections in the form of spots or stripes. Subsequently, the surface is cleaned with a vacuum cleaner, clean dry compressed air or a clean brush. It must then correspond in appearance to the prints designated Sa 2 1/2.

Mechanical cleaning should only be used when procedures (a) and (b) are not practicable.

1.5.1.3 **Commercial Blast Cleaning** Sa 2

Sa 2 Blast cleaning until atleast two-thirds of each element of surface area is free of all visible residues. This method of Blasting is suitable for steel required to be painted with conventional paints for exposure to mildly corrosive atmosphere for longer life of the paint system.

1.5.1.4 **Near white metal blast cleaning** P Sa 2 1/2 DIN 55928

Very thorough blast cleaning. Very adhesive coatings remain. From all other surface mill scale and rust are to be removed to such an extent that the only traces remaining are slight imperfections in the form of spots or stripes. Further treatment see Sub b).

1.5.1.5 **Very thorough mechanical scraping and wire brushing** St 3

St 3 very thorough scraping and wire-brushing - machine brushing - grinding - etc. are to be preferred. Surface preparation as for St 2. But much more thoroughly. After the removal of dust, the surface must have a pronounced metallic sheen and correspond to the prints designated St. 3.

1.5.1.6 **Thorough scraping and wire brushing**: St 2

St 2 Thorough scraping and wire-brushing - machine brushing - grinding - etc. The treatment shall remove loose mill scale, rust and foreign matter. Subsequently, the surface is cleaned with a vacuum cleaner, clean dry compressed air or a clean brush. It should then have a faint metallic sheen. The appearance must correspond to the prints designated St 2.

**Table -1 (Surface Preparation Standards)**

| Surface preparation methods | SIS 055900 | DIN 55928, Part-4 | BS 4232 only for blasting | SSPC-Vis |
|---|---|---|---|---|
| Blasting ACC to item (a) | Sa 3 | | First quality | White metal SP 5 |
| Blasting ACC to item (b) | Sa 2 1/2 | | Second near quality | White SP 10 |
| Blasting ACC to item (c) | Sa 2 | | Third quality | Commercial blast SP 6 |
| Hand / or power tool derusting ACC to item (f) | St 2 | | -- | Hand tool cleaning SP 2 |
| ACC to items (e) | St 3 | | -- | Power tool cleaning SP 3 |
| Flame jet cleaning | | F1 | -- | Flame cleaning SP 4 |
| Pickling | | Be | -- | Pickling |

Steel structures to be blast cleaned have to be free of pitting and other severely corroded places in accordance with B.S. 4232 and SIS 055900.

The abrasives used for blast-cleaning shall be graded flint, grit, shot or silica sand and shall be such that they will produce an average keying profile on the blast-cleaned surface of not more than 40 microns.

An air pressure of 7 bar (g) at the nozzle shall be used.

After blast-cleaning all accumulated grit, sand, dust etc. must be removed leaving the surface clean, dry and free of mill scale, rust grease and other foreign matter.

In the event of rusting after completion of the surface preparation, the surface must be cleaned again in the manner specified.

Oil, grease, soil, cement, salts, acids or other corrosive chemicals shall be cleaned from steel surfaces, by the use of solvents, emulsions or cleaning compounds. The final wiping shall be with clean solvent and clean rags or brushes. There shall be no detrimental residue left on the surface.

Primed areas which suffer damage must be spot blasted on site to a degree of cleanliness P Sa 2 1/2 before touching up.

Protective coating must be applied as quickly as possible after the completion of surface preparation no matter what cleaning method has been used.

No blast-cleaned surface shall be allowed to remain uncoated overnight.

Steel work protected by shop primer after arrival on site must be cleaned of salt, sand, oil etc. before the coat of paint is applied on site. Shop primer damaged during transport must be rectified by blast-cleaning and coating before application of the site coats.

Wood surfaces shall be sanded clean. All nail holes shall be puttied and sanded before priming.

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Concrete: If a protective coating is required, concrete shall be allowed to cure before painting.

1.5.2 **Rub Down and Touch up of Primer**

The shop coated surfaces shall be rubbed down thoroughly with emery paper to remove all dust, rust and other foreign matters, washed, degreased, then cleaned with warm fresh water and air dried. The portions, from where the shop coat has peeled off, shall be touched up and allowed to dry before applying a coat of primer. The compatibility between shop coat and field primer should be ascertained from the paint manufacturer. In case degreasing with white spirits is not effective, the surface should be finally wiped clean with aromatic solvent like xylol or light naphtha.

1.5.3 **Non Compatible Shop Primer**

The compatibility of finishing coat should be confirmed from the paint manufacturer. In the event of use of primer such as zinc rich epoxy, inorganic zinc silicate etc., the paint system shall depend on condition of shop coat. If the shop coat is in satisfactory condition showing no major defect, the shop coat shall not be removed. The touch up primer and finishing coat(s) shall be identified for application by Engineer.

Shop coated (coated with primer & finishing coat) equipment shall not be repainted unless paint is damaged.

Shop primed equipment and surfaces shall only be spot cleaned in damaged areas by means of power tool brush cleaning or hand tool cleaning and then spot primed before applying one coat of field primer unless otherwise specified. If shop primer is not compatible with field primer then shop coated primer shall be completely removed before application of selected paint system for particular environment.

For package units / equipment, shop primer shall be as per the paint system given for particular environment.

In case of existing paint, compatibility between finishing coat and new selected finish coat shall be ascertained before application of finish coat. In case the coat is selected for upgrading existing alkyd coating to high performance coating, then surface preparation can be by manual / mechanical means to remove loose rust, peeled off/damaged paint, but sound old coating need not be removed. It should be touched with red oxide zinc chromate primer wherever it has peeled of before application of the coat. The tie coat shall be applied after 7 days of curing of red oxide zinc chromate primer. If new paint system is not suitable to upgrade existing coating then complete paint shall be removed by mechanical or blast cleaning before application of new coating system.

## 2.0.0 SCHEDULE OF PRIMER & FINISH COATS

### 2.1.0 PRIMERS

P-1 Red Oxide zinc chromate primer
P-2 High build chlorinated rubber zinc phosphate primer
P-3 High build zinc phosphate primer
P-4 Etch primer/wash primer
P-5 Epoxy zinc chromate primer
P-6 Epoxy zinc phosphate primer
P-7 Epoxy high build mio paint
P-8 Epoxy red oxide zinc phosphate primer
P-9 Epoxy based tie coat finish coats
P-10 Inorganic zinc silicate coating.

### 2.2.0 FINISH COATS

F-1 Synthetic enamel
F-2 Acrylic polyurethane paint
F-3 Chlorinated rubber paint
F-4 High build chlorinated rubber mio paint
F-5 Chemical resistant phenolic based enamel
F-6 Epoxy high build coating
F-7 High build coal tar epoxy
F-8 Self priming epoxy high build coating
F-9 High build black
F-10 Heat resistant aluminium paint suitable upto 250°c
F-11 Heat resistant silicone paint suitable upto 400°c
F-12 Synthetic rubber based aluminium paint suitable upto 150°c
F-13 Heat resistant silicone paint suitable upto 600°c

### 2.3.0 PRIMER

**a)** **Primer (P-1)** Red oxide zinc chromate primer

| | | |
|---|---|---|
| Type and composition | : | Single pack modified phenolic alkyd medium pigmented with red oxide and zinc chromate |
| Volume solids | : | 30 - 35% |
| DFT | : | 20 ~ 40 microns/coat (min) |
| Covering capacity | : | 11-13 sq. m/Lit/coat |

**b)** **Primer (P-2)** High build chlorinated rubber zinc phosphate primer

| | | |
|---|---|---|
| Type and composition | : | Single pack Chlorinated rubber medium plasticised with unsaponifiable plasticiser pigmented with zinc phosphate |
| Volume solids | : | 35-40% |

DFT : 50 microns/coat (min).
Covering capacity : 7-8 sq. m/lit/coat

**c) Primer (P-3)** High build zinc phosphate primer

Type and composition : Single pack Synthetic medium, pigmented with zinc phosphate
Volume solids : 40 - 45%
DFT : 35 - 50 microns/coat
Covering capacity : 10 - 12 sq. m/lit/coat
Heat resistant : Upto 100 $^{0}$C (dry)

**d) Primer (P-4)** Etch primer / Wash primer

Type and composition : Two pack of Polyvinyl butyl resin medium cured with phosphoric acid solution pigmented with zinc tetroxy chromate
Volume solids : 7 - 8%
DFT : 8 - 10 microns/coat
Covering capacity : 7 - 8 sq. m/lit/coat

**e) Primer (P-5)** Epoxy zinc chromate primer

Type and composition : Two pack of Polyamide cured epoxy resin medium pigmented with zinc chromate
Volume solids : 40% (min.)
DFT : 35 microns/coat
Covering capacity : 11 - 12 sq. m/lit/coat

**f) Primer (P-6)** Epoxy zinc phosphate primer

Type and composition : Two pack of Polyamide cured epoxy resin medium pigmented with zinc phosphate
Volume solids : 40% (min)
DFT : 35 microns/coat (min)
Covering capacity : 11 - 12 sq. m/lit/coat

**g) Primer (P-7)** Epoxy high build MIO paint (Intermediate coat)

Type and composition : Two pack of Polyamide cured epoxy resin medium pigmented with micaceous iron oxide
Volume solids : 50% (min)
DFT : 100 microns/coat (min)
Covering capacity : 5.0 sq. m/lit/coat

**h) Primer (P-8)** Epoxy red oxide zinc phosphate primer

Type and composition : Two pack of Polyamide cured epoxy resin medium pigmented with red oxide and zinc phosphate
Volume solids : 42% (min)
DFT : 30 microns/coat (min)
Covering capacity : 13 - 14 sq. m/lit/coat

**i)** **Primer (P-9)** Epoxy based tie coat

(Suitable for conventional alkyd based coating prior to application of acrylic polyurethane / epoxy finishing coat).

| | | |
|---|---|---|
| Type and composition | : | Two pack of Polyamide cured epoxy resin medium suitably pigmented |
| Volume solids | : | 45-60% |
| DFT | : | 40 microns/coat (min) |
| Covering capacity | : | 10 - 12 sq. m/lit/coat |

**j)** **Primer (P-10)** Inorganic Zinc silicate coating

| | | |
|---|---|---|
| Type and composition | : | Two pack of Self cured Ethyl - silicate solvent based Inorganic Zinc coating. |
| Volume solids | : | 60% (min) |
| DFT | : | 65-75 microns/coat |
| Covering capacity | : | 8-9 sq.m./lit/coat |

2.4.0 **FINISH COATS**

**a)** **Finish coat (F-1)** Synthetic Enamel

| | | |
|---|---|---|
| Type and composition | : | Single pack<br>Alkyl medium pigmented with superior quality water & weather resistant pigments |
| Volume solids | : | 30 - 40% |
| DFT | : | 20 - 25 microns/coat (min) |
| Covering capacity | : | 16 - 18 sq. m/lit/coat |

**b)** **Finish coat (F-2)** Acrylic Polyurethane paint

| | | |
|---|---|---|
| Type and composition | : | Two pack<br>Acrylic resin and isocyanate hardener suitably pigmented. |
| Volume solids | : | 40 % (min) |
| DFT | : | 30-40 microns/coat |
| Covering capacity | : | 10-12 sq.m./lit/coat |

**c)** **Finish Coat (F-3)** Chlorinated Rubber paint

| | | |
|---|---|---|
| Type and composition | : | Single pack<br>Plasticised chlorinated rubber medium with chemical & weather resistant pigments. |
| Volume solids | : | 30 % (min) |
| DFT | : | 30 microns/coat (min) |
| Covering capacity | : | 10 sq.m./lit/coat |

**d)** **Finish Coat (F-4)** High build chlorinated rubber MIO paint.

| | | |
|---|---|---|
| Type and composition | : | Single pack<br>Chlorinated rubber based high build pigmented with micaceous iron oxide. |
| Volume solids | : | 40-50 % |
| DFT | : | 65-75 microns/coat |
| Covering capacity | : | 6-7 sq.m./lit/coat |

**e)** **Finish Coat (F-5)** Chemical Resistant Phenolic based Enamel

| | | |
|---|---|---|
| Type and composition | : | Single pack<br>Phenolic medium suitably pigmented. |
| Volume solids | : | 30-40% |
| DFT | : | 25 microns/coat (min) |
| Covering capacity | : | 15 sq.m./lit/coat |

**f)** **Finish Coat (F-6)** Epoxy High Building Coating

| | | |
|---|---|---|
| Type and composition | : | Two pack<br>Polyamide cured epoxy resin medium suitably pigmented. |
| Volume solids | : | 55-65% |
| DFT | : | 100 microns/coat (min) |
| Covering capacity | : | 6.0-6.5 sq.m./lit/coat |

**g)** **Finish Coat (F-7)** High build coal tar Epoxy.

| | | |
|---|---|---|
| Type and composition | : | Two pack<br>Polyamine cured epoxy resin blended with coal tar. |
| Volume solids | : | 65 % (min) |
| DFT | : | 80-125 microns/coat |
| Covering capacity | : | 6.0-6.5 sq.m./lit/coat |

**h)** **Finish Coat (F-8)** Self priming epoxy high build coating (complete rust control coating)

| | | |
|---|---|---|
| Type and composition | : | Two pack<br>Polyamido-amine cured epoxy resin suitably pigmented. Capable of adhering to manual prepared surface and old coatings. |
| Volume solids | : | 65-85% |
| DFT | : | 100-125 microns/coat |
| Covering capacity | : | 4-5 sq.m./lit/coat |

**i)** **Finish Coat (F-9)** High build black.

| | | |
|---|---|---|
| Type and composition | : | Single pack Reinforced Bituminous composition phenolic based resin. |
| Volume solids | : | 55 - 66 % (min) |
| DFT | : | 100 microns/coat (min) |
| Covering capacity | : | 5.5 – 6.0 sq.m./lit/coat |

**j)** **Finish Coat (F-10)** Heat Resistant Aluminium Paint Suitable upto 250°C

| | | |
|---|---|---|
| Type and composition | : | Dual container (paste & medium) Heat resistant special Ole Ore resinous medium with leafing aluminium. |
| Volume solids | : | 20 - 25 % |
| DFT | : | 20 microns/coat (min) |
| Covering capacity | : | 10 - 12 sq.m./lit/coat |

**k)** **Finish Coat (F-11)** Heat Resistant Silicon paint suitable 250 - 400°C.

| | | |
|---|---|---|
| Type and composition | : | Single pack of Silicon resin based with aluminium flakes |
| Volume solids | : | 15-25 % |
| DFT | : | 20 microns/coat (min) |
| Covering capacity | : | 7-12 sq.m./lit/coat |

**l)** **Finish Coat (F-12)** Synthetic Rubber Based Aluminium Paint suitable upto 150°C.

| | | |
|---|---|---|
| Type and composition | : | Single pack of Synthetic rubber medium combined with leafing Aluminium. |
| DFT | : | 20-25 microns/coat (min) |
| Covering capacity | : | 9.5 sq.m./lit/coat |

**m)** **Finish Coat (F-13)** Heat Resistant Silicon paint suitable 500 - 600°C

| | | |
|---|---|---|
| Type and composition | : | Single pack of Silicon resin based with aluminium flakes. |
| Volume solids | : | 25-35% |
| DFT | : | 20 - 25 microns/coat (min) |
| Covering capacity | : | 12 - 14 sq.m./lit/coat |

## 3.0.0 PAINT SYSTEM

| SL. NO. | SURFACE/LOCATION | TEMP. °C | SURFACE PREPARATION | PAINT SYSTEM | | | PER COAT MICRONS Dft | APPLICATION | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | COAT | NO. OF COATS | GENERIC TYPE | | IN SHOP | ON SITE |
| 1 | Structural steel work, piping (oil + water) tanks outside surface, transmission towers, cranes, steel floors, galleries, stairways, outdoor. | upto 130°C | Sa 2½ | Prime | 2 | P6 | 35 | x | |
| | | | | | | | 35 | x | |
| | | | | Intermediate | 1 | P7 | 100 | | x |
| | | | | Finish | 1 | F2 | 50 | | x |
| | | | | | | Total DFT | **220** | | |
| 2 | Structural steel work, piping, indoor and outdoor | 130 to 200°C | Sa 2½ | Prime | 1 | F9 | 75 | x | |
| | | | | Intermediate | 1 | F9 | 20 | | x |
| | | | | Finish | 2 | F11 | 20 | | x |
| | | | | | | | 20 | | x |
| | | | | | | Total DFT | **135** | | |
| 3 | Structural steelwork, piping, un-insulated carbon steel, indoor and outdoor | 200 to 400°C | Sa 3 | Prime | 1 | F9 | 75 | x | |
| | | | | Intermediate | 1 | F12 | 20 | | x |
| | | | | Finish | 1 | F12 | **20** | | x |
| | | | | | | Total DFT | **115** | | |
| 4 | Structural steel work, piping (oil + water), tanks, indoor | upto 130°C | Sa 2½ | Prime | 2 | P6 | 35 | x | |
| | | | | | | | 35 | x | |
| | | | | Finish | 1 | F6 | 100 | | x |
| | | | | | | Total DFT | **170** | | |

| SL. NO. | SURFACE/LOCATION | TEMP. °C | SURFACE PREPARATION | PAINT SYSTEM | | | PER COAT MICRONS Dft | APPLICATION | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | COAT | NO. OF COATS | GENERIC TYPE | | IN SHOP | ON SITE |
| 5 (a) | Structural steel work in the battery rooms, Chlorination plant and water treatment plant (extreme aggressive atmosphere) | Ambient | Sa 3 | Prime | 2 | P8 | 30 | x | |
| | | | | | | | 30 | x | |
| | | | | Finish | 2 | F6 | 100 | | x |
| | | | | | | | 100 | | x |
| | | | | | | Total DFT | **260** | | |
| (b) | Un-insulated - equipment, tanks and piping etc. | upto 80°C | Sa 3 | Prime | 2 | P3 | 35 | x | |
| | | | | | | | 35 | x | |
| | | | | Finish | 2 | F6 | 100 | | x |
| | | | | | | | 100 | | x |
| | | | | | | Total DFT | **270** | | |
| 6 | Steel tanks inside surface (total) for oil storage | normal | Sa 2½ | Prime | 2 | P3 | 35 | x | |
| | | | | | | | 35 | x | |
| | | | | Finish | 2 | F6 | 100 | | x |
| | | | | | | | 100 | | x |
| | | | | | | Total DFT | **270** | | |
| 7 | Steel tanks inside surface (total) for water storage (potable and distilled water) | normal | Sa 2½ | Prime | 2 | P2 | 50 | x | |
| | | | | | | | 50 | x | |
| | | | | Finish | 2 | F3 | 30 | | x |
| | | | | | | | 30 | | x |
| | | | | | | Total DFT | **160** | | |
| 8 | Cast iron water pipe lines-outside surface, buried in the soil | upto 60°C | Sa 3 | Prime | 2 | P8 | 30 | x | |
| | | | | | | | 30 | x | |
| | | | | Finish | 3 | F7 | 125 | | x |
| | | | | | | | 125 | | x |
| | | | | | | | 125 | | x |
| | | | | | | Total DFT | **435** | | |

| SL. NO. | SURFACE/LOCATION | TEMP. °C | SURFACE PREPARATION | PAINT SYSTEM | | | PER COAT MICRONS Dft | APPLICATION | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | COAT | NO. OF COATS | GENERIC TYPE | | IN SHOP | ON SITE |
| 9 | Steel pipes inside surface such as cooling water lines | upto 60°C | Sa 2½ | Finish | 4 | F7 | 125 | | x |
| | | | | | | | 125 | | x |
| | | | | | | | 125 | | x |
| | | | | | | | 125 | | x |
| | | | | | | Total DFT | **500** | | |
| 10 | Water pipelines - outside surface, indoor | upto 60°C | Sa 3 | Prime | 2 | P2 | 50 | x | |
| | | | | | | | 50 | x | |
| | | | | Finish | 3 | F3 | 30 | | X |
| | | | | | | | 30 | | X |
| | | | | | | | 30 | | X |
| | | | | | | Total DFT | **190** | | |
| 11 | Oil pipelines - outside surface, above ground | upto 90°C | Sa 3 | Prime | 2 | P3 | 50 | x | |
| | | | | | | | 50 | x | |
| | | | | Finish | 2 | F6 | 100 | | x |
| | | | | | | | 100 | | x |
| | | | | | | Total DFT | **300** | | |

### 3.1.0 Colour Code for Piping

The colour code scheme is intended for identification of the individual group of the pipeline. The system of colour coding consists of a ground colour and colour bands superimposed on it. The colour coding for the identification of pipelines should comply with the standard and shall submit for Owner/Owner's representative's approval. (For colour code for piping and fire equipment refer Annexure-1).

**Notes :**

1. Covering capacity and DFT depends on method of application. Covering capacity specified above are theoretical. Allowing the losses during application, min specified DFT should be maintained.

2. All primers and finish coats should be cold cured and air dried unless otherwise specified.

3. Selected chlorinated rubber paint should have resistance to corrosive atmosphere and suitable for marine/saline environment.

4. All paints shall conform to relevant Indian Standard and shall be applied in accordance with manufacturer's instructions for surface preparation, intervals, curing and application. The surface preparation, quality and workmanship should be ensured.

5. Technical data sheets for all paints shall be supplied at the time of submission of quotations.

6. In case of use of epoxy tie coat, manufacturer should demonstrate satisfactory test for inter coat adhesion. In case of limited availability of epoxy tie coat (P-9) alternate system may be used taking into consideration the service requirement of the system.

7. All primers should be top coated immediately as per manufacturer's recommendations.

8. In ONGC Hazira complex no sand blasting or shot blasting shall be done. All equipment shall be protected with anti-corrosive coat and after final painting only shifted to project site for further erection. Touch – up painting for the damage area during transportation can be done at project site.

3.2.0 **Specific Requirement**

3.2.1 Following paint schedules shall be followed :

- Acid resistant paint for DM plant building / structure, neutralisation pit, battery room, other corrosive area.
- Synthetic enamel paint for Structural steel, structural sheds, window grills, hand railings, etc.
- Epoxy high build paint for DM plant equipment with piping valves.

3.2.2 All steel work not embedded in concrete to be given one coat of commercial grade zinc chromate primer before painting.

3.2.3 Synthetic enamel paint :

a) General building / structure :

- Surface preparation : ST – 2 according to Swedish standard SIS 055900
- Primer paint : Two coats of Zinc phosphate in phenolic alkyd medium (DFT = 35 microns / coat)
- Finish paint : Two coats of Synthetic enamel (DFT = 25 microns / coat) confirming IS 2932, 1974.

b) Part of steel structure embedded in concrete :

- Surface preparation : ST – 2 according to Swedish standard SIS 055900
  One coat of port land cement slurry.

c) Epoxy high building coating:

- Epoxy zinc phosphate primer : two coats of 35 DFT per coat.
- Epoxy high build coating : one coat of 100 DFT.

## VOLUME - III

## SECTION - 2

## DETAILED TECHNICAL SPECIFICATION – MECHANICAL

## SUB-SECTION - 2.16

## WORKSHOP EQUIPMENTS

## SUB-SECTION - 2.16

## WORKSHOP EQUIPMENTS

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## SUB-SECTION - 2.16

## WORKSHOP EQUIPMENTS

### 1.0.0 GENERAL

This section is intended to specify the detailed technical requirements of workshop equipments.

The workshop equipments shall be designed, manufactured, inspected, shop tested, erected at site tested and commissioned to well established engineering practices, safety codes and other relevant codes and standards.

Compliance with this specification shall not relieve the Bidder of the responsibility of furnishing material and workmanship to meet the specified conditions.

The workshop equipment's are to be located in the proposed compressor house.

### 2.0.0 SCOPE OF WORK

### 2.1.0 Scope of Supply

2.1.1 The supplier shall supply complete and workable Workshop equipments including motors and all other accessories in accordance with the requirements of the specifications. The supplier's scope of supply shall include all the equipments listed in this specification and in addition all associated devices the supplier deems necessary.

The various workshop machines with brief technical specification, quantities and list of special accessories are listed below:

| Sl. No. | Machine | Technical Specification |
|---|---|---|
| **1.0** | **Drilling Machines** | |
| 1.1 | One (1) radial drilling machine | Drilling capacity : 50 mm (steel)<br>Drilling radius (max) : 1500 mm |
| **2.0** | **Grinding Machines** | |
| 2.1 | One (1) double ended pedestal grinder | Wheel size 350 mm |
| **3.0** | One (1) no. Table mounted Vice | Size 200 mm |
| **4.0** | **Other Equipment** | |
| | Support with all anchor fasteners including plates, bolts, nuts etc. with 10 % spares required for anchoring on concrete floor to hold / support the equipment being supplied and erected under this specification | |

2.1.2 All necessary painting and corrosion protection.

2.1.3 Supply of all consumables required for erection and commissioning is included in the basic scope and same shall be supplied by Bidder. List of such item shall be identified & furnished with bid & finally included in the bill of material document. Supply of oil, lubricants and grease is as per Cl. 13.0.0 mentioned in Vol. II /Section 1 General technical specification.

2.1.4 Supply of all erection and commissioning spares as required.

2.1.5 Supply of O&M recommended spares for 3 years trouble free operation of the equipment.

2.1.6 One (1) set of special tools and tackle required for operation, maintenance, inspection and repair shall be supplied in neatly packed-in steel boxes complete with operating instructions for the equipment as necessary. The cost of this shall be included in the base price. Also the price of the special tools & tackles shall be indicated separately.

2.1.7 For workshop equipment operated by Electrical power, motor, Starter, power supply/Control module, push button station, interconnecting cables etc. as applicable shall be provided.

## 3.0.0 DESIGN AND CONSTRUCTION

### 3.1.0 Radial Drilling Machine

The drilling machine shall be of the radial type complete with the accessories. It shall be of double-column construction for rigidity and light centering. In addition to a fine feed hand wheel, a single lever control for rapid reverse of the spindle and for tap withdrawal shall be provided. All gears in the main drive and feed drive shall be of alloy steel case-hardened and ground. Automatic vertical movement of the drill bit (spindle head) as well as automatic vertical movement of the drilling head (with hydraulic locking mechanism) shall be provided.

### 3.2.0 Pedestal Grinder

The Pedestal grinding machine shall be complete with all accessories. The motor shall be specially constructed with robust end covers designed to serve as hoods for wheel safety and dust trapping. Deep groove ball bearings shall be provided to ensure vibration free working. In the case of the fine tool grinder; the table for supporting the tool being ground shall be capable of being swiveled on either side. The table shall be capable of being compensated for wheel wear thereby ensuring safety for the operator. Wheels shall be partially covered with swiveling and sliding spray traps. A coolant pump with an automatic filtering arrangement shall be provided in the pedestal housing. Dust Collecting unit with separate motor, blower, Pipe fittings and Tank to be provided. A simple mounting arrangement shall be provided in the pedestal housing for the wheels so that the time required for changing the wheels is kept to a minimum

## 4.0.0 ELECTRICAL SYSTEM

Electrical equipment shall be suitable for the following voltage levels.

3 Phase Supply : 415V (±) 10%, 50Hz (+) 3% to (-)5%
Single Phase Supply : 240V (±) 10%, 50 Hz (+) 3% to (-)5%
Combined Voltage &
Frequency variation : 10% (Absolute sum)

Any control voltage supply required shall be derived by the Vendor from the above said supply.

Motors shall be conforming to IS 325 and shall meet the operating duty cycle of the equipment.

For motor operated equipment, starters shall be provided which shall include the following as a minimum :

- Switch fuse Unit
- Contactors
- Over load relay
- Start / Stop push buttons
- Indicating lamps

Interconnecting cables between starter unit and motor shall be provided. All Electrical equipment shall have earthing terminals for effective earthing as per IS: 3043

## 5.0.0 TESTING AND INSPECTION

All shop and field testing shall be conducted by Bidder at their own cost and measuring and testing equipment shall be made available by them and all shall have valid calibration certificate.

All motors shall be subjected to routine tests as per IS 325 and routine test certificates and type test certificate shall be furnished for review / approval.

All material test certificates and inspection test reports shall be submitted to Owner/Owner's representative for review / approval and final dispatch clearance note.

## ANNEX - 2.1

## SPECIFIED DESIGN DATA

### 1) DRILLING MACHINE

### RADIAL DRILLING MACHINE

| SPECIFICATION | RANGE | REMARKS |
|---|---|---|
| Quantity | 1 | |
| Drilling capacity ( in Steel) | 50 mm | |
| Spindle taper | MT5 | |
| No. of spindle speeds & RPM | 6 (min) ( 40-1500) | |
| Spindle feeds | 0.05 to 1.25 mm/rev | |
| Min. / Max. drilling radius | 450 / 1500 | |
| Distance Base Plate to Spindle<br>a) when the spindle is in upward position<br>b) when the spindle is in downward position | 1300* mm<br>150 mm | |
| Diameter of column sleeve | 310* mm | |

* Manufacturer's standards are acceptable.

**2) GRINDING MACHINE**

**DOUBLE ENDED GRINDER**

| DESCRIPTION | PEDESTAL GRINDER | REMARKS |
|---|---|---|
| Quantity | 1 | |
| Size of grinding wheel | 350 x 40 x 40/50 | |
| Wheel centres | 450 (min) | |
| Base to wheel centre | 206 (min) | |
| Power | (V) | |
| Speed | 2400 rpm* | |
| Electrical | 415V 3 Ph, 50 Hz | |
| Standard accessories | Tool rest bracket<br>Eye protection shield<br>Coolant and Dust exhaust system,<br>A set of wheels | |
| Set of service tools | 1 set | |
| Drill bit grinding attachment | 1 Set upto 50 mm | |

* Manufacturer's standards are acceptable.

# VOLUME - III

## SECTION - 2

## DETAILED TECHNICAL SPECIFICATION – MECHANICAL

## SUB-SECTION - 2.17

## ELEVATOR

## SUB-SECTION - 2.17

## ELEVATOR

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# SUB-SECTION - 2.17

# ELEVATOR

## 1.0.0 GENERAL

This specification covers the requirement of Elevator. The equipment shall be designed as per the design criteria and material specification given in this specification. It is not the intent to specify completely herein all details of the equipment; nevertheless, the equipment shall be complete and operative in all respects and shall conform to the highest standard of engineering, design and workmanship.

## 2.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant Indian Standards and IEC publications except where modified and/or supplemented by this specification. The design and testing shall follow the following standards.

| | |
|---|---|
| IS: 4666 | Specification for Electric Passenger and Goods Elevator |
| IS: 14665 | Specification for Electric Traction Lifts |
| IS: 1860 | Code of practice for installation, operation and maintenance of Electric Passenger and Goods Elevator |
| IS: 3534 | Outline dimension of Electric Elevator |
| IS: 7759 | Specification for Elevator door locking devices and contacts. |
| IS: 325 | Specification for 3 phase Induction motors. |
| IS: 3043 | Code of practice for Earthing |

National Electrical Code

National Building Code.

## 3.0.0 TECHNICAL REQUIREMENTS

All the equipment and its components shall be designed for design ambient temperature of 50 ºC. All equipment and accessories shall be given tropical protection involving special treatment of metal and insulation against fungus, insects and corrosion. The elevator shall be passenger elevator with the loading capacity of **680 kg** minimum.

**Elevator Control System**

Control system shall be Selective-Collective-Automatic type, Microprocessor based. The system shall have self health monitoring and built in service diagnostics for minimum system down time.

The Elevator shall also include provisions for operation by an attendant by use of a key switch installed in the “Car Operating Panel”.

The car shall stop at all landings for which calls have been registered in the order where the landings are reached by the car irrespective of the sequence in which the buttons have been pressed.

When operating without an attendant the doors shall close automatically after a predetermined time interval has elapsed. When operating with an attendant, by pressing of either the “Up” or “Down” button in the car, it shall automatically initiate the closing of the doors.

An overload warning alarm shall be installed inside the car. Overload of the Elevator car to be monitored such that an overload of passengers should render the Elevator car controls inoperative, the car doors unable to close and a car overload buzzer to sound.

The car shall be provided with a keyed switch installed in the car operating panel marked ‘Service’. When the switch is turned to ‘Service’ position it shall cancel all car calls while the keyed switch is activated the car shall be sent to the corresponding floor where it shall remain with the doors open until another button is pressed or until the key is removed from the switch. Removal of the key shall restore the car to normal self – service operation.

The doors shall automatically open as the Elevator is leveling and close either after the expiration of a time interval, or the moment a Car Button Call is registered. However a Door Hold Button or switch on the Controller Panel shall permit a Door to be held open as long as required. On pressing call buttons from intermediate landing (when car is at that floor) the doors shall automatically open, and the time interval shall be reset automatically.

It shall be possible to stop or reverse the door closing through the door open Button in the Elevator car. In the event of power interruption or failure of the Operator, it shall be possible to open the doors manually from within the car. Emergency devices and keys for opening the doors from the Landing shall be provided.

A positive electromechanical and electrical interlock for the car and Hoist way doors shall be provided, which will prevent Elevator Car moving away from the Landing unless the doors are in the closed position.

When the car door panel is touched by a person or object while the car door is closing, the car and Hoist way doors shall return to their open position. The doors shall remain open until expiration of a pre - determined interval and then close automatically.

Elevator shall have means to cut off power from the motor, whenever an excessive descending speed is reached, and apply the normal brake prior to the application of the safety brake.

In case of Emergency, a telephone instrument wall mounted shall be provided inside the car for interacting with the main control room and security.

A light music shall be played when the car is in operation.

The illumination system of the elevator shall be from the Emergency power supply.

**Controls at Floors**

One luminous button to call Car to be provided at Top Floor, intermediate floors if required and Bottom Floor.

One luminous button for Up and One luminous button for Down to call Car to be provided at each floors.

Travel direction indicator, Call indicator, Car Position indicator both Audio & visual shall be provided at every landing.

An emergency alarm shall be provided in the ground floor which shall alarm when emergency push button in the car is pressed.

Fireman's switch shall be provided in the ground floor which shall permit a fireman to call the Elevator to the ground floor by cancelling all car and landing calls.

The car and hoist way doors shall be power operated, designed to open from the closed position to within 75 mm from the jamb opening. The doors shall open automatically when the car is leveling to or has reached the respective landing.

The Elevator shall be provided with a self-levelling feature that will automatically bring the car to floor landings. This self-levelling shall, within its zone, be entirely automatic and independent of the operating device and shall be self-correcting for over-travel or under-travel and rope stretch.

The Elevator shall be equipped with an automatic stopping device, arranged to bring the car to a stop at the terminal landings independently of the regular operating device in the car. Final limit switches shall be provided in the hoist way, operated by the car and arranged to stop the car and prevent normal operation should it travel beyond the zone of the normal stopping device.

**Car Operating Panel**

The Car operating panel shall be flush mounted in the car enclosure provided with stainless steel face plate with waterproof controls and shall include the following controls as a minimum:

- Luminous pushbuttons numbered to correspond to various landings served.
- An emergency stop switch for stopping the car independently of the regular operating device.
- An Emergency light, an emergency alarm push button connected to the alarm bell with battery & Charger.
- Automatic/Attendant key switch
- Switches for fan & Light
- "Door Open – Door Close" pushbuttons
- Up-Down indicators
- Digital car position indicators above the door
- Ventilation fan
- Recessed fluorescent fixtures
- Over load warning indication/alarm
- 240V, AC, 3 pin industrial socket with switch for hand lamp on roof of car.
- Emergency stop switch on roof of car
- Intercom connection without handset

- Load Plate

**Car Frame and Platform Construction**

The car frame shall be constructed of structural steel shapes, plates and castings designed to sustain the required load and stresses in accordance with the requirements of applicable standard.

Lift car shall be carried in a complete frame of steel which shall be sufficiently rigid to withstand the operation of the safety gear without permanent deformation to the car frame. At least four renewable guide shoes with renewable linings or set of roller guides shall be provided, two at the top and two at the bottom of the car frame.

The car platform shall be all steel construction, formed of steel shapes bolted or riveted together and shall have Ceramic tiles flooring. The platform shall be equipped with an abrasive type metal threshold formed with a guide track suitable for operation of the car doors. The platform shall be provided with a sheet steel toe guard, the full width of the door opening and extending downward from the car sill.

The platform shall be mounted on rubber pads, designed to form isolation cushioning between the car frame and car enclosure.

The car enclosure shall be sanitary type fully enclosed, formed of cold-rolled stainless steel of not less than 18 gauge. The ceiling shall be adequately framed and reinforced designed to withstand a minimum weight of 150 kg (also suitable for maintenance personnel to stand on ceiling).

The wall panels shall be assembled with sound – deadening features, butted and interlocked at corners and secured to the car frame and platform with concealed fastenings.

The car doors shall be flush type sound – deadening proof hollow metal construction. The door shall be two speed sliding design reinforced for suspension hangers. Elevator door panel shall be reinforced as required for hangers, interlock, door close or operator and keyways.

Each hoist way entrance shall be provided with the necessary structural material including sills, struts, and hanger support and cover, fascia and dust cover or toe guard.

Car shall be enclosed on all sides by means of car body and door. The sides of the car shall be lined with heavy gauge sheet steel panels properly braced and reinforced. The enclosure shall be flush on the inside and securely fastened to the platform. Car of the elevators specified herein shall be equipped with hand rails on three sides. Ventilation openings shall be provided in the enclosure walls as per requirement of IS-14665. The enclosure of lift car shall withstand the maximum possible thrust of 345 N applied normally at any point, excepting any vision panel, without permanent deformation.

Since, the car leveling devices will be used; substantial aprons of sufficient depth shall be fitted to the car floor to ensure that no space is permitted between the threshold and the landing while the car is being leveled to a floor.

The door operation shall have power opening and power closing. Necessary electric type door operators shall be furnished. The car door and the hoist way door shall be mechanically connected and shall move simultaneously during opening and closing. The necessary door cushioning devices shall be furnished. The car door and the hoist way door shall open automatically when the car stops at a landing. Should the electric power fail, the door operator shall be so designed that doors can be manually opened from within the car. Necessary door locking devices shall be furnished. Necessary switches shall be furnished in the elevator machine room to control the operation of the door.

Safety shoe device shall be furnished on car doors. Safety shoe shall extend the full height on the closing edges of the car doors. The arrangement shall be such that should the safety shoe touch a person or an object while the door is closing, the car and the hoist way door shall return to the open position. The doors shall remain open until the expiration of a pre-determined interval and then close automatically.

**Elevator Machine**

The machine shall be the worm-geared traction type, designed to be mounted over the hoist way on beams. Sound reducing pads shall be provided under the machine, consisting of rubber or other suitable material.

Facility for Hand Winching in an emergency shall be provided. Brake shall be spring applied, electrically released, and designed to be applied instantly in the event of a power failure.

Governor shall be located over the Hoist way and a safety brake mounted below the car to progressively slow the car whenever an excessive descending speed is reached.

The car and counterweight guide rails shall be of cold-rolled and/or planned T-section finished with machined, tongues or grooved ends.

The guides shall be provided with heavy pattern cast iron or forged steel clamps and brackets designed for fastening to the framing members at each end and at each tier. Guide rail sections shall be fitted with splice plates for the car rails and for counterweight rails. The splice plates shall be secured to the rails.

The hoisting ropes shall be of traction steel standard cable. The minimum number of the hoisting ropes shall be three (3). The factor of safety of the hoisting ropes shall be ten (10) minimum.

The Elevator machine shall be counter weighted to the extent of the weight of the car, plus approximately 40 percent of the rated capacity load. The counter weights shall consist of cast iron or steel sections, fitted in a frame of structural steel or wrought iron shapes securely bolted or riveted together with adjustable guides on both sides at the top and bottom of the frame.

The terminal buffers shall be furnished for stopping the car and the counter-weight at the extreme end of travel.

Spring buffers supported on a suitable framing shall be provided for the car, and one buffer of similar type shall be provided for the counterweight.

Counterweight screen shall be provided at the bottom of the hoisting pit.

Counter-weight sections shall be mounted on structural metal frames so designed to retain the weights securely in its place. Counter-weight frames shall be guided on each guide rail by upper and lower guiding members attached to the frame. A substantial metal counter-weight guard of required length shall be provided at the bottom of the hoist-way. Car and counter-weight guides shall be of rigid steel and shall be continuous throughout the entire length and shall be provided with adequate steel bracings and stiffeners. The necessary lubrication device for guide rail shall be provided.

Normal Terminal Limit Switches and to slowdown and stop the car automatically, shall be provided at terminal landings and final limit switches shall be furnished to automatically cut-off the power and apply the brake, should the car travel beyond the terminal landings.

The car shall be provided with safety grips, designed to become operative whenever the descending speed limit exceeds the required downward speed. The guide grips shall be operated by an endless steel hoisting rope, passing through a clamping device that is controlled by a centrifugal governor at the top of the hoist way. The safety device shall operate the guide grips so as to stop and hold the car with maximum load on. Provisions shall be made to release the guide grips from within the car without the necessity of having to go under the car. The car safety shall include a gradual stopping device.

**Motors**

Motors shall be suitable for Elevator duty. Motors shall comply with the latest revisions of all relevant standards of BIS except as modified herein. The Motor shall be reversible, gear less type with brake and driving sheave, designed for Elevator service, with high starting torque and low starting current. Motor frame shall be derated as they are VFD operated VFD duty.

Motors shall be capable of running continuously at full load under following variations in power supply:

| | | |
|---|---|---|
| Voltage | : | 415V (±) 10% |
| Frequency | : | 50 Hz +3% -5%. |
| Combined voltage & frequency | : | 10% (sum of absolute percentage value of voltage and frequency variation). |

Motors shall be suitable for direct online starting. Continuous motor rating shall be at least ten (10) percent above the kW requirement of driven equipment under entire operating range including voltage and frequency variation. Maximum torque shall not be less than 200% of full load torque.

Motor shall capable of starting and accelerating to full speed at full load (including loaded equipment at Eighty-five (85) percent nominal voltage at motor terminals).

Class of insulation shall be Class F. however temperature rise shall be restricted to limits corresponding to Class – B insulation.

Motors shall be designed for ambient of 50°C.

Degree of Protection shall be IP-55. Method of cooling shall be IC 01 41 (TEFC)

Two (2) grounding terminals one (1) on either side at the bottom suitable for connecting mild steel flat / GI wire grounding conductor of specified size shall be provided.

**Control Panel**

The Control Panel shall be suitable for 415 V ±10%, 3 phase, 4 wire and 50 Hz, +3% - 5% solidly grounded system. The control panel shall be provided with incoming switch & fuse, ammeter with selector switch, Voltmeter with selector switch and indicating lamps. The Panel shall be of Rittal make and shall be complete with thyristors, transducers, microprocessor based control system etc. Motor controls shall be provided with switch-fuse, contactor and O/L relay, indicating lamps and Push buttons. Drive shall be variable voltage, variable frequency type.

The Panel shall be floor mounted, made of minimum 1.6 mm CRCA thick sheet steel cubicle. The thickness of doors/ covers shall not be less than 1.2 mm. The panels shall be suitable for bottom cable entry. The Panel shall have rolled edges with neoprene rubber gaskets to form IP52 degree of protection. Terminal blocks shall be provided for cable terminations. The Panel shall be provided with removable gland plates.

Protective relays shall be furnished on the controller to protect against phase, reversal, low voltage and phase failure. Overload and other protective relays shall also be furnished for traction motor. Single phasing preventer shall also be provided to protect motor while running at no-load.

All switches, indicating lamps and indicating instruments shall be flush mounted on the panel. Control supply voltage shall be 110V AC derived through dry type 415/110V Control transformers.

The switches shall be TPN heavy duty, air break mechanism operated by a suitable external handle with position indicator. Switches for motor circuits shall be of AC 23 category.

The fuses shall be of HRC link type with a breaking capacity of 80 kA. Visual indication shall be provided to indicate fuse failure. The motor contactors shall be vacuum type (irrespective of ratings for crane / elevator applications and for motors – pump / fan applications shall be as per the LT swgr specifications) triple pole AC4 duty with minimum 2 NC and 2 NO auxiliary contacts and shall be electrically and mechanically interlocked.

Thermal over load relay shall be three elements, ambient temperature compensated, time lagged, bimetal thermal overload relays. Each overload relay shall be provided with a built-in single phasing preventer.

All measuring instruments shall be of flush mounting type with 90° scale 96 x 96 mm and shall have the accuracy class of 1.5 on full scale. All indicating instruments shall be provided with zero adjuster, accessible from the front.

Low wattage, LED type indicating lamps shall be provided with the lamp assembly complete with series resistor, bulb, holder and suitably coloured lens and a nameplate showing its function.

All push buttons shall be heavy duty, spring return type with 2NO+2NC contacts and integral escutcheon plate marked with its function, suitable for flush mounting on sheet metal cubicle doors.

Panels shall be provided with space heaters with thermostat and switch suitable for operating at 240V, 1 phase 50 Hz. AC. All the Motors shall be provided with motor contactor controlled space heaters, so that the space heaters are 'ON' only when the motor is `OFF'.

The wiring shall be done with 1100 V grade, PVC insulated, stranded copper conductors of minimum 2.5 mm² size. Each control cable shall be identified at either side by interlocking type PVC ferrules.

Power and control terminals shall be stud type, complete with crimping type connectors. Screw type terminals with screws directly impinging on conductors are not acceptable. At least 10% spare terminals shall be provided.

Control Panel shall have earthing bus/stud for connecting to the plant earthing grids at two ends. All doors and movable parts shall be connected to the earth bus with flexible copper connections. All non-current carrying metallic parts of the mounted equipment shall be earthed.

**Lighting**

Lighting shall be provided in lift well and lift car. Required recessed type Fluorescent/CFL fitting shall be provided in lift car. All necessary copper wires, GI conduits, junction boxes shall be supplied.

One no. 5 / 15 A, 3 pin, 240 V socket and a bulk head lighting fitting shall be provided at every 3 metre interval in the hoist way for maintenance.

**Power and Control Cables**

Cables shall conform to relevant IS standards amended upto date. All the cables shall be armoured and shall be FRLS (Flame retardant and low smoke type).

Separate cables shall be provided for circuit of different plant and auxiliaries for different voltage levels and for circuits fused separately. Power, control and instrumentation circuits shall be taken through separate cables.

Power cables shall be as per the requirements. Minimum size of control cables shall be not less than 2.5 sq.mm copper and maximum no. of cores shall be limited to 19. 20% spare cores shall be provided in all control cables.

The LV Power cables shall be of 1.1 kV grade, XLPE insulated, PVC inner sheathed (extruded),armoured,FRLS PVC outer sheathed, compacted copper conductor upto 10 sq.mm and above 10 sq.mm aluminium conductor.LT XLPE cables shall be confirming to IS 7098 and LT PVC cables shall be confirming to IS 1554.

The control cables shall be OF 1.1 kV grade, multicore,XLPE insulated,PVC inner sheathed,armoured,FRLS PVC outer sheathed stranded copper conductor confirming to IS:1554.

Trailing cables shall be suitable for the duty intended and shall be elastomeric outer sheathed with copper conductor. Separate trailing cable shall be used for power & Control circuits. Trailing Cables for power, control and earthing between the Elevator Car and the Elevator Control Room shall be provided and shall be properly suspended such that no strains are imposed on the conductors

Special care and precaution shall be taken regarding the handling of lift trailing cable loops between the points of suspension. A 1/4" sling rope should be used for trying up. Conductor and insulation of these trailing cables shall be flexible with suitable reinforcement provided.

All control cables shall have crimped type lugs and wire numbering ferrules at either ends.

Cable Trays, Conduits, Cabling and Accessories

Cable trays shall be ladder type / perforated type. Cable trays, fittings and accessories shall be fabricated out of mild steel. These shall be hot dip galvanized. Thickness of mild steel sheets used for fabrication of cable trays and fittings shall be minimum 2 mm.

Cable trays shall be complete with all necessary hot dip galvanized sheet steel accessories such as coupler plates, ground continuity connections, nuts, bolts, washers, clamps etc. Also necessary horizontal/ vertical bends, horizontal/vertical Tees, Reducers, Horizontal cross pieces etc. shall be supplied to make the system complete.

Tray support system shall be fabricated from standard structural steel members. The tray supports shall be painted. Tray supports shall be welded / bolted to insert plates/ structural members.

Power and control cables shall be laid on separate tiers. Cable glands shall be tinned brass, shrouded, double compression type, complete with necessary armour clamp and tapered washers etc. Cable lugs shall be tinned copper lugs, crimping type suitable for termination of different sizes of LT Power & control cables.

Conduits shall be of heavy duty, hot dip galvanised.

Any wall/ceiling opening for cable/conduit entries shall be sealed with fire seal compound.

Cabling inside the car shall be concealed.

Earthing System

Earthing system shall be carried out as per IS 3043. Above ground earthing system shall comprise of galvanised steel earth conductors. All the electrical equipment (motors, control panels, junction boxes, cable trays, push button stations, etc.) shall be earthed at two points. For equipment earthing Owner/Owner's representative shall provide earthing riser (two nos.) near the machine room. The Vendor shall provide earthing ring from riser up to equipment.

Painting

Painting shall be carried out by an approved process. Pretreatment shall conform to applicable standard. The equipment shall be subject to a coat of red oxide primer paint. All inside & outside surface shall be painted with corrosion resistant paint. The final thickness of paint film on steel shall not be less than 80 microns. Final shade will be informed to the Successful bidder during award of the Contract. Sufficient quantity of touch-up paint shall be furnished for application at site

## 4.0.0 SPECIFIED DESIGN DATA SHEET

| Sl. No. | Item Description | Units | Technical Particulars |
|---|---|---|---|
| **1.0** | **GENERAL** | | |
| a) | No of Lifts | nos. | One |
| b) | Type of System | - | Passenger Lift |
| c) | Type | - | Gr + Floor Lift System with Car |
| d) | Travel | - | Bidder to decide considering landing at every floor |
| e) | Location | - | Switchgear cum control building |
| f) | Number of Stops | - | Stops at every floor |
| g) | Type of Operation | - | With/without attendant |
| h) | Minimum Carrying Capacity | - | 10 passengers |
| i) | Speed | m/ sec | 1.0 |
| j) | Size of the Machine room (LxWxH) | M | Bidder to indicate |
| k) | Car Size | mm | As per IS 14665 (Part 1):2000 |
| l) | Size of lift well | mm | Bidder to decide |
| m) | Car enclosure | - | Stainless steel |
| n) | Car doors<br>Door opening (WXH) | -<br>mm | Stainless steel automatic door<br>As per IS 14665 (Part 1):2000 |
| o) | Hoist way door opening | - | Stainless steel automatic door |
| p) | Drive | - | Electrical Variable speed drive. |
| q) | Controls | - | Fully automatic Microprocessor based full collective logic |
| r) | Operation of car and hoist way doors | - | Manual with interlock safety feature |
| s) | Car floor | - | Ceramic Tiles |
| t) | Design ambient temperature | ºC | 50 |
| u) | Loading capacity | Kg | As per IS 14665 (Part 1):2000 |
| **2.0** | **Car Frame and Platform Construction** | | |
| a) | Car enclosure material | | Cold-rolled stainless steel not less than 18 gauge |

| Sl. No. | Item Description | Units | Technical Particulars |
|---|---|---|---|
| b) | Ceiling load withstand capacity | Kg | Bidder to decide |
| c) | Withstand capacity of lift car | N | Bidder to decide |
| d) | Number of Hoisting ropes | | Minimum n +1 |
| e) | Factor of Safety for Hoisting ropes | | Minimum 10 |
| **3.0** | **Motors** | | |
| a) | Voltage | V | 415 (±) 10% |
| b) | Frequency | Hz | 50 +3% -5% |
| c) | Combined voltage & frequency | | 10% (sum of absolute percentage value of voltage and frequency variation). |
| d) | Starting method | | Direct online starting |
| e) | Maximum Torque | | Not less than 200% of full load torque |
| f) | Class of Insulation | | Class F, with temperature rise limited to class-B |
| g) | Degree of Protection | | IP-55 |
| **4.0** | **Control Panel** | | Shall be of **Rittal make** |
| | | | |

# VOLUME – III

# TECHNICAL SPECIFICATIONS

## SECTION - 3

## DETAILED TECHNICAL SPECIFICATION - ELECTRICAL

**VOLUME - III**

**SECTION - 3**

**DETAILED TECHNICAL SPECIFICATION - ELECTRICAL**

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# VOLUME - III

# SECTION - 3

# DETAILED TECHNICAL SPECIFICATION – ELECTRICAL

# SUB-SECTION - 3.1

# GENERAL ELECTRICAL REQUIREMENT

**VOLUME - III**

**SUB-SECTION - 3.1**

**GENERAL ELECTRICAL REQUIREMENT**

## 1.0.0 INTENT OF SPECIFICATION

1.1.0 This specification covers the design, manufacture, assembly, testing at manufacturer's works, packing, transportation to site including transit insurance, unloading, erection, testing & commissioning of Electrical Equipment complete with all accessories for efficient and trouble-free operation of combined cycle captive power project.

1.2.0 It is not the intent to specify completely herein all details of the equipment; nevertheless, the equipment shall be complete and operative in all respects and shall conform to the highest standard of engineering, design and workmanship.

## 2.0.0 ELECTRICAL SYSTEM DESCRIPTION

2.1.0 The proposed Power plant consisting of one Gas Turbine Generator (GTG) & one Steam Turbine Generator (STG). GTG shall be connected to the new 66kV indoor type Gas Insulated Switchgear (GIS) through a Step-up Generator Transformer using phase segregated bus duct. STG shall be connected to the 66kV Outdoor type Gas insulated switchgear (GIS) through a Step-up Generator Transformer using phase segregated bus duct. Power shall be evacuated from 66kV GIS to the grid through the 66kVoutgoing line feeders. For commissioning of plant the start-up power shall be drawn from grid to the 66kV GIS.

2.2.0 Auxiliary Power supply is envisaged at 11kV & 415V level. Two numbers of Station Transformers are provided for supplying unit loads.

2.3.0 Required numbers of unit and station service transformer (11/0.415 kV) are provided for supplying 415V loads. Electrical Auxiliary power distribution arrangement & Power Evacuation Arrangement is shown in the enclosed "**Key Single Line diagram"(Drg. No. 00-5111168-E-201, 2 sheets).**

2.4.0 One number Black start cum Emergency DG set shall be considered for starting of Gas turbine and safe shutdown of units. During blackout condition Diesel Generator (DG) set shall feed essential loads, same Diesel generator set shall feed unit emergency loads for safe shut down of Units.

2.5.0 To provide uninterrupted power supply to DCS and other Control Panels, a dedicated 110 V AC UPS system shall be provided. To feed essential loads, such as the emergency oil pumps, Control Supply to Switchgears / Panels, Emergency DC lighting etc, 110 V DC supply backed by DC Batteries shall be provided. DC system shall include 66kV GIS control supply requirements also.

2.6.0 If 125V DC system is required by the Gas Turbine supplier as per manufacturer's standard the same shall also be provided.

2.7.0 Plant communication system shall be provided with Public address system & telephone system.

2.8.0 For all electrical MV/LV/Control panels, Local control panels and Junction boxes, Transformers, etc shall be painted with RAL 7032.

## 3.0.0 ELECTRICAL SYSTEM DESIGN

3.1.0 The plant shall be designed to operate in islanding mode of operation on tripping of all the grid incoming lines and Steam Turbine generator, so that the Gas Turbine generator unit can be made running with the available plant load under such condition.

3.2.0 The design, manufacture, assembly, shop testing, erection, testing & commissioning as well as performance of the equipment shall conform to the latest edition of relevant IS / IEC specifications.

3.3.0 Before starting manufacture of any equipment the Contractor shall have to take approval of relevant drawings and data from the Owner/Owner's representative.

3.4.0 All equipment supplied and all work carried out including design and detailed engineering shall comply with the statutory requirements local Government as well as Central Government and with the Indian Electricity Rules. The accuracy class of meters, CTs, PTs (inside GIS) for energy accountability shall be as per latest GETCO regulations.

3.5.0 Unless otherwise specified in the respective section, Electrical design ambient for all equipment sizing shall be considered as 50 Deg C dry bulb temperature and 95% RH. All the equipment are required to operate in a highly corrosive environment and highly humid (at costal area) atmosphere.

3.6.0 Unless otherwise specified, at least 20 % margin shall be considered in equipment sizing over and above the calculated load current/fault current/power requirements.

3.7.0 Makes of all Electrical equipment are subject to prior approval by the purchaser. Similar equipment and components shall be of same make. Equipment of same type and rating shall be interchangeable.

3.8.0 The 415V PCC & MCC panels shall be of minimum FORM 3B type of construction.

3.9.0 In respect to the above LV circuit breaker selection, following should be considered as per IEC:-

| Utilisation Category | Application |
|---|---|
| Category A | Circuit-breakers with no assigned short-time rating (e.g Current limiting ACBs and MCCBs) cannot be used if coordination is required with downstream switchboard feeders. Applicable for the outgoing feeders |
| Category B | Circuit-breakers with assigned short-time rating (e.g ACBs and some Supplier's larger rated MCCBs) that shall be used if coordination is required with downstream switchboard / MCCs. Applicable for the incomer and outgoing feeders. |

Outgoing feeders not requiring any coordination for example motor feeders Category "A" MCCB can be considered.

3.10.0 In switchgear for Motor feeders rated 15kW & above an ammeter & transducer shall be provided. All transducers will be of dual output type.

3.11.0 All LT motors rated 90 kW & above shall be controlled through Air Circuit Breakers. LT motors rated below 90 kW shall be controlled by fused contactor. In addition to the above ELCB shall be provided for all 415V motor feeder. Each feeder shall also provided with O/L relay and SPPR relay.

3.12.0 For the motor feeders, the essential auxiliaries shall have contactors with delayed drop out feature adjustable up to 3 sec and necessary auto reset facility and the relay should be of digital type. The

list of motors shall not be limited to BFP, AOP, JOP, lube oil pump, compressors, barring gear and any other drive recommended by GTG,STG & HRSG vendor.

3.13.0 The power cables upto and including 10 sq.mm should be copper conductor and above 10 Sqmm. Aluminium conductor may be used. For CT circuits minimum cable size shall be 4sq.mm copper. Minimum size of control cables shall be 2.5sqmm. 20% spare cores shall be provided in all control cables. The maximum no. of cores shall be limited to 27.

3.14.0 The equipment supplied shall meet the requirement of state electricity and Indian grid code.

3.15.0 The Substation Automation System (SAS) shall have provision for interfacing with remote PLDC (Regional Load Dispatch Centre) through suitable gateways with adequate number of ports along with modems at substation level.

3.16.0 Voltage Levels shall be as follows:

- Power Evacuation : 66 kV (±10%), 3 phase, 3 wire 50 Hz, effectively earthed.
- Generation Voltage : Manufacturer's standard Voltage,3 phase,50 Hz
- Plant HT Auxiliary Supply : 11000V (±10%), 3-phase, 3W, 50 Hz, earthed through resistance.
- Plant LT Auxiliary Supply : 415V (±10%), 3 phase, 4 wire, solidly earthed.
- Plant LT Emergency Supply : 415V (±10%), 3 phase, 4 wire ungrounded.
- Plant DC Supply : 110V (+10% to –15%), DC 2 wire unearthed.
- Plant UPS Supply : 110V (±10%), 1 phase, 2 wires 50 Hz, A.C.
- Transducers : 110V DC (For LT boards 230V AC)
- Metering : 110V AC PT Voltage
- Control & protection : 110V, DC 2 wire unearthed
- Panel lighting and space heaters : 240V, 1-phase, 2wires 50 Hz, A.C. with one point earthed.
- Control Supply for Breaker feeders : 110V, DC 2 wire unearthed
- Control Supply for LV DOL modules : 110V, 1 phase, 2 wires
- Permissible Frequency variation for generator : +3% to – 5%
- Permissible Frequency variation for auxiliaries : +5% to – 5%
- Voltage level for AC Motors below 0.2 kW : 240 V, Single phase, 50 Hz, with DOL start.
- Voltage level for AC Motors from 0.2kW up to and including 160 kW : 415 V, 3 phase, 50 Hz, with DOL start.
- Voltage level for A.C Motors above 160 kW : 11000V, 3 phase, 50 Hz, with DOL start.

3.17.0 Design short circuit levels shall be at least the following and has to be supported by calculation:

- Three phase symmetrical short circuit ratings of 66kV System : 40 kA for 3 sec
- Three phase symmetrical short circuit ratings of 11kV System : 44 kA for 3 sec
- Earth fault current for 11kV System : 100A.
- Three phase symmetrical short circuit ratings of 415V System : 50 kA for 1sec
- Short circuit ratings of 110V DC System : 20 kA for 1 sec (min)

3.18.0 Insulation level at various voltages shall be as follows:

**66kV System**

One minute Power Frequency withstand voltage : 140 kV (rms)
Switching Impulse withstand Voltage : 325 kV (peak)

**11kV System**

One minute Power Frequency withstand voltage : 28 kV (rms)
1.2/50 Micro sec, impulse withstand voltage : 75 kV (peak)

**415 V System**

One minute Power Frequency withstand voltage : 3 kV (rms)

3.19.0 Sizing criteria for auxiliary transformers

Design Criteria for Auxiliary Transformer and Generator Transformer

i. The Contractor shall size the auxiliary transformer as per sizing criteria furnished below:

| | | |
|---|---|---|
| Min. Rating of each Auxiliary transformer ( in kVA at p.f.0.8) | = | 1.2 x (Sum of total connected load + Max of (sum of 20% of total standby loads or the largest standby load) + max of (sum of 50% total intermittent loads or the largest intermittent load)) |

The auxiliary transformers shall be sized for 2x100%

**4.0.0 QUALITY ASSURANCE, TESTING & INSPECTION**

4.1.0 All materials, components and equipment covered under this specification shall be procured, manufactured, erected, tested, and commissioned at all the stages, as per approved Quality Plan.

4.2.0 All tests shall be conducted as per relevant IS/IEC/IEEE standards and shall be performed in the presence of purchaser's representative, if so desired by the purchaser. The Bidder shall give at least 15 days advance notice of the date when the tests are to be carried out.

4.3.0 Equipment offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished. Type testing shall be conducted without any cost implication to the purchaser if type testing is not already carried out for any equipment supplied. For the various bought out items test certificates from equipment manufacturer shall be furnished. Routine tests shall be carried out for all the equipment as per applicable standards whether specifically mentioned or not. Specific type tests are to be carried out as specified in individual equipment specifications.

4.4.0 Copies of certified reports of all tests carried out at the works shall be furnished. The equipment shall be dispatched from works, only after receipt of Purchaser's written approval of the test reports.

The charges for carrying out all routine tests shall be deemed to be included in the Bid price. The charge of carrying out each type test/ special test if any shall be given separately in "Unit Price Schedule".

# VOLUME - III

# SECTION - 3

# DETAILED TECHNICAL SPECIFICATION - ELECTRICAL

# SUB-SECTION - 3.2

# GENERATOR & ACCESSORIES

**VOLUME - III**

**SUB-SECTION - 3.2**

**GENERATOR & ACCESSORIES**

## 1.0.0 GENERAL

This specification covers the design, manufacture, supply, erection, testing and commissioning of Generator and its auxiliaries.

It is not the intent to specify completely herein all details of the equipment, nevertheless, the equipment shall be complete and operative in all respects and shall conform to the highest standard of engineering, design and workmanship.

## 2.0.0 SCOPE OF WORK

The scope of work shall include but not limited to the following:

- One Gas Turbine Generator (GTG) & one Steam Turbine Generator (STG) complete with all auxiliaries.
- Brushless Excitation system.
- Automatic voltage regulator (Digital type)
- All consumables such as lubricants, chemicals, sealing materials, etc, for the complete commissioning, trial operation and an operation period specified elsewhere.
- List and supply of one (1) set of special tools and equipment for maintenance and inspection in steel boxes including identification and operation instructions.
- Necessary erection hard wares and touch up paints.
- Mandatory spares as listed in Vol. II / Section-1.0 and recommended spares for two (2) years trouble free operation.

## 3.0.0 CODES & STANDARDS

The generator and its auxiliaries shall conform to IEC-60034 and other relevant standards.

## 4.0.0 TECHNCIAL REQUIREMENTS

### 4.1.0 Design Criteria

4.1.1 Generator shall be capable of delivering continuously the rated power with winding temperature rise limited to Class ‘B’ insulation at rated voltage, frequency, power factor and at rated cooling water temperatures and rated gas pressure. But additional reliability shall be obtained by using insulation material of Class-F. The generator shall be capable of satisfactory continuous operation at rated MVA and power factor with ±5% voltage variation and +3% and -5% frequency variation occurring simultaneously without exceeding safe temperature rise limits and in any case not exceeding Class F limits.

4.1.2 The designed maximum continuous rated (MCR) output of the generator shall be more than the gas turbine output for the entire ambient temperature range prevailing at site specified in project information (Vol. II / Section-1.0). The designed MCR output of the Steam Turbine Generator shall exceed the maximum output of the ST under all operating conditions.

4.1.3 The Generator shall be capable of operating continuously with a negative sequence current as specified in IEC-34.

4.1.4 The design of generators shall be coordinated with that of the steam turbine and gas turbine and shall result in a completely compatible installation.

4.1.5 The generator shall be three phase, totally enclosed, horizontal, two pole, cylindrical rotor, Wye connected machine with phase and neutral terminals brought out for connection to isolated phase bus duct.

4.1.6 Depending on the sudden load changes occurring in service, it shall be possible to put load on the generator up to its rated output, and to unload it similarly, without unacceptably high voltage rises or drops occurring.

4.1.7 The generator unit shall be capable of withstanding 3 phase short circuit at the generator terminals when operating at rated MVA and power factor, 5% overvoltage and with rated excitation for 3 seconds.

4.1.8 The generator phase and neutral side terminals shall be brought out through seal off bushings.

4.1.9 For gas turbine generator an automatic $CO_2$ fire extinguishing system shall be provided as per manufacturer's standard.

4.1.10 Generator auxiliary system like cooling, excitation, etc. shall be provided with respective local control panels with required control, indication / annunciation and necessary main control system interfacings.

4.2.0 **Constructional Feature**

4.2.1 **Stator**

a) The Stator body shall be of totally enclosed air tight construction. The stator shall be stress relieved after complete welding and subjected to pressure test.

b) Stator coil insulation and taping of the coils shall be such as to provide adequate corona shielding. Coil ends shall be adequately braced to prevent distortion due to any abnormal operating condition. Stator supports shall be so designed as to withstand maximum short circuit stresses.

c) The insulation of the windings shall be of low flammable and self-extinguishing type.

d) The stator winding shall be fully insulated through out and shall be suitable for operation with non effectively earthed neutral. The stator winding shall be star connected with all the three phase and three neutral ends brought out through terminal bushings. The terminals shall be liberally sized for carrying the rated current of the Generator and shall be provided with clearances specified for the terminal voltage under relevant standards. The terminal arrangement shall be suitable for phase segregated bus duct connections on phase & neutral side for both GTG and STG.

e) The stator windings shall be provided with not less than twelve (12) duplex type RTD (distributed around the periphery). In the stator core, not less than Six (6) duplex RTD shall be provided. Additional RTDs / thermocouples / thermostats at locations where the highest temperatures are expected shall be provided. All the temperature sensors shall be monitored and recorded at control room.

4.2.2 **Rotor**

a) The rotor is to be manufactured in one piece, the inertia constant of which shall be designed to give a large margin between the critical and running speeds under normal operating conditions.

b) The rotor winding shall be provided with a complete damper winding or damper wedges with short circuit rings on both sides.

c) Provision shall be made for rotor earth fault protection, first stage for alarm and second stage for tripping.

d) The rotor after complete assembly shall be balanced at all speeds up to 120% of the rated speed.

4.2.3 **Bearings**

a) The generator bearings shall be of plain and self aligned type, and shall be provided with at least two duplex resistive type temperature sensors for remote indication of the bearing metal temperatures.

b) Each bearing shall be provided with oil sight flow indicator.

c) Generator bearings shall be insulated form stator frame and foundation plate to prevent shaft current. Provision shall be made for bearing insulation measurement while machine is in operation.

d) Vibration monitoring system with monitoring pick up shall be provided.

4.2.4 **Frame and housing**

a) The generator housing shall be of welded steel plate with provision for preventing stator movement from causing undue vibration in the external frame and foundation.

b) All components requiring inspection and maintenance to be designed for easy access and replacement.

4.3.0 **Cooling System**

The generator cooling system shall be closed air circuit ventilation with intermediate cooling water system. The contractor shall provide all the air ducting system required for air intake and air outlet from the generator to the air cooler.

The design of the generator cooling system shall be such that one (1) extra element/cooler section is provided to take care of continuous operation at maximum load with one (1) element out of operation.

4.4.0 **Excitation System**

Excitation system shall be of brushless type with PMG. The excitation system offered shall be of proven design. The excitation system shall be designed for field forcing capability of minimum 150% exciter voltage corresponding to the generator MCR output at rated power factor for not less than 10 seconds even for close-in faults.

The excitation system shall be capable of operating the generator at maximum load, rated power factor and rated frequency at 105% rated voltage. Excitation system shall have sufficient reserve and redundancy to permit effective utilization of generator capability over the entire operating range and under all service conditions without any restrictions. The rectified current and voltage output of the exciter shall be at least 120% of the rated excitation current and 110% of the no-load excitation voltage of the generator with a 200% minimum ceiling voltage.

The excitation system shall have proper field suppression equipment with properly rated DC field breaker and field discharge facility.

4.4.1 **Brushless Excitation System**

The brushless type excitation system shall consist of a rotating armature AC generator as main exciter directly coupled to the generator rotor. The field of the main AC exciter shall be powered from a Permanent Magnet Generator (PMG). The output of AC exciter shall be rectified by the rotating diodes and connected to generator field winding through leads run along generator shaft.

The brushless excitation system shall be provided with diode arms such that failure of 25% diode arms in any leg of the three phase rectifier bridge will not cause restriction on the unit operation at its rated conditions including field forcing. The exciter shall be equipped with suitable devices to detect diode failure when the machine is in operation.

In case of failure of PMG, the field of the main exciter shall be changed over to a supply from 415V auxiliary system through suitable control circuitry. This shall be capable of being controlled in both auto and manual mode of AVR.

Individual diode fuse failure shall be detected by suitable stroboscopic arrangement. An inspection window shall be provided in the exciter cover to inspect the fuse failure.

4.5.0 **Automatic Voltage Regulators**

A microprocessor digital voltage regulator with dual channel automatic and dual channel manual (2 Auto + 2 Inbuilt Manual channels), with a control deviation of 0.5% from no-load to full load at rated frequency shall be provided. A suitable transfer control system with transfer switch and necessary meters and controls shall be provided for a smooth bumpless transfer from automatic channels to manual and manual to automatic voltage control. Bumpless and smooth transfer shall be automatically initiated in the event of a sudden failure of the voltage regulator or of the associated VT.

The voltage regulator shall be complete with rotor current limiter, stator current limiter, rotor angle limiter, compensators, over fluxing limiter, monitors, power system stabilizers etc.

All essential indications/annunciation system required for AVR/excitation system shall be provided. Provision shall be made for remote operation with necessary controls, indications and annunciations.

The excitation system shall have digital microprocessor based automatic voltage regulator (AVR) to maintain steady generator terminal voltage under variable load conditions and for parallel operation with the grid and / or with the other generators. In addition independent manual voltage regulator shall be provided in order to take care of excitation requirement in case of AVR failure. An automatic follow-up device shall be provided to allow the changeover from automatic to manual mode of regulation or vice versa. In each mode of operation separate power supply, Thyristor etc. shall be considered to work independently in case of failure of any channel.

AVR designs shall incorporate features, in which the manual VR unit is maintained in step with the automatic VR unit, so that on reference voltage failure to the automatic VR unit, the changeover can be affected by a protective relay to the manual regulator with a minimum disturbance to excitation level.

Fully automatic and manual operated synchronising facilities shall be incorporated in the AVR unit, including controls to permit manual run up of the machine, after which the automatic unit synchronizes and connects the generator on to the system.

Besides the maximum excitation limiter, the AVR shall incorporate maximum volts per hertz excitation limiter which should be designed to prevent sustained magnetic saturation of the generator and its associated generator transformer, by only permitting over-excitation for definite pre-selected time intervals.

i. The AVR/Excitation shall include the following limiters, fault detectors/protection features:-

- A minimum excitation limit device to prevent AVR from reducing generator excitation below a value that endangers power system stability.
- Over excitation limiter
- Under excitation limiter with P/Q limiter, Stator current limiter, Minimum field current limiter
- Over voltage limiter
- Over current limiter
- VT Fuse Failure protection.
- AVR fail protection.
- Over fluxing limiter
- AVR power supply fails protection.
- Rotating diode failure detection relay.
- The AVR / Excitation system shall also be provided with automatic power factor regulator unit with appropriate timers for protection to prevent generator being overexcited / overloaded due to steady state grid under voltage occurring due to reactive power shortage in the grid.

ii. Necessary quadrature AVR droop (adjustable droop and with no droop / droop selection switch) shall be provided to enable proper sharing of power and for satisfactory parallel operation of generators between themselves and for parallel operation with Grid.

4.6.0 **Gas Turbine Generator Unit Start-up System**

*The GTG essentially has to be equipped with a Black start facility.* The Gas Turbine is started via the Generator by use of frequency converter or starting motor or diesel engine. The Bidder shall provide start up transformer for feeding SFC in frequency converter starting method.

SFC offered shall be complete in all respects. Additional thyristors in converter / inverter units to take care of thyristor failure, redundancy for critical items and self monitoring features. The voltage to frequency ratio of the start-up system output shall be maintained constant throughout the start-up and shall not lead to over fluxing condition of generator and neutral grounding transformer. Over fluxing shall be limited to 110%.

All the protection shall be set for normal operation of the plant and the settings will not be altered during start-up. To this extent the contractor shall provide suitable protections on the start-up system output to protect the generator, CTs, VTs, etc. and cut off the start-up system in the event of operation of these protections.

4.7.0 **Generator Neutral Earthing**

Generator Neutral Earthing shall be non effectively earthed through a distribution transformer with its secondary winding loaded with a suitable resistance.

4.8.0 **Insulation Level**

The generator windings shall withstand voltages as per IEC. Surge arrestors of suitable rating and surge capacitors shall be provided for the surge protection of the generator.

4.9.0 **Generator Remote Automation System Control Facilities**

In addition to local controls of features stated below, each turbine driven generator set shall have features for interface with remote generator control/monitoring and remote automation system such as SAS / DCS.

These shall include:-

- Local / Remote or Auto selection switch with their status indication to remote system
- Initiation of remote generator auto synchronizing.
- Remote automatic and/or manual changeover of generating operating mode along with their remote status indication such as those associated with:-
  - Generator excitation / AVR control in either of the Voltage Control or Power Factor or Mvar control mode.
  - Generator Speed control in either of the droop or isochronous or isochronous load sharing or isochronous base load operation.
- Remote automatic and / or manual generator voltage and frequency control:-
  - Generator power reference setting/Speed raise and lower control
  - Generator voltage raise and lower control
  - Generator load acceptance and reduction rate change
- Remote automatic and/or manual equal or unequal load allocation/sharing between sets as required
- Remote annunciation of all generator fault and alarm signals
- Remote transfer of generator capability diagram and generator operating point on the capability curve for mimicking of generation capability and operating point at the HMI of the remote automation system

Generator and the generator control system supplier shall:-

- Include and list all analogue inputs, analogue outputs, digital inputs, digital outputs, transducer input / outputs, pulse control inputs required and incorporated by them for remote automation system control.

- Furnish details of communication protocol and access address of all analogue inputs, analogue outputs, digital inputs, digital outputs, transducer input / outputs, pulse control inputs as required for interface by the remote automation system supplier.

5.0.0 **TESTS**

5.1.0 **Tests on Generator**

5.1.1 The turbine generator and accessories covered against this specification shall be subjected to tests by the Vendor during manufacture, as also during erection and commissioning. Before any equipment / plant is packed or dispatched from the Vendor's or his Sub-Vendor's works, all tests called for shall be carried out in the presence of the Purchaser's representative.

5.1.2 Only type tested machine shall be supplied. Type test reports as per IEC- 60034, of similar rating and type of Generator shall be submitted.

The generator shall be subjected to routine tests as per latest IS / IEC. In addition to the above routine test, following type tests shall be carried out as per latest IS 5422.

- High voltage test
- Insulation resistance test
- Overload test
- Temperature rise test
- Determination of efficiency by separation of losses method.
- Vibration test
- Zero sequence impedance measurement test
- Total Harmonic Distortion test
- Generator rotor balancing
- Measurement of negative phase sequence reactance.
- Instantaneous short circuit test & determination of transient & sub transient reactance's & time constants.
- Measurement of DC resistance of stator & rotor windings.
- Phase sequence.
- Impedance of the rotor windings.

5.1.3 The following Routine Mechanical tests shall be carried out on each generator as a minimum:

- Mechanical inspection.
- Measurement of bearing vibrations.
- Over speed test.
- Pressure tests on machine housings.
- Rotor balance.
- Material tests on rotor during manufacture to establish physical and chemical properties as well as non-destructive tests.

5.2.0 **Tests On AVR**

The routine tests on AVR shall include all functional tests, performance Characteristic test & high voltage tests as a minimum

**6.0.0 PAINTING**

All equipment shall be finished with two (2) under coats of high quality epoxy based primer followed by two coats of epoxy painting. Painting shall be carried out by approved process.

**7.0.0 SPECIFIED TECHNICAL DATA**

| Sr. No | DESCRIPTION | UNITS | REQUIREMENTS |
|---|---|---|---|
| 1.0 | Applicable standard | | IEC-60034 |
| 2.0 | Rated Output | MW | Ref Clause 4.1.1 & 4.1.2 |
| 3.0 | Rated Terminal Voltage | Volt | Manufacturer's Standard Voltage |
| 4.0 | Voltage Variation | | +5% to -5% |
| 5.0 | Rated Frequency | Hz | 50 |
| 6.0 | Frequency Variation | | +3% to -5% |
| 7.0 | Rated Power Factor | | 0.8 lag |
| 8.0 | Rated Speed | rpm | 3000 |
| 9.0 | No. of phases | | 3 |
| 10.0 | Cooling | | Air cooled |
| 11.0 | Insulation Class of Generator & exciter | | Class F with temperature rise limited to Class B |
| 12.0 | Stator winding connections | | Star |
| 13.0 | Continuous & short time operation under unbalanced / Unsymmetrical load | | As per IEC-60034 ; Part-1 |
| 14.0 | No. of terminals to be brought out | Nos. | 3 |
| 15.0 | Short circuit ratio | | Not less than 0.5 |
| 16.0 | Protection class of Generator and Exciter | | IP 54 |
| 17.0 | Over speeding capability | | 120% of rated speed |
| 18.0 | Rated Power Factor | Cos φ | 0.8 |
| 19.0 | Direct axis saturated sub-transient reactance (x"d) | % | Bidder to furnish. |

| Sr. No | DESCRIPTION | UNITS | REQUIREMENTS |
|---|---|---|---|
| 20.0 | Negative sequence and zero sequence reactance | % | Bidder to furnish. |
| 21.0 | Cooling | | Closed air circuit ventilation with intermediate cooling water system |
| 22.0 | Maximum auxiliary cooling water temperature | °C | Bidder to furnish |
| 23.0 | Stator core and rotor | | Air cooled closed circuit (CACW) |
| 24.0 | Insulation Class of Generator & exciter | | Class `F' with temperature rise limited to `B'. |
| 26.0 | Type of excitation | | Brushless with static rotating Rectifier |
| 27.0 | Applicable standard | | IEC – 34/IS-5422 |
| 28.0 | Excitation system response ratio | | 0.2/ Sec. |
| 29.0 | Protection class of Generator and Exciter | | IP 54 |
| 30.0 | Automatic Voltage Regulator (2 x 100% Auto and manual) | | Automatic channels with manual tracking. (Hot standby) |
| | a. Voltage range of electronic voltage regulator | % | ± 12% |
| | b. Type | - | Digital microprocessor based |
| | c. Accuracy | % | 0.2% |
| | d. Response time | m sec | 20 |
| | e. Quantity | Nos. | 1 (dual) / unit |

# VOLUME - III

# SECTION - 3

# DETAILED TECHNICAL SPECIFICATION - ELECTRICAL

# SUB-SECTION - 3.3

# GENERATOR CONTROL & RELAY PANEL

**VOLUME - III**

**SUB-SECTION - 3.3**

**GENERATOR CONTROL & RELAY PANEL**

## 1.0.0 GENERAL

This specification covers the design, manufacture, supply, erection, testing and commissioning of Generator Relay Panels.

It is not the intent to specify completely herein all details of the equipment; nevertheless, the equipment shall be complete and operative in all respects and shall conform to the highest standard of engineering, design and workmanship.

## 2.0.0 SCOPE OF WORK

The scope of work shall include the following:-

- Generator Relay Panel (GRP) for Gas Turbine Generator.
- Generator Relay Panel (GRP) for Steam Turbine Generator.
- Mandatory spares as listed in Vol. II / Section-1.0. and recommended spares for two (2) years trouble free operation.

## 3.0.0 CODES AND STANDARDS

Relay panels shall conform to relevant IS/IEC standards as amended up to date.

## 4.0.0 TECHNICAL REQUIREMENT

4.1.0 The relay panel shall be of free standing, floor mounting, sheet steel enclosed, with a degree of protection of not less than IP 42. The panel shall be fabricated out of CRCA sheet steel of not less than 2 mm thickness.

4.2.0 GRP shall also accommodate a digital tri-vector meter (TVM) with test terminal block and energy accounting /audit meters. The accuracy class of TVM / energy accounting/audit meters shall be Cl.0.2S. Tri-vector meters shall have pulse output for interfacing with DCS / SAS.

4.3.0 Necessary transducers for current, voltage, power, power factor, frequency etc. required for remote metering shall be provided. All transducer shall be of dual output type.

4.4.0 The various protections considered for generator shall be as per the Typical Metering & Protection diagram for GTG/STG (Drg.No.20-5111168-E-202). All protective relays, auxiliary relays, timers, etc., to protect the complete generator, its subsystems shall be housed in GRP. The generator protection shall be implemented using redundant multifunction microprocessor based numeric relays. All protective relays shall be numerical type with serial interface facility to communicate with DCS / SAS. All protective relays and meters shall be provided with test terminal blocks for secondary injection testing. All main protection relays shall be with IEC 61850 communication protocol.

4.5.0 The generator protection system relays shall be classified into different categories and the logic shall be worked out by the Bidder to suit the system offered.

4.5.1 **Gas Turbine Generator**

- Class-A Trip (Tripping of 66kV generator transformer breaker, field breaker, turbine, GT HV breaker).
- Class-B Trip (Tripping of 66kV generator transformer breaker, field breaker and turbine).
- Class-C Trip (Tripping of 66kV generator transformer breaker).

4.5.2 **Steam Turbine Generator**

- Class-A Trip (Tripping of 66kV generator transformer breaker, field breaker and turbine).
- Class-B Trip (Turbine is tripped first for turbine faults and certain electrical faults, with 66kV generator transformer circuit breaker still closed; subsequently 66kV generator transformer circuit breaker trips on sensing low forward power through class-A trip relays).
- Class-C Trip (Tripping of 66kV generator transformer circuit breaker alone)

4.6.0 The protective relaying system shall be a coordinated application of individual relays. For each monitored abnormal condition, there shall exist a designated primary device for detection of that condition. A failure of any primary relay shall result in the action of a secondary overlapping scheme to detect the effect of the same abnormal occurrence. Secondary rated current and voltage signals produced by current transformers (CT) and potential transformers (PT) shall be 1 ampere and 110 volt respectively.

4.7.0 Generator lockout relays shall be used to receive signal inputs from protective relays and to provide the contacts needed to initiate protective action and alarms. Required number of lock out relays shall be provided to meet the scheme requirement. All lockout relays shall have a manual reset feature which shall require an operator to manually reset the lockout relay prior to returning the affected equipment to service.

4.8.0 All protection relays shall have facilities for communication with DCS / SAS system. All hardware/software required for interfacing with the Purchaser's DCS / SAS system shall be supplied. Relays shall have IEC 61850 communication protocol for direct access of data through laptop. One lap top / PC common for all generator relay panels shall be provided for communicating with RS232 front port for the following purposes:

- Retrieving data from numerical relays
- Uploading settings & I/O configuration.
- Retrieving & viewing disturbance recorder data

4.9.0 The following 2 x 100% redundant protections shall be provided in GRP as a minimum. Additional protection, if any, to meet system requirements shall also be provided.

**For Generator:**

Each of the protection listed below shall be provided in both the groups.

- Generator differential protection (87G)
- 95% Stator earth fault protection (64G1,G2)
- 100% Stator earth fault protection (64G3,G4)
- Pole slipping protection (78G)
- Rotor earth fault protection- two stages ( 64R)

- Loss of excitation protection (40G)
- Under voltage element of loss of excitation protection (27 / 40G2)
- Negative phase sequence protection (46G)
- Back up impedance protection (21G)
- Stator over load alarm (50GS)
- Definite time over load protection(51G)
- Over fluxing protection (99G)
- Reverse power protection (32G)
- Low forward power protection ( 37G)
- Under frequency protection (81G)
- Over frequency protection (81G)
- Over voltage protection (59G)
- Dead machine protection (50GDM)
- Excitation transformer (if applicable) over current protection.
- VT fuse failure protection
- Generator winding inter turn fault protection (if required)
- CB failure protection (50)
- Bus ground relay (59BN)

4.10.0 The following protection features/equipment shall also be provided.

- Field earth fault relay
- Diode fuse failure monitor
- On line shaft leakage current monitor.
- Load shedding relay

4.11.0 Equipment furnished with the generator's excitation equipment shall provide the following additional protections:

- Under excitation.
- Over excitation.
- Generator field ground faults.
- Exciter field ground faults.
- Excessive volts per hertz.

4.12.0 Additional generator protective monitoring equipment shall be provided to monitor the following:

- High bearing temperatures.
- Over speed conditions.
- Excessive vibrations.
- Generator overheating.
- Generator disturbance recorder.

4.13.0 **Synchronizing Scheme**

Though the CCCPP is envisaged to operate in synchronized mode with grid, Islanded or fixed mode to feed its plant load. The synchronizing, scheme shall be provided for operation of TPP in parallel with grid or Island mode.

**Synchronization of CCCPP**

- Synchronizing facility shall be considered in generator control panel (synchronising control panel) located in CCCPP control room.

- Double voltmeters, Double frequency meters, synchroscope, check synchronizing relay with guard relay, auto-synchronizer relay and necessary selector switches with synchro-permissive indication lamp etc. to complete the synchronizing scheme shall be considered in generator control panel. Auto synchronizing system will also be provided in DCS / SAS as well as from control panel.

**5.0.0 TESTS**

Panel shall be subjected to all type, routine and acceptance tests as per relevant standards.

**6.0.0 PAINTING**

All equipment shall be finished with two (2) under coats of high quality epoxy based primer followed by two coats of epoxy painting. Painting shall be carried out by approved process.

# VOLUME - III

# SECTION - 3

# DETAILED TECHNICAL SPECIFICATION - ELECTRICAL

# SUB-SECTION - 3.4

# BUSDUCTS

**VOLUME - III**

**SUB-SECTION - 3.4**

**BUSDUCTS**

## 1.0.0 GENERAL

This specification covers, the design, manufacture, supply, erection, testing and commissioning of phase segregated bus ducts for GTG and STG, Non segregated phase bus duct for connection between LV Transformer and PCC, Generator neutral grounding equipment, PT/SP cubicles and associated equipment.

It is not the intent to specify completely herein all details of the equipment, nevertheless, the equipment shall be complete and operative in all respects and shall conform to the highest standard of engineering, design and workmanship.

## 2.0.0 SCOPE OF WORK

The scope of work shall include but not limited to the following:

- Segregated Phase Bus Ducts (SPBD) for GTG and STG.
- Surge protection and VT cubicles (SPVT).
- Neutral grounding Transformer cubicle for generators (NGT).
- Current Transformers located inside Bus duct.
- Non Segregated Phase Bus ducts (NSPBD) for connection between LT transformer & LT PCC.
- List and supply of one (1) set of maintenance tools and tackles as required.
- Necessary support structures, erection hardware and touch up paints.
- Mandatory spares as listed in Vol. II / Section-1.0. and recommended spares for two (2) years trouble free operation.

## 3.0.0 CODE & STANDARDS

- IS 5082 : Wrought aluminium & aluminium alloy bars, rods, tubes and sections for electrical purposes.
- IS 2544 : Specification for Porcelain Post Insulators for system with nominal Voltages greater than 1000 Volts.
- IS 8084 : Interconnecting bus bars for AC voltage above 1.1 kV up to & including 36kV.

The Bus ducts and associated equipment shall also conform to other applicable IEC/IS standards amended up to date.

4.0.0 **TECHNCIAL REQUIREMENT**

4.1.0 **Segregated Phase Bus Duct (SPBD) & Non Segregated Phase Bus Duct (NSPBD)**

4.1.1 The generator busduct shall be such that the continuous rating can be delivered at site ambient conditions without exceeding the following temperatures considering the specified electrical design ambient temperature and duly considering the effect of solar radiation.

| | | |
|---|---|---|
| Main conductor | : | 90°C |
| Plain bolted joint | : | 90°C |
| Silver plated bolted joint | : | 105°C |
| Bus duct enclosure | : | 70°C |

4.1.2 The continuous rating of the generator bus ducts shall be arrived considering the maximum continuous output of the Generator at the rated power factor and loaded to 105% with 95% of the rated voltage and rounded off to the next standard rating.

4.1.3 The main run of the busduct (in case of GTG) shall be designed to withstand the following cases for three (3) second.

4.1.4 Fault current contribution from the Generator and Fault current contribution from the EHV system. For this purpose the EHV system fault contribution shall be considered as limited only by the impedance of the Generator Transformer.

4.1.5 In case of STG, the bus duct shall be designed to withstand the Fault current contribution from the Generator (or) Fault current contribution from the EHV system, whichever is higher for three (3) second.

4.1.6 The tap off run of the bus ducts to SPVT cubicle shall be designed to withstand for three (3) second, the sum of the fault current contribution from Generator and EHV system for both GTG & STG.

4.1.7 Segregated phase bus duct (SPBD) shall be used between Generator and generator transformer.

4.1.8 Negative tolerance on impedance value for Generator shall be considered for calculation of short time ratings in the above clauses. At least 5% margin shall be considered in the short time rating arrived in the above clauses.

4.1.9 The complete enclosure for star point formation on neutral side of generator from Generator terminal to neutral earthing equipment shall also be provided.

4.1.10 Bus bars shall be of high conductivity Copper for HT & Aluminium for LT in forms of straight extruded length, rigidly supported vertically on porcelain insulators/cast resin insulator with resilient pads in the enclosure. Flexible connections shall be provided between the bus sections to allow for expansion and contraction of the conductor and enclosure. Flexible connections shall also be provided between equipment and bus duct terminations. To accommodate thermal expansion, vibration etc. neoprene rubber or suitable synthetic material bellow shall be provided at all equipment connection points for bus duct enclosure. Suitable inspection opening shall be provided for access to bus joints/terminal connection/CTs/ insulators. Adapter box of aluminium sheets with seal-off bushing near Generator end and wherever required shall be provided. All contact surfaces shall be silver plated to ensure an efficient and trouble free connection.

4.1.11 Bus sections shall be capable of withstanding electro mechanical and thermal stresses due to short circuit current without any damage. Calculations for determining sizes of conductors and enclosure,

spacing of insulators, heat loss and temperature rise and also short circuit force withstand capability shall be furnished.

4.1.12 Shorting links shall be provided at Generator end, Generator transformer end etc. The shorting link shall be rated for continuous current of bus duct.

4.1.13 Removable bolted type disconnect link shall be provided in the tap off bus. Disconnect link shall consist of a removable section of conductor and shall be so constructed as to permit easy removal and reinsertion without alignment difficulties. Hardwares such as bolts, etc., shall be of non magnetic material.

4.1.14 Seal off bushings shall be provided at all the equipment end and turbine building wall crossing of busduct. All seal-off bushings shall be dry non-hygroscopic, porcelain/epoxy type. The bushing shall withstand the maximum short circuit forces under short-circuit conditions.

4.1.15 The electrically continuous bus enclosure shall be used as the grounding bus. All parts of the bus enclosure, supporting structure and equipment frames shall be grounded to earthing mat.

4.1.16 The enclosure shall be insulated at the equipment connections so that longitudinal current will not flow through or transmitted to any connecting equipment.

4.1.17 The continuous rating of NSPBD shall be same as the rated current of associated 415V Switchgear incomer breaker rating. The temperature rise of conductors, joints & enclosure mentioned for SPBD shall be applicable for NSPBD also.

4.1.18 The short time & momentary current ratings of the NSPBD shall be same as that of associated 415V Switchgear incomer breaker rating. Negative tolerance on impedance value for LT transformer shall be considered for calculation of short time ratings. The bus conductors and their support insulators shall be designed to withstand, without damage, the forces developed while carrying the rated short time current.

4.1.19 The Bus ducts shall be totally enclosed, self cooled with Aluminium conductor for 415V. Enclosure material shall be Mild steel for all SPBD.

4.1.20 Flexible braided copper connections and bimetallic connectors shall be provided for connection at the transformer terminals & switchgear end. To accommodate thermal expansion, vibration, etc., neoprene rubber or suitable synthetic material bellow shall be provided at all equipment connection points for busduct enclosure.

4.1.21 Expansion joints shall be provided wherever required to take care of expansion / contraction of busbars under normal operating condition.

4.1.22 The busduct shall be suitable for outdoor installation with weather proof construction. The enclosure shall conform to IP-55. A continuous hood made of Mild sheet steel. The inside of enclosure shall be treated with black matt paint.

4.1.23 Wall frame assembly shall be provided wherever the busduct passes through the building from indoor to outdoor. The wall sealing arrangement shall be complete with seal off bushings, connecting bolts nuts and all other accessories.

4.1.24 Necessary inspection covers with gaskets shall be provided in the enclosure for easy inspection/ maintenance / installation of busbar connections.

4.1.25 Necessary space heaters shall be provided to avoid condensation in bus ducts when not in operation. Drain plug to drain moisture shall be provided at low points along the busduct.

4.1.26 Continuous run of GI earth bus shall be provided all along the bus duct.

**4.2.0 Current transformers (CT)**

4.2.1 The CTs shown in the enclosed drawing "Typical Metering & protection scheme of GTG / STG (Drg.no:10-3111168-E-202)" shall be provided in Segregated Phase busduct as a minimum. The current transformer shall be cast-resin, ring type, with high stability under short circuit conditions, mounted within the busduct and suitable for continuous operation at a temperature of 90°C. CT mounting arrangement shall be such as to permit easy removal and replacement of the CTs without dismantling the bus run or supports.

4.2.2 All CT secondary leads shall be brought to a common CT terminal box and test links shall be provided in the secondary circuits for carrying out current and phase angle measurements. Proper approach to CT terminal box shall be provided.

4.2.3 All the CTs are of single core type to be provided.

4.2.4 All wiring shall be carried out by heat resistant wire in non-magnetic metallic conduits suitably clamped along the run. The minimum conductor size shall be 2.5 $mm^2$ stranded copper.

4.2.5 The terminal box shall be of IP 54 construction, fabricated out of aluminium alloy and complete with removable gland plate for cable entry and screwed cover for access to the terminals. Facilities for shorting and grounding the terminal shall be provided at the terminal block. 10% Spare terminals shall be provided.

4.2.6 The minimum requirement of accuracy class of the current transformers shall be as follows:

| | | |
|---|---|---|
| For differential protection | - | Class PS. |
| For AVR & other metering | - | Class 0.5 |
| For energy accounting/performance testing | - | Class 0.2S. |

4.2.7 Short circuit withstand capability of CTs shall be same as that of Bus ducts. CT secondary shall be rated for 1A. VA burden calculations of CT shall be furnished for Owner/Owner's representative's review and approval.

**4.3.0 Neutral Grounding Equipment cubicle**

4.3.1 Generator Neutral earthing shall be non effectively earthed through a distribution transformer with its secondary winding loaded with a suitable resistance. The generator star point shall be earthed through the primary winding of the distribution type neutral grounding transformer with a resistor connected across its secondary winding. The transformer shall be dry type, single phase air cooled connected between Generator neutral and earth.

4.3.2 The resistor will be rated to limit the maximum earth fault current through the generator star point to 5 A. NGTR primary Knee-point voltage shall not be less than 1.3 times maximum generator voltage rating. Earthing transformer insulation & current ratings shall be selected after including field forcing voltage requirements. 30 seconds withstand for maximum EF current shall be considered for the NGTR. NGTR X/R shall not exceed 2 (two). NGTR & resistor rating selection calculation shall be furnished by supplier for Owner/Owner's representative's approval. Supplier shall furnish technical data of KVA rating, voltage ratio, Knee point voltage, short time KVA withstand for 30 seconds, %X &%R of NGTR along with secondary loaded resistor value required to limit EF to as low a value of approximately 5 A.

4.3.3 The Earthing resistor will be of the heavy duty, non inductive, rustless, oxidation resistant, joint less and unbreakable Punched stainless steel grid type. The resistor will be housed in a vermin proof, water proof & weather proof protected metal clad enclosure suitable for outdoor installation.

**4.4.0 Voltage Transformers and surge protection cubicle (VT & SP)**

a) Voltage transformer and surge protection shall be housed in phase separated sheet steel/aluminium cubicle with grounded barriers having degree of protection of IP 54. Voltage transformer shall be of cast resin, drawout type with accuracy class 0.5 for synchronizing, class 3P for protection and class 0.2 for Performance testing and energy metering. Suitably rated fuses shall also be provided on HV and LV side. VT secondary shall be rated for 110V AC. One non-linear surge arrestor and one surge capacitor with built-in discharge resistor designed for rotating machine protection shall be furnished per phase. The voltage class of surge protection equipment shall match the rated voltage of the generator. Surge Arrestor shall be station class hermetically sealed type complete with discharge counter. The cubicle shall be complete with space heater, cubicle lamp, receptacles etc.

b) VT's shall be provided on both sides of generator circuit breaker (generator side as well as generator transformer side for synchronizing as well as earth fault protection (with broken delta tertiary winding).

**5.0.0 TESTS**

5.1.0 For bus ducts & their auxiliaries, all routine tests shall be conducted as per IS 8084 & other relevant IS/IEC. Also test certificates shall be furnished for bought out items.

5.2.0 Bus duct shall be of type tested one. Relevant Type test reports as per IS 8084 shall be submitted.

5.3.0 **Site Tests**

a) Power frequency voltage withstand test at 80% of routine test voltage.

b) Insulation resistance test for enclosure circuit.

c) Air tightness test & water tightness tests.

**6.0.0 PAINTING**

All equipment shall be finished with two (2) under coats of high quality epoxy based primer followed by two coats of epoxy painting. Painting shall be carried out by approved process. The bus conductor and inside surface shall be treated with matt black paint for efficient heat dissipation. Bus duct supports shall be hot dip galvanized.

## 7.0.0 SPECIFIED TECHNICAL DATA

| Sr. No | Description | Unit | Data |
|---|---|---|---|
| **A** | **Generator Segregated Phase Bus Duct** | | |
| 1.0 | Rated Voltage | V | Same as that of generator |
| 2.0 | Rated frequency | Hz | 50 +3% -5% |
| 3.0 | Enclosure | | Mild Steel |
| 4.0 | Conductor | | Copper |
| 5.0 | Degree of protection | | Dust tight weather proof Min. IP-55 |
| 6.0 | Minimum clearance | | |
| | a. Phase to Phase | mm | 450 |
| | b. Phase to Earth/Neutral | mm | 90 |
| 7.0 | Insulation level | | |
| | a. Voltage class | kV | 12 |
| | b. Power frequency withstand Voltage | kV rms | 28 |
| | c. Impulse withstand Voltage | kVp | 75 |
| **B** | **Non-Segregated Phase Bus Duct** | | |
| 1.0 | Rated Voltage | V | 415 |
| 2.0 | Rated frequency | Hz | 50 +5% -5% |
| 3.0 | Enclosure | | Mild Steel |
| 4.0 | Conductor | | Aluminium |
| 5.0 | Degree of protection | | Dust tight weather proof Min. IP-55 |
| 6.0 | Minimum clearance | | |
| | a. Phase to Phase | mm | 25 |
| | b. Phase to Earth/Neutral | mm | 19 |
| 7.0 | Power frequency withstand Voltage | kV rms | 2.5 |

# VOLUME - III

# SECTION-3

# DETAILED TECHNICAL SPECIFICATION - ELECTRICAL

# SUB-SECTION - 3.5

# TRANSFORMERS

**VOLUME - III**

**SUB-SECTION - 3.5**

**TRANSFORMERS**

## 1.0.0 GENERAL

This specification covers the design, manufacture, supply, erection, testing and commissioning of HT & LT Transformers.

It is not the intent to specify completely herein all details of the equipment; nevertheless, the equipment shall be complete and operative in all respects and shall conform to the highest standard of engineering, design and workmanship.

## 2.0.0 SCOPE OF WORK

The scope of work shall include but not limited to the following:

- Generator Transformer for GTG
- Generator Transformer for STG
- Station Transformer (ST)
- Required number of LT Service Transformers
- Fittings & accessories of above transformers
- List and supply of maintenance tools and tackles.
- Mandatory spares as listed in Vol. II / Section-1.0 and recommended spares for two (2) years trouble free operation.

## 3.0.0 CODES & STANDARDS

- IS 2026 : Specification for Power Transformers
- IS 10028 : Code of practice for selection, installation and maintenance of transformers.
- IS 8478 : Application Guide for On Load Tap changers.
- IS 2099 : Specification For Bushings for Alternating voltages above 1000V.
- IS 4257 : Porcelain Bushings for Transformers
- IS 6600 : Guide For Loading Of Oil Immersed Transformers
- IS 10028 : Code of practice for selection, installation and maintenance of Transformers.
- IEC 60185 : Specification For Bushings for Alternating voltages above 1000V
- IEC 60076 : Power Transformers
- CBIP Manual on Transformers

Transformers shall also conform to other relevant IEC/IS Standards as amended up to date.

## 4.0.0 TECHNICAL REQUIREMENTS

### 4.1.0 Design Criteria

4.1.1 The transformer shall be designed for a rated frequency of 50Hz. The transformer shall be capable of delivering the rated output at any particular tap continuously without exceeding the specified temperature limits under the following operating conditions.

- Voltage variation of ± 10% of rated voltage of that particular tap.
- Frequency variation of +3% -5% of rated frequency.
- Combined voltage and frequency variation of 10% (absolute sum).

4.1.2 The transformers shall be capable of operating continuously at its rated output without exceeding the temperature rise limits as given below over an ambient temperature of 50°C.

- In oil by thermometer 50°C.
- In winding by resistance 55°C

Hot spot temperature based on maximum yearly weighted average temperature of 32°C shall not exceed 98ºC.

4.1.3 The transformer shall be capable of operating at rated output at any tap position with out exceeding the specified temperature rise limits, provided the voltage corresponding to that tap does not vary by more than ±10% of rated voltage. The winding including the tapping arrangement shall be designed such that the electromagnetic balance is maintained between HV and LV windings at all voltage ratios.

4.1.4 The maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be such that under 10 per cent continuous over-voltage condition it does not exceed 1.62 Tesla for Generator transformer, 1.65 Tesla for Unit and Station Auxiliary Transformers and 1.72 Tesla for LT auxiliary transformers. The current density shall be maximum 2.8A/sqmm.

4.1.5 Transformers shall be designed for over fluxing withstand capability of 110% continuous and 125% for at least 1 minute.

4.1.6 The transformers shall be free from annoying hum and vibration when it is in operation, even at 110% rated voltage.

4.1.7 Generator Transformers shall be capable of operating at 125% rated voltage for a period of one (1) minute and 140% rated voltage for a period of ten (10) seconds due to sudden load throw.

4.1.8 All the transformer shall be designed to withstand without injury, the thermal and mechanical effects of any external short circuit to earth and of short circuits at the terminals with full voltage maintained behind it for a period of 3 seconds for GT and 2 sec for LT transformers.

4.1.9 The Generator Transformer shall be equipped with detachable type flange radiators and motor driven fans / pumps for forced cooling. Each radiator group shall be fitted with drain valve and air release plug. Separately mounted radiators for higher capacity transformers are also acceptable. All transformers shall be with radiators N+1 (Failure one radiator shall not affect the performance of transformer) at continuous maximum rating. Radiator cooling fin thickness shall be of minimum 1.2 mm.

4.1.10 GT Transformers shall be capable of operating under natural cooled condition up to the specified load. Forced cooling equipment shall come into operation automatically by pre-set contacts of winding temperature indicator.

4.1.11 The transformers shall be capable of being loaded in accordance with IS: 6600/ IEC-60076 Part-7. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.

4.1.12 The noise level of transformer, when energized at normal voltage and frequency with fans and pumps running shall not exceed, when measured under standard conditions, the values specified in NEMA standard publication TR-1.

4.1.13 Transformer shall be suitable for oil filling by full vacuum.

4.1.14 The oil shall be pure mineral oil, free of additives, acids and with properties complying to the latest revision of IS 335 / IEC.

4.1.15 Sizing calculations/DBR/GTP of each transformer shall be furnished for Owner/Owner's representative's review and approval.

4.1.16 **Generator Transformer**

a) Generator Transformer shall be used to connect Generator to a 66 kV network to evacuate power. The rating of the generator transformers shall be selected such that there will not be any limitation on the generator transformer for evacuating the full Gas Turbine/Steam Turbine output under all operating conditions at site.

b) The Generator Transformer shall be designed for bi-directional power flow. The Transformer shall have ONAN / ONAF cooling.

c) The generator transformer shall be provided with ON load Tap changer(OLTC) on HV winding for +10% to -10% voltage variation in steps of 1.25%.

4.1.17 **Station Transformer (ST)**

a) 2x100% ST shall be provided for supplying station and auxiliary loads as per the Single line diagram. The rating of Station Transformer shall be taken as mentioned in Key Single line diagram. Starting requirements of higher size motors shall be duly considered while sizing the transformer.

b) ST shall have ONAF/ONAN cooling.

c) ST shall be provided with ON Load Tap Changer (OLTC) on HV winding for +10% to -10% voltage variation in steps of 1.25%.

d) The impedance of the transformers at taps corresponding to nominal transformation ratio (primary taps) shall be selected keeping in view the short circuit level of the 11 kV and 415V switchgear & the voltage dip at motor terminals not exceeding the limits specified in this specification.

4.1.18 **LV Service Transformers**

a) LV service transformer shall be 11 / 0.433 kV, 3 phase, 2 winding with Off-Circuit Tap on HV winding for +5% to -5% voltage variation in steps of 2.5%.

b) Each 415V Switchgear shall be powered by two LV service transformer. The rating of all the LT transformers shall be decided considering the maximum possible load at any instant. Starting load of higher size motors shall also be duly considered while sizing the transformers. All the LT transformers shall be selected with 100% standby i.e 2 x 100% rating.

c) Off-Circuit Tap changers shall be provided with lockable operating handle & mechanical tap position Indicator.

d) Lighting Dry type transformer shall be Class `F' insulated with temperature rise limited to Class B enclosed in sheet steel enclosure of atleast IP 33 degree of protection, complete with door and interlocking facility.

**4.2.0 Constructional requirement**

4.2.1 **Transformer Tank**

a) The transformer tank shall be of welded construction and fabricated from good commercial grade low carbon steel of adequate thickness to withstand without any deformation continuous internal gas pressure of 0.35 kg/cm¨ over normal oil pressure. The transformer tank shall withstand the full vacuum under standard atmospheric conditions. Transformer tank of Generator Transformer, UAT shall be of Bell type Construction.

b) The tank cover shall be bolted on with the weather proof, hot oil resistant, resilient gasket in between for complete oil tightness.

c) All fasteners and bolts shall be galvanized or zinc passivated.

d) Inspection openings of sufficient size shall be provided in the tank cover to give access to leads, bottom terminals of bushings, taps and testing earth connections.

e) In case Nitrogen is used to fill the transformer tank during transportation, the information shall be stenciled on the tank prominently.

4.2.2 **Core & Winding**

a) The core shall be constructed from high grade, non-ageing, cold rolled, super grain oriented, and silicon steel laminations. The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angles to the plane of laminations which may cause local heating.

b) Core and winding shall be capable of withstanding the shock during transport, installation and service. Adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

c) The coil shall be manufactured from electrolytic copper of suitable grade and shall be properly insulated and stacked. The end turns of the high voltage windings shall have reinforced insulation to take care of the voltage surges likely to occur during switching or other abnormal conditions.

d) The coils would be made up, shaped and braced to provide for expansion and contraction due to temperature changes. The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalize the distribution of currents and temperature along the winding.

4.2.3 **Bushings**

a) Bushings shall be homogenous, non-porous porcelain type, uniformly glazed and free from blisters, burns and other defects and shall be furnished complete with suitable terminal connectors of adequate capacity. No arcing horn to be provided.

b) Neutral & Phase bushing CTs shall be furnished as required with its secondary leads wired upto the terminal blocks. The terminals for CT secondary leads shall have provision for shorting. The arrangement shall be such that the CT can be removed from the transformer without removing the tank cover.

4.2.4 **OFF Circuit tap changer**

The Off-Circuit tap changer shall have an external three phase gang operated tap change switch. The operating handle shall be provided with a hand wheel so that it can be operated conveniently from ground level. The operating handle shall be padlocked at any tap position. The design shall be such that the lock cannot be inserted unless the contacts are correctly engaged. All contacts shall be silver plated and shall be held under strong contact pressure to ensure low contact drop and avoid pitting. The mechanism shall be provided with a mechanical tap position indicator.

4.2.5 **On Load Tap Changer ( OLTC)**

a) The OLTC gear shall be designed to complete successfully tap changes at 150% of rated current. Devices shall be incorporated to prevent tap change when the through current is in excess of the safe current that the tap changer can handle. The OLTC gear shall withstand through fault current without injury.

b) Oil, in compartments which house the making and breaking contacts of the OLTC shall not mix with oil in other compartments of the OLTC or with transformer oil. Gases released from these compartments shall be conveyed by a pipe to a separate oil conservator or to a segregated compartment within the main transformer conservator. An oil surge relay shall be installed in the above pipe. The conservator shall be provided with oil level gauge.

c) Oil filled compartments shall be provided with filling plug, drain valve with plug, air release vent, oil sampling device, inspection opening with gasketted and bolted with lifting handles.

d) The OLTC shall be provided with the Local – Manual / Local – Electrical / Remote Electrical modes of operation. The electrical operation shall be performed through a raise / neutral / lower control switch. A remote tap control cabinet (RTCC) shall be provided to rise or lower the taps from remote. This RTCC shall be housed in the central control room.

e) The local tap changer cubicle shall be provided for housing drive mechanism for OLTC preferably mounted on the tank of the transformer. The cubicle shall be fabricated of minimum 2mm. thick sheet steel complete with all wiring, fuses, links, cubicle illumination lamps, anti-condensation heater with thermostatic control switch, gland plate etc. The cubicle shall conform to IP 55 degree of protection.

f) The remote tap changer control panel shall be housed in indoor sheet steel cubicle fabricated of minimum 2mm. thickness complete with wiring, fuse links, illumination lamp with door switch, anti-condensation heater with thermostatic control switch, gland plate etc. Tap position indication with suitable lamp indications shall be made available in the RTCC panel.

4.2.6 **Fittings and Accessories**

a) Transformers shall be provided with all accessories like, but not limited to inspection manholes / handholes, lifting lugs, jacking pads, bi-directional flanged wheels, haulage lugs, skids, earth ads, neutral earthing down comers (2 nos.) supported on pin insulators, terminal marking, rating and diagram plates, marshalling boxes, conservators (breatherless) (flexible oil resistance air bag), valves for various purposes including draining, filtering, filling, double float buchholz relay, oil and winding temperature indicators with high and very high contacts, magnetic (150 mm dia) and prismatic oil level gauges, Oil flow indicators, tap position indicators, anti-earthquake clamping arrangement, tank mounted radiators with accessories, and pressure relief valve.

b) One set of winding temperature indicators with necessary current transformer, heating coil and a detector element and one set of oil temperature indicator with maximum reading pointer shall be mounted locally so as to be readable at a standing height from ground level. Each of the above indicators shall be provided with necessary contacts for alarm and trip and transducers with 4-20mA output for remote logging of winding / oil temperature.

c) The Buchholz Relay shall be provided with two floats and two pairs of electrically separate contacts for alarm and trip. Separate oil surge relay shall be provided for OLTC compartment.

d) Oil preservation shall be done by means of conservator tank provided with air bellow breathing through silica gel breather.

e) A sheet steel weather proof marshalling box of IP 55 construction, shall be mounted on the tank of transformer and shall accommodate all auxiliary devices except those which must be located directly on the transformer. All terminal blocks for external cable connections shall be located in this box. Terminal shall be of stud type.

f) Each cooling fan and pump motor shall be provided with isolating switch, starter, thermal overload, single phase preventer and short circuit protection. Separate on/off switch for each incoming power supply with HRC fuse shall be provided. All cooling equipment trouble shall be indicated in local control panel with repeat alarm in central control room.

g) Terminals shall be brought out through bushings to a detachable air insulated cable box as required. The cable box shall be self-supporting type with disconnecting chamber so that the transformer can be moved without affecting the cable terminations. Degree of protection for cable box shall be IP 55.

h) For bus duct connection, suitable bus duct flanges shall be provided. Transformers terminal connections shall be suitably brought out through disconnect chamber for connections with bus duct conductor.

i) Two grounding pads, located on the opposite sides of the tank, shall be provided for connection of station ground mat.

j) 2 Nos. ground terminals each shall also be provided on marshalling box and cable box to ensure effective earthing.

The Neutrals of the windings shall be brought out through neutral bushings at suitable location.

4.2.7 **Auxiliary Supply**

All indications, alarms, trip contacts provided shall be suitable for operation on a nominal 110 V DC system.

Redundant DC control supply with changeover facility shall be provided to the cooler control cubicle.

**5.0.0 TESTS**

5.1.0 All Routine tests & Acceptance tests shall be conducted for each transformers as per IS 2026 / IEC-76 for transformer tank pressure test & vacuum test shall also be conducted as per CBIP manual.

5.2.0 The following additional routine tests on each of the transformer shall be conducted.

(a) No load loss and excitation current at 400V from LV side and at 90% and 110% rated voltage.
(b) Oil leakage test – 12 hours.
(c) Magnetic balance test
(d) Measurement of tan delta and capacitance of each winding.
(e) Measurement of zero sequence impedance.

5.3.0 Transformers shall be of type tested one. Relevant type test reports as per IS 2026 / IEC-60076 shall be submitted. If type test reports are not available, the type tests shall be conducted without any cost implication.

For Generator Transformer temperature rise test shall be conducted.

**6.0.0 PAINTING**

The interior of transformer tanks and other oil filled chambers, internal steel work shall be cleaned by sand blasting. The surfaces shall be painted with not less than two coats of heat resistant, oil insoluble, insulating varnish. Other steel surfaces of transformer & accessories, shall be finished with two (2) under coats of high quality epoxy based primer followed by two coats of epoxy painting. Painting shall be carried out by approved process.

**7.0.0 SPECIFIED TECHNICAL DATA**

| Sr. No. | Description | Unit | Date |
|---|---|---|---|
| **A** | **Generator transformers** | | |
| 1.0 | Type | | Out door, Three Phase Oil filled Transformer |
| 2.0 | Number of transformers | | • As per Single line diagram (Drg no. 3110155-E-201)<br>• One no. 31 / 36 MVA (For existing GTG-3 supply to be shifted to new 66kV GIS) |
| 3.0 | Rated output | MVA | To suit Generator rating (Minimum rating given in SLD) |
| 4.0 | No-load voltage ratio | kV/kV | 66/Generator rated voltage |
| 5.0 | Frequency | Hz | 50 +3% -5% |
| 6.0 | Impedance (nominal pos.) at max. rating | % | (Minimum rating given in SLD) Bidder to decide. |
| 7.0 | Winding connection | | |

| Sr. No. | Description | Unit | Date |
|---|---|---|---|
| | HV | | Star |
| | LV | | Delta |
| 8.0 | Vector group | - | As per Single line diagram (Drg no. 3110155-E-201) |
| 9.0 | Earthing of H.V Neutral | - | Solid grounded |
| 10.0 | Termination detail | | |
| | HV side | | Over head lines / 66kV cables |
| | LV | | Segregated Phase bus duct / cables |
| 11.0 | Type of cooling | - | ONAN / ONAF |
| 12.0 | Impulse & Power frequency withstand voltages | | |
| | HV | kV | 325 kVp & 140 kV rms |
| | LV | kV | As per IS 2026 & generator voltage level |
| 13.0 | Tap Changer | | OLTC on HV side |
| 14.0 | OLTC Range | - | -10% to +10% in steps of 1.25% |
| 15.0 | Maximum temperature rise of oil at 110% of full load for 24 hrs above ambient 50 degree cent… | Deg C | 50 |
| 16.0 | Maximum temperature rise of winding at 110% of full load for 24 hrs above ambient 50 degree cent.... | Deg C | 55 |
| 17.0 | Voltage class of bushings | | |
| | HV | kV | 72 |
| | LV | kV | Bidder to decide as per generator voltage |
| 18.0 | HV Neutral Bushing CTs | | One PS Class & one 5P20 class |
| 19.0 | Creepage distance | mm/ Kv | 31 |
| 20.0 | Over fluxing capability | | 110% continuous<br>125% for 1 minute and<br>140% for 10 sec |
| **B** | **LT Service Transformers** | | |
| 1.0 | Type | - | Out door, 3 Phase Oil filled transformer |
| 2.0 | No. of transformer & rated output | | According to the requirements. |

| Sr. No. | Description | Unit | Date |
|---|---|---|---|
| 3.0 | No-load voltage ratio | kV/kV | 11 / 0.433 |
| 4.0 | Frequency | Hz | 50 +5% -5% |
| 5.0 | Winding connection | | |
| | HV | | Delta |
| | LV | | Star |
| 6.0 | Earthing of LV neutral | | Solidly grounded. |
| 7.0 | Vector group | - | Dyn11 |
| 8.0 | Terminal details | | |
| | HV | | Cables |
| | LV | | Non Segregated Phase bus duct |
| 9.0 | Off circuit tap changers | - | ± 5% on HV side in steps of 2.5% |
| 10.0 | Type of cooling | - | ONAN |
| 11.0 | Maximum temperature rise of oil at 110% of full load for 24 hrs above ambient 50 degree cent. | Deg C | 50 |
| 12.0 | Maximum temperature rise of winding at 110% of full load for 24 hrs above ambient 50 degree cent. | Deg C | 55 |
| 13.0 | Impulse & Power frequency withstand voltages | | |
| | HV | kV | 75 kVp & 28 kV rms |
| | LV | kV | 3 kV rms |
| 14.0 | Voltage class of bushings | | |
| | HV | kV | 12 |
| | LV | kV | 1.1 |
| 15.0 | LV Neutral Bushing CTs | | One PS Class & one 5P20 class |
| 16.0 | Creepage distance | mm/ kV | 31 |
| 17.0 | Over fluxing capability | | 110% continuous and 125% for 1 minute |
| **C.** | **Station Transformer** | | |
| 1.0 | Type | - | Out door, 3 Phase Oil filled transformer |
| 2.0 | Number of transformers | - | 2X 100% (As per SLD) |

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| Sr. No. | Description | Unit | Date |
|---|---|---|---|
| 3.0 | Rated output | MVA | 40 / 45 |
| 4.0 | No-load voltage ratio | kV/kV | 66 / 11.55 |
| 5.0 | Frequency | Hz | 50 +3% -5% |
| 6.0 | Impedance (nominal pos.) at Max. rating | % | Bidder to decide. |
| 7.0 | Winding connection | | |
| | HV | | Star |
| | LV | | Star |
| 8.0 | Vector group | - | Dyn11 |
| 9.0 | Earthing of L.V Neutral | - | Resistively grounded; Earth fault current limited to 100A. |
| 10.0 | Type of cooling | - | ONAN/ONAF |
| 11.0 | Terminal details | | |
| | HV side | | Over head lines |
| | LV side | | Segregated Phase bus duct |
| 12.0 | Tap changer | | OLTC on HV side |
| 13.0 | OLTC range | - | +10% to -10% in steps of 1.25% |
| 14.0 | Impulse & Power frequency withstand voltages | | |
| | HV | kV | 325 kVp & 140 kV rms |
| | LV | kV | 75 kVp & 28 kV rms |
| 15.0 | Maximum temperature rise of oil at 110% of full load for 24 hrs above ambient 50 degree cent. | Deg C | 50 |
| 16.0 | Maximum temperature rise of winding at 110% of full load for 24 hrs above ambient 50 degree cent..... | Deg C | 55 |

| Sr. No. | Description | Unit | Date |
|---|---|---|---|
| 17.0 | Voltage class of bushings | | |
| | HV | kV | 72 |
| | LV | kV | 7.2 |
| 18.0 | LV & HV Neutral bushing CTs | | One PS Class CT & One 5P20 class CT |
| 19.0 | Creepage distance | mm/ kV | 31 |
| 20.0 | Over fluxing capability | | 110% continuous<br>125% for 1 minute and<br>140% for 10 sec |

# VOLUME - III

# SECTION - 3

# DETAILED TECHNICAL SPECIFICATION - ELECTRICAL

## SUB-SECTION - 3.6.1

## 66 kV INDOOR GIS

**VOLUME - III**

**SUB-SECTION - 3.6.1**

**66 kV INDOOR GIS**

## 1.0.0 INTENT OF SPECIFICATION

1.1.0 This specification intended to cover the design, engineering, manufacture, assembly testing at manufacturer's works, inspection, properly seaworthy packed for transportation, delivery at site, unloading, storage, receipt, transportation at site , erection, testing and commissioning of complete 66 kV Indoor type Gas Insulated Substation package including it's substation automation system, control & protection requirements.

1.2.0 It is the intent of this specification to describe primary features, materials, design & performance requirements and to establish minimum standards of the work.

1.3.0 It is not the intent to specify completely herein, all aspects of design and construction of equipment. Nevertheless, the equipment shall conform in all respects to high standard of engineering and workmanship in all respects and shall be capable of performing continuous operation in a manner acceptable to purchaser.

## 2.0.0 SYSTEM DESCRIPTION

The Power generated by the combined cycle power plant i.e. One (1) Gas Turbine Generator and One (1) Steam Turbine Generator will be stepped up to 66 kV through Generator Step up transformers. The 66kV Indoor GIS systems will be used to evacuate the Power generated from the plant to the Grid and also to receive power from Grid. The GIS System will be installed indoor and will comprise of following bays:

a) Two (2) new Generator Transformer bays

b) One (1) existing GTG-3 Generator transformer bay

c) Two (2) Line Bays

d) One (1) Bus Coupler bay

e) Two (2) new Station Transformer bays

f) Two (2) existing grid transformer bays

g) One (1) spare transformer bay

## 3.0.0 SCOPE OF SUPPLY

3.1.0 The scope of works under this package shall include but not limited to complete project management, design, engineering, manufacture, shop testing, packing, loading, transportation to site, insurance, receipt, unloading, storage, transportation at site , erection, testing & commissioning of 66 kV GIS Substation package as per the detailed scope mentioned here.

3.2.0 **66 kV Indoor GIS System**

3.2.1 One no. 3 - Isolated phase, SF6 gas insulated metal enclosed busbars, each comprising of:

a) Three numbers individual bus bar enclosures running the length of the switchgear to interconnect each of the circuit breaker bay modules in double main bus system.
b) Three numbers inductive type voltage transformers complete with isolator switch & safety ground switches
c) Three numbers inductive type voltage transformers, inside the GIS Compartment.
d) Interconnecting wiring and piping
e) Grounding support structures and platforms
f) GIS duct with gas monitoring devices, barriers, pressure switches etc as required

3.2.2 One no. Bus-coupler bay comprising of:

a) One number 3 phase SF6 insulated circuit breaker complete with operating mechanism
b) Single core single phase current transformers.
c) 3 phase, single pole group operated isolator switches, complete with manual and motor driven operating mechanism.
d) 3 phase, single pole group operated safety ground switches, complete with manual and motor driven operating mechanism.
e) GIS duct with gas monitoring devices, barriers, pressure switches etc as required
f) Bay marshalling boxes, Local Control panels

3.2.3 Three nos. Generator transformer circuit breaker bays, each comprising of:

a) One number 3 phase SF6 insulated circuit breaker complete with operating mechanism
b) Single core single phase current transformers
c) 3 phase, single pole group operated isolator switches, complete with manual and motor driven operating mechanism
d) 3 phase, single pole group operated safety ground switches, complete with manual and motor driven operating mechanism
e) Three numbers inductive type voltage transformers, inside the GIS Compartment.
f) Three numbers out door type surge arresters (surge arresters inside transformer cable termination box can be accepted.)
g) Three numbers 1 phase SF6 Ducts to outdoor air bushings required for conductor termination. ( required for existing GTG-3 transformer bay in case of OHL connection).
h) GIS duct with gas monitoring devices, barriers, pressure switches etc as required
i) Bay marshalling boxes, Local Control panels

3.2.4 Two nos. 66 kV transmission line circuit breaker bay modules, each comprising of:

a) One number 3 phase SF6 insulated circuit breaker complete with operating mechanism
b) Single core single phase current transformers
c) 3 phase, single pole group operated isolator switches, complete with manual and motor driven operating mechanism
d) 3 phase, single pole group operated safety ground switches, complete with manual and motor driven operating mechanism
e) One 3 phase single pole, high speed fault making ground switch, complete with manual and motor driven operating mechanism.
f) Three numbers inductive type voltage transformers, inside the GIS Compartment.
g) Three numbers 1 phase SF6 Ducts to outdoor air bushings required for conductor termination.
h) Three numbers Outdoor type surge arresters
i) GIS duct with gas monitoring devices, barriers, pressure switches etc as required
j) Bay marshalling boxes, Local Control panels

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3.2.5 Four Station transformer circuit breaker bay (two nos. existing & two nos. new) comprising of:

a) One number 3 phase SF6 insulated circuit breaker complete with operating mechanism.
b) Single core single phase current transformers.
c) 3 phase, single pole group operated isolator switches, complete with manual and motor driven operating mechanism.
d) 3 phase, single pole group operated safety ground switches, complete with manual and motor driven operating mechanism.
e) Three numbers inductive type voltage transformers, inside the GIS Compartment.
f) Three numbers out door type surge arrestors (surge arresters inside transformer cable termination box can be accepted for new station transformers, existing Surge arresters can be used for existing transformers).
g) Three numbers 1 phase SF6 Ducts to outdoor air bushings required for conductor termination.
h) GIS duct with gas monitoring devices, barriers, pressure switches etc. as required.
i) Bay marshalling boxes, Local Control panels

3.2.6 One spare Generator transformer circuit breaker bay, each comprising of:

a) One number 3 phase SF6 insulated circuit breaker complete with operating mechanism.
b) Single core single phase current transformers.
c) 3 phase, single pole group operated isolator switches, complete with manual and motor driven operating mechanism.
d) 3 phase, single pole group operated safety ground switches, complete with manual and motor driven operating mechanism.
e) Three numbers inductive type voltage transformers, inside the GIS Compartment.
f) Three numbers out door type surge arrestors (surge arresters inside transformer cable termination box can be accepted.).
h) GIS duct with gas monitoring devices, barriers, pressure switches etc. as required.
i) Bay marshalling boxes, Local Control panels.

Refer the attached drawing 00-5111168-E-203 66kV GIS Key Single diagram for details.

3.3.0 Balance of equipment / accessories like bus post insulators, clamps & connectors, spacers, aluminum tubes, Conductors, ground wire, insulators & hardware, gantry and equipment structures, bay marshaling kiosks as required to complete the 66kV GIS Substation package.

3.4.0 SF6 Gas Filling.

3.5.0 Breaker operation analyzer with transducers.

3.6.0 All jumpers and connections to surge arrester and 66 kV Gantry is in Bidder's scope.

Each of the 66 kV overhead line circuits shall be protected with numerical line distance protection relay suitable for operation through OPGW cable as the main protection communication link. Any modification work required at GETCO end shall be in EPC contractor's scope. Approximate route length from ONGC 66kV switchyard to GETCO Ichhapore Substation is around 4 kM.

3.7.0 Protection & Relay panels shall consist of the following:

a) Bus bar Protection Relay panels for Main & Check zones for each 66 kV bus.
b) Islanding protection scheme with three channels of under frequency and df/dt functions.
c) Line Protection relay panels consisting of BPU's with Distance protection.
d) Generator transformer Protection relay panels consisting of BPU'.
e) One Portable dynamic Relay test kit, Phantom Load sets, Test plugs & Relay tool kits.
f) All necessary licensed software for communication with Numerical relays, BPU along with dedicated engineering work station.

3.8.0 Substation Automation system (SAS) consisting of following:

a) Bay controller units (BCU) for each 66kV GIS.
b) Fully dual redundant communication bus.
c) SAS I/O Cabinets, marshalling panels.
d) Transducers for transmitting electrical analog quantities (Voltage, Current, active & reactive Power, frequency etc.).
e) All necessary Remote Terminal units (RTU), HMI, engineering work stations at the GIS control room.
f) One Remote HMI at Central control room along with connectivity and printers. Remote HMI shall also be duplicated at new GIS control room. The new SAS system shall have provision to communicate with the proposed plant SCADA system of ONGC and also with the new DCS system for the new power plant.
g) All required printers, scanners and consumables like paper, toners, and printer ribbons shall be supplied.

Refer the attached 66 kV GIS SAS configuration Dwg No: 10-5111168-E-204 for details.

3.9.0 Existing Main Availability based tariff (ABT) metering kiosk (outdoor) for both 66kV line bays may be used with suitable relocation as per GETCO guidelines for GETCO *& DGVCL guidelines for their* metering purpose. *If it is required to replace these existing ABT meters with kiosk as per GETCO & DGVCL guidelines, contractor to provide new GETCO & DGVCL approved meters with their installation as per GETCO & DGVCL guidelines.* Additional requirement of Check Availability based tariff (ABT) meter shall be provided for each 66kV line bay for GETCO *& DGVCL* tariff metering, Standby ABT meter shall be provided for ONGC purpose in both 66kV Overhead lines. Trivector meter suitable for tariff metering for all outgoing bays shall be provided. *Suitable relocation / renewal provision as per GETCO & DGVCL provisions would need to be made.*

3.10.0 *Any additional requirement of CTs / PTs for GETCO & DGVCL approved ABT metering, same shall be provided by contractor as per GETCO & DGVCL guidelines.*

3.11.0 110 V DC System with Two (2) 100 % rated batteries and two (2) 100 % rated float cum boost chargers along with DC distribution boards for 66 kV GIS.

3.12.0 415 V AC Distribution boards required for complete 66kV GIS package.

3.13.0 Lightning protection for complete GIS building & existing switchyard area.

3.14.0 Design and supply of earthing material shall be in Bidders scope. Connections to Bidder's earth riser from embedded earth mesh is in Bidders Scope.

3.15.0 All necessary platforms, supports, ladders etc. for maintenance work.

3.16.0 Set of Special Tools & Tackles, Start-up & Commissioning spares.

3.17.0 Recommended spares for 3 years of operation & maintenance.

3.18.0 Demolition / dismantling of existing 66kV switchyard equipment with their associated structures & foundations. Existing 66kV switchyard equipment after dismantling shall be dumped at the designated site as decided by ONGC.

3.19.0 Design of complete Civil works for the 66kV GIS system including that for GIS building, new Gantry structures, grading, gravel spreading, foundations, cable trenches, trench covers, drains, fencing, gates etc. to complete the installation . Bidder shall furnish all the civil drawings applicable as "Release for construction" for complete GIS building and switchyard area.

3.20.0 Required Documentation, Responsibility of calling State Electrical Inspector and getting statutory approval/certification of the GIS installation.

**4.0.0 SCOPE OF SERVICES BY BIDDER**

4.1.0 Development of General arrangement drawings.

4.2.0 Development of detailed layout for 66kV GIS building & existing 66kV switchyard area.

4.3.0 Development of Single line drawings with parameters of equipment and details of metering & protection.

4.4.0 Development of protection & control philosophy, selection of protection, control and annunciation schemes.

4.5.0 Development of interlocking schemes.

4.6.0 Development of earthing system.

4.7.0 Insulation coordination and lightning protection design calculations.

4.8.0 Development of power & control cable laying and termination schedules.

4.9.0 Development of erection key diagrams with bill of material.

4.10.0 Design of foundation and release of civil construction drawings for complete GIS building.

4.11.0 Development cable trench layout and sections & release of construction drawings.

4.12.0 Relay setting calculations along with programming charts.

4.13.0 Shop inspection and testing procedures along with QAP.

4.14.0 Complete erection, testing commissioning of all the equipment required for complete 66 kV GIS substation package. The field testing equipment required for site testing shall be arranged by the Bidder.

4.15.0 Furnishing of all labor, skilled and unskilled, supervisory and administrative personnel, erection tools and tackles, testing equipment, implements, supplies, consumables, and hardware, for timely and efficient execution of the erection work.

4.16.0 Transport vehicles necessary for efficient transportation of equipment from stores to site of erection and of excess material back to stores.

4.17.0 Submission of engineering, manufacturing and erection schedules so as to carry out the works in a phased timely manner.

4.18.0 Training of Owner/Owner's representative's engineers.

**5.0.0 CODES AND STANDARDS**

5.1.0 All the equipment/system shall in general confirm to the latest addition of relevant National and International codes & Standards especially Indian Statutory Regulations.

5.2.0 The accompanying sections also indicates the applicable codes and standards.

5.3.0 The Equipment/material/systems confirming to other equivalent national and international standards shall also be considered provided the same ensures equal or better features compared to standards listed in the following section.

**6.0.0 DETAILED TECHNICAL SPECIFICATIONS**

6.1.0 The design and constructional requirements of 66 kV indoor GIS system is covered under clause 10.00.00 of this specification.

6.2.0 The detailed technical requirements of 66 kV GIS equipments like Circuit breakers, instrument transformers, disconnections switches are covered in Section 3.6.2. This section also covers about the outdoor switchyard equipment like Surge arrestors, String insulators and all miscellaneous items. The detailed technical requirements of the OPGW are also covered in Section 3.6.2.

6.3.0 The detailed technical requirements of Substation Automation system (SAS) & Protection panels of 66 kV GIS system is covered in Section 3.6.3 The Section 3.6.2 also covers requirements about ABT metering & Fault Disturbance recorders.

7.0.0 **DESIGN & CONSTRUCTION REQUIREMENTS FOR 66 KV GIS SYSTEM**

7.1.0 The GIS shall comply with IEC 62271-203/60694. The general requirements and special requirements for Gas insulated switchgear are given in this section. Materials and components not specifically stated in this specification but are necessary for the satisfactory operation of the equipment shall be deemed to be included unless specifically excluded and shall be supplied at no extra cost.

7.2.0 The switchgear assembly shall be suitable for installation in indoor area. Constructional features shall be selected not only to withstand satisfactorily the specified atmospheric conditions under Project Information but allow for thermal expansion during its normal use.

7.3.0 Gas enclosures shall be designed to withstand high vacuum by provision of suitable reinforcement(s) at all the required locations. The gas filled enclosures shall conform to relevant pressure vessel code of ANSI/IEC.

7.4.0 Equipment shall be complete with all necessary supports, platforms, ladders, staircases, catwalks, mechanism cabinets, internal cable raceways etc for each bay and it shall be of extensible design.

7.5.0 The GIS shall be modular in structure and shall be housed indoor. The modules shall be single phase encapsulation and provided with hooks for handling by overhead cranes to be provided in the building. The modular design shall be capable of extension on either side without any major dismantling.

7.6.0 The equipment and connections within each compartment shall be arranged so as to allow removal and replacement of any section both during normal and abnormal (fault) working conditions with minimum disturbance to adjacent pressurized sections.

7.7.0 The lines shall be terminated on take-off gantry. The take-off from GIS shall be through bushing and the surge arrestor & Line trap shall be outdoor type. The terminations of Generator transformer shall be underground cables. High speed earth switches shall be provided where ever required.

7.8.0 The bus bars shall be rated for the duty specified and current rating shall be derived considering maximum possibilities.

7.9.0 The metal enclosures for the GIS shall be made up of non-magnetic material and shall be suitable designed and fabricated from mechanical and electromagnetic aspects. The enclosure surface shall be painted suitably for deterioration due to corrosion, humidity, temperature ageing, and attack from fungus , rodents. Interior finishing shall not contain any substances which could contaminate the SF6 gas and its insulating properties over a period of time.

7.10.0 The enclosures shall be such as to eliminate dangerous electrostatic charges. The enclosures shall meet the pressure vessel requirement as per ASME or equivalent. The modular design shall offer maximum flexibility from the design, operation and maintenance point of view. The enclosures shall be sectionalized with gas tight barriers between sections or compartments. The wall thickness of the enclosure shall be based on the design pressure as well as considering a burn through duration of 0.1 sec.

7.11.0 The support insulators and section barriers shall be free from voids and shall be so designed so as to reduce the electrical stresses to the minimum. Gas barrier insulators and support insulators shall have the same basis of design. The support insulator shall have holes on both sides for proper flow of gas. The section barriers and enclosure walls shall be gas tight (permissible leakage rate of 0.5% per annum) and capable of withstanding the maximum pressure differential i.e. vacuum on one side and maximum gas pressure on other side.

7.12.0 Minimum assembly work is envisaged during installation. Each section shall have plug-in or easily removable connection pieces to allow easy replacement of any component with minimum disturbance to the remainder of the equipment.

7.13.0 Inspection windows / access openings shall be provided at the switchgear to ensure that each switchgear component can be inspected / monitored during installation and future maintenance.

7.14.0 The manufacturer shall guarantee that the pressure loss within each individual gas filled compartment shall not be more than half percent (0.5 %) per year.

7.15.0 Each Gas filled compartment shall be equipped with static filters, density switches, filling valve and safety diaphragm. The filters shall be capable of absorbing any water vapor as well as any by products of SF6 during interruption.

7.16.0 Each gas compartment shall be fitted with separate non-return valve connectors for evacuating, gas filling, and for checking the gas pressure

7.17.0 The internal components shall be maintenance free for at least 10 years. Routine replacements of insulating gas shall not be required in intervals of less than ten years.

7.18.0 The thermal rating of all current carrying parts shall be minimum for three second for the rated symmetrical short circuit current.

7.19.0 The arrangement of individual switchgear bays shall be such so as to have optimum space saving, neat, logical arrangement and adequate accessibility to all external components.

7.20.0 It should be impossible to unwillingly touch live parts of the switchgear. All interlocks that will prevent potentially dangerous mal-operations shall be provided both electrical & mechanical.

7.21.0 The enclosure surface shall be smooth with no projection or irregularities which may cause visible corona. No corona shall be visible in complete darkness when the equipment is subjected to specified test voltage.

7.22.0 The enclosure shall be of continuous design and shall confirm to clause 10 of IEEE 80 Year 2000. The enclosure shall be sized for carrying induced current equal to the rated current of bus. The enclosure shall be designed to practically eliminate the external electromagnetic field. And there by electromagnetic stresses even under short circuit conditions.

7.23.0 The average intensity of electromagnetic field shall not be more than 50 micro tesla. The Bidder shall furnish all calculations and documents in support of above during detailed engineering.

7.24.0 The CT''s for GIS shall be of external or internal mounted type with SF6 Gas insulated or cast resin type. The secondary terminals shall be brought out in a dustproof enclosure.

7.25.0 The switchgear shall have provision for connection with ground mat risers. This shall consist of grounding pads to be connected the ground mat risers with in the vicinity of the equipment.

7.26.0 **Indication & Verification of Switch position:**

a) All circuit breakers, isolators and earth switches shall have externally mounted indicators to show clearly the 'open' and 'Close' positions. The indications shall be mechanically coupled directly to the main contact operating drive or linkage and shall be mounted in a position where they are clearly visible. The positions shall be designated as 'Open 'and 'Close '. Use of color code alone to differentiate position indication is not acceptable.

b) The Bidder shall offer equipment fitted with viewing ports on each isolator and earth switch for viewing and illuminating the position of switch. Viewing port shall be of a type whereby the open/close position can be checked without any danger to the eyes should a flashover occur at that time.

7.27.0 **Local Control Panel**

7.27.1 Individual local control panels for each circuit shall be supplied to facilitate local control of circuit breakers, isolators and earth switches. Theses panels shall also house the various relays, timers etc. to realise specified interlock requirement among circuit breakers, isolators and earth switches. The contacts, signals and conditions originating from/going to the switchgear, associated auxiliary, monitoring equipment and CT/VT wiring from the terminal boxes shall be wired up to the local control panels.

7.27.2 Completely separate and isolated circuit shall be used for operating mechanism control, tripping alarms and auxiliary devices. CLOSE and TRIP circuits shall be kept isolated to their final mechanical or electrical actuators. Trip circuits shall have individual monitoring facilities.

7.27.3 Mimic diagrams shall be provided on local control panels. The mimic strips shall be made of anodised aluminium and shall be screwed onto the panel. Colours of the various voltages of the mimic bus shall be subject to the approval of the Purchaser/comply with relevant IEC standard. The width of mimic strip shall not be less than 5 mm. Discrepancy switches and semaphore indicator shall be provided on the mimic diagram as applicable.

7.28.0 **Switches / MCBs**

7.28.1 Switches/MCBs shall be hand operated, air break, heavy duty, quick make, quick break type conforming to applicable IEC standards.

7.28.2 It shall be the responsibility of the Manufacturer to fully coordinate the overload and short circuit tripping of the MCBs with the sub circuit MCBs/fuses to provide satisfactory discrimination.

7.28.3 Switch handle shall have provision for locking in both fully open and fully closed positions. MCBs shall preferably be provided with suitable locking facility.

7.28.4 Single throw isolating switches for complete isolation of the DC control circuits shall be provided.

7.29.0 **Fuses**

7.29.1 Only HRC fuses shall be used.

7.29.2 Fuses shall be provided with visible operation indicators to show that they have operated.

7.30.0 **Control & Auxiliary Power Supply**

7.30.1 Control and selector switches shall be of the rotary type provided with properly designated escutcheon plates clearly marked to show the operating positions. Control switches shall have momentary contacts, spring return to normal, with pistol grip handle. Selector switches shall have stay put contacts. With oval handles. The local/remote selector switch shall be lockable in both positions. Colour of these switches shall be black. The number of contacts and their operation in each switch position shall be as per the requirements of the connected circuit. The switches shall be rated for minimum 10 A at 240 AC and 1 A inductive break at specified DC voltage.

7.30.2 All control equipment shall be suitable for operation on specified DC system.

7.30.3 Separate circuits with switches, fuses, etc. of adequate rating shall be provided for control of space heater, lighting and power receptacle. Theses shall be on 240 V, ph AC supply, unless specified otherwise.

7.30.4 D.C. & A.C. power supply shall be done in a manner which will enable isolation of individual equipment. Common supply bus shall be formed in the cubicle and then power supply shall be distributed to individual equipment through MCBS/fuses.

7.31.0 **Relays**

7.31.1 All relays excluding auxiliary relays shall be numerical microprocessor based only with IEC 61850 communications Protocol. Relays for various controls, monitoring and blocking functions of particular circuit element shall be of solid state design installed in associated local control panel. All relay shall have dust tight covers.

7.31.2 Necessary auxiliary relays for alarm, time-delay relays, voltage relays as required for control and protection shall be mounted inside the local control panel. Voltage operator relays shall have sufficient thermal capacity for continuous energisation, using external resistors, if necessary.

7.31.3 Auxiliary relays shall be rated to operate satisfactorily between 80% and 110% of the specified rated voltage.

7.31.4 Each relay shall be provided with at least 2 NO and 2 NC potential free contacts for external use.

7.31.5 Coils of all the relays shall be adequately rated to avoid spurious operation of relays on D.C. system ground or induced surges.

7.31.6 All relays shall be tropicalised and shall be suitable for maximum ambient temperature of 500C.

7.31.7 Make and type of relay shall be subject to approval of the Purchaser.

7.32.0 **Push Buttons**

All push buttons shall be of push to actuate type having 2 NO and 2 NC self-reset contacts. They shall be provided with integral escutcheon plates, engraved with functions. Push button contacts shall be rated for 10 A at 240 V AC and 1 A inductive breaking at specified DC voltage.

7.33.0 **Indicating Lamps**

Cluster LED type lamps are to be provided.

7.34.0 **Space Heater**

Strip type space heaters of adequate capacity shall be provided inside each cabinet/control panel. Heaters shall be complete with rotary type ON-OFF switch, HRC fuse on phase or a single-pole MCB with overload and short circuit protection, link on the neutral and a thermostat to cut off the heater at $45^0$ C. The heaters shall be suitable for operation on a 240V, 1 phase 50 Hz supply.

7.35.0 **Internal Wiring**

Cabinets / Panels shall be supplied completely wired ready for external connections at the terminal blocks. All wiring shall be carried out with wires of 650 V grade, stranded copper conductors. The insulation shall be halogen free and flame retardant. Power circuits shall be wired with stranded *copper* conductors of adequate sizes to suit the rated current. Unless otherwise specified, control alarm and indication circuits shall be wired with stranded, tinned copper conductors of sizes not smaller than 1.5 sq.mm. CT and VT circuits shall be wired with stranded copper conductor of size, not smaller than 2.5 sq.mm.

7.35.1 Engraved identification ferrules, marked to correspond with the wiring diagram shall be fitted at both ends of each wire. All wiring shall be terminated on terminal blocks. Terminals shall be adequately rated for the circuit current, minimum rating shall be 10 A. Control wiring shall be protected against mechanical damage.

7.35.2 CT/PT terminals shall have disconnecting links for test purpose and other device terminals shall be of stud type.

7.35.3 The wire terminations shall be made with solder less crimping type of tinned copper lugs.

7.35.4 Wiring shall be colour coded and be firmly supported, neatly installed by lacing and taping, readily accessible and connected to equipment terminals and terminal blocks. Halogen free, flame retardant plastic wiring channels/throughs with strap on covers shall be used for this purpose.

7.36.0 **Local Alarm/Annunciation**

7.36.1 Window type alarm annunciation shall be provided on local control panels of each bay for the specified abnormal conditions. The alarm windows shall have provision for differentiating cleared and uncleared faults and flashing for new faults.

7.36.2 In addition to the above, the manufacturer may add any other condition, as felt necessary for annunciation. In case of auto reclosing feeders, all four stages breaker operation due to hydraulic pressures – pressure low, reclose blocked, closing blocked and tripping shall be provided.

7.36.3 All 66kV GIS transformer feeders shall have transformer annunciations / indications on metering panel.

7.37.0 **Labels and Diagram Plate**

7.37.1 Every GIS equipment and devices mounted in the cabinet/control panel shall be provided with individual labels with equipment designation/rating. Also, the cabinet/control panel shall be provided on the front with a non-rusting label engraved with the designation of the cabinet/control panel.

7.37.2 Inside the door, a metal pouch shall be provided along with as built drawings copy of the respective panel.

7.38.0 **EARTHING**

7.38.1 The BIDDER shall provide a “Main Ground Bus” for the specified short circuit current magnitude and duration to which all intentionally earthed parts of the assembly shall be bonded.

7.38.2 It shall be the responsibility of the Manufacturer to provide a sufficient number of earth connections so that dangerous voltages are not induced in the enclosure by the fault currents circulating in the inner conductor.

7.38.3 Provision shall be made for future extension and/or bonding to ground bus of other switchgear.

7.38.4 The Bidder shall furnish full details of the circulating currents expected to flow from the switchgear metal cladding to enable the Purchaser to design the main earthing grid.

7.38.5 Every section of the SF6 switchgear equipment including all panels, cubicles, kiosks and boxes shall be solidly bonded to the earthing system, by at least two independent leads.

7.38.6 The design of the earthing system shall be such as to ensure the safety and protection of all operating and maintenance personnel under all normal and fault conditions.

# VOLUME - III

# SECTION - 3

# DETAILED TECHNICAL SPECIFICATION - ELECTRICAL

## SUB-SECTION - 3.6.2

## 66 kV GIS SWITCHGEAR EQUIPMENT

**VOLUME - III**

**SUB-SECTION - 3.6.2**

**66 kV GIS SWITCHGEAR EQUIPMENT**

## A. CIRCUIT BREAKERS

### 1.0.0 CODES & STANDARDS

| | | | |
|---|---|---|---|
| i) | Gas Insulated Switchgear | : | IEC 62271-203 / IEC 60694 |
| ii) | Circuit Breakers | : | IEC 62271-100, IS: 2516 |
| iii) | SF6 Gas | : | IEC 60376 |
| iv) | SF6 Cylinders | : | IS : 4379, IS : 7285 / IEC |
| v) | Air Receivers | : | BS : 5179, BS : 5500 / IEC |
| vi) | Air Piping | : | BS : 2871 / IEC |

**2.0.0 TYPE** Indoor SF6, single pressure puffer type re-strike free and without opening resistors

### 3.0.0 RATING

3.1.0 **66 kV Circuit Breaker**

| | | | |
|---|---|---|---|
| (a) | Voltage | : | 66 kV |
| (b) | No. of poles | : | 3 |
| (c) | Rated Continuous Current | : | As required. |
| (d) | Rated Short | : | 40 kA with percentage of DC component as per Circuit Breaking IEC 62271-100 corresponding to minimum opening current time under operating conditions specified. |
| (e) | Short Circuit making current | : | 100 kAp |
| (f) | First Pole To Clear Factor | | 1.3 |
| (g) | Rated Break Time | | a) Not more than 40 ms under test duties 2, 3 & 4 at rated values.<br>b) Not more than 45 ms under test duties 1 to 5 and short line fault test duties and combined variation of trip coil voltage, operating pressure and quenching media pressure, etc. |

## 4.0.0 OPERATIONAL REQUIREMENTS

| | | |
|---|---|---|
| 4.1.0 | Rated Operating Duty Cycle O-0.3 sec.–CO-3 min-CO | |
| 4.1.1 | Re-Closing | Single and three phase high speed auto re-closing. |
| 4.1.2 | Trip and closing coil voltage | 110V DC. |
| 4.1.3 | Auxiliary contacts | As required plus 10 NO and 10 NC contacts per pole as spare. |
| 4.2.0 | Controls | |
| 4.2.1 | Closing Circuits | Shall operate correctly at all values of supply voltage between 85% and 110% of rated voltage. |
| 4.2.2 | Trip Circuits | Two independent tripping circuits, valves, pressure switches and coils to be provided for connection to different set of relay. The circuits shall operate correctly under all operating conditions upto rated breaking capacity and at all values of supply voltage between 70% to 100% of rated supply voltage. However even at 50% of rated supply voltage the breaker shall be able to operate. Trip coil supervision to be provided in both open and close position. |
| 4.2.3 | Operation | Shall have both local and remote operation of breaker with local/remote lockable selector switch and close and trip control switch/push buttons shall be provided in the breaker control cabinet. |
| 4.2.4 | Pressure Switch Contacts | Shall have density meter and pressure switch contacts suitable for direct use as permissive in closing and tripping circuits. Separate contacts to be used for each of tripping and closing circuits. Fail safe logic/schemes to be employed if multiplying relays used. |
| 4.2.5 | Supply Voltage monitoring | DC supply voltage for all auxiliary circuits to be monitored. Provision to be made for remote annunciations and operation lockout in case of supply failure. |
| 4.3.2 | Operational requirement for PIR | The resistor shall have thermal rating to the following successive closing operation : duties with no allowance for heat dissipation between |
| 4.3.5 | Out of phase closing | One closing operation under phase opposition with twice rated voltage across terminals. |
| 4.4.0 | Safety aspect | Breaker position to be maintained on loss of operating media and/or quenching media pressure. |
| 4.5.0 | Central Control Cabinet | A central control cabinet shall be provided which shall house all the control equipment required for operation, indication, lockout and all requirements as per detailed list given below : |

a) Local/remote changeover switch

b) Operation counter

c) Pneumatic/ hydraulic pressure gauges

d) SF6 pressure gauges

e) Power supply control switches

f) Fuses

g) Anti-pumping relay

h) Pole discrepancy relay

i) AC/DC supervision relays

4.6.0 The circuit breaker shall also be capable of:

a) Interrupting line charging current as per IEC without any restrikes and without use of opening resistors.

b) Clearing short line fault current with source impedance behind the bus equivalent to symmetrical fault current specified.

c) Breaking 25 % of the rated fault current at twice rated voltage under phase opposition condition.

## 5.0.0 DESIGN AND CONSTRUCTIONAL FEATURES

| | | |
|---|---|---|
| 5.1.0 | Interrupter | Shall be with adsorbing product box to minimize the effect of SF6 decomposing product and moisture. |
| 5.2.0 | SF6 Density Monitoring | (i) SF6 Density shall be monitored and regulated on each pole using individual pressure switches and pressure gauges.<br>(ii) Density Monitor shall be adequately temperature compensated.<br>(iii) It shall be possible to dismantle the monitor with out draining SF6 gas & also to remove SF6 gas from each pole separately for maintenance purpose. |
| 5.3.0 | D.C. Supply | Dual DC supply shall be provided for connection to independent trip circuits, monitoring & control circuits. |
| 5.4.0 | Aux. switch | Aux. switch of breaker to be positively driven by operating rod. |
| 5.5.0 | Operating Mechanism | |
| 5.5.1 | Type | Electro-hydraulic / spring charged or combination of these with Anti-pumping and trip free features. |
| 5.5.2 | Housing | Operating box / cabinet shall be accessible to man standing on ground and shall be hot dip galvanized. |
| 5.5.3 | Operation indicator | A mechanical indicator to show open/close position of breaker shall be provided which should be visible with housing closed. |
| 5.5.4 | Power supply | Dual DC power supply with changeover facility. |

5.5.5 Spring Operated Mechanism

(i) Shall be complete with motor, opening and closing spring with limit switch for automatic charging and shall generally meet all the design and operation requirements for satisfactory and trouble free operation.

(ii) Motor shall be rated to fully charge the closing springs in less than 30 seconds and shall have adequate thermal rating for repeated sequence of closing and opening operations of breaker.

(iii) Closing action of mechanism shall compress/charge the opening spring so that it is ready for tripping. Closing springs shall be immediately charged after the closing operation. After failure of power supply, at least one CO operation should be possible. Breaker operation shall be prevented when spring is in partial charged condition. Indication of spring in charged condition shall be provided in local and remote cabinet.

5.5.6 Hydraulically Operated Mechanism

(i) Shall comprise of power cylinder, control valves, high & low pressure reservoir, motor, etc. Hydraulic oil used shall be fully compatible for the specified temperature range. Further it shall generally meet all the design and operation requirements for satisfactory and trouble free operation.

(ii) On failure of power supply and pressure equal to the lowest pressure of autoreclose duty, at least two CO operations should be possible. Also complete duty cycle of breaker to be possible meeting all parameters of break/opening time when oil is at lowest permissible pressure before make up.

(iii) Provision to be made to continuously monitor oil/nitrogen pressure both local and remote.

(iv) One hand operated pump shall be provided per station for emergency operation.

5.6.0 The gap between open contacts shall withstand at least rated phase to ground voltage for eight (8) hours at zero gauge pressure of SF6 gas. The breaker shall also withstand all dielectric stresses in open position at SF6 lockout pressure for 60 minutes.

5.7.0 Multi-break interrupters shall have uniform voltage distribution across them.

5.8.0 Breakers shall have provision for attaching operational analyzer.

5.9.0 Contractor shall supply spare SF6 gas equal to 20% of the total requirement for the station.

## 6.0.0 TESTS

In addition to the tests as per IEC, speed curve tests shall be conducted at works and site. Speed curves for each breaker pole to be obtained with the operational analyzer to determine the breaker contact movement during opening, closing, auto-reclosing and trip free operation under normal and limiting conditions of control voltage and operating medium. The tests shall show speeds of contacts at various stages of operation, travel of contacts, opening time, closing time, shortest time between separation and meeting of contacts at break make operation, pole discrepancy, etc.

## 7.0.0 MANDATORY MAINTENANCE EQUIPMENT

The following (1 no. each) shall be supplied along with circuit breakers.

7.1.0 SF6 gas handling equipment

Shall be of proven make and shall be supplied complete with all necessary pipes, plants, coupling, flexible tube and valves and shall comprise of the following:

(i) SF6 Gas filling and evacuating plant

Portable plants, shall evacuate SF6 to required vacuum and fill to required pressure in a complete three pole breaker within a reasonable time.

ii) SF6 gas filtering, drying, storage and recycling plant

a) Shall have a capacity to store and handling at least 300 liters of SF6 Gas & suitable to transfer SF6 gas directly from breaker to plant reservoir.

b) Shall include necessary equipment for purging the plant before filling SF6.

c) Shall be mounted on trolley or rollers.

d) Shall include devices to measure purity, moisture content (or dew point measurement), air content, decomposition products, etc. of SF6 gas. The devices shall have built-in calibration facility & the sensitivity shall not be affected by dust, humidity, heat, wind, etc.

7.2.0 SF6 gas leak detector

Shall have an accuracy of at least 5ppm. & shall reach leakages are possible. Shall be free from induced voltage effects.

7.3.0 Operational Analyzer

(i) Shall be one complete system of proven make for out-door use with necessary transducers (three to record speed and travel of 3 poles of breaker), cables, pickups, attachments, etc.

(ii) Shall have provision to record at least 12 function of breaker.

(iii) Shall be suitably shielded against induced charges.

(iv) shall record breaker contact movement during opening, closing, auto re-closing and make break operations, speed of contacts at various stages of operation, travel of contacts, opening time, closing time, make break time, etc.

(v) Shall have output on plain paper requiring no special storage facility.

(vi) Shall be suitable for outdoor use and shielded against induced charges.

Above features shall be demonstrated as site.

7.4.0 Nitrogen filling — Shall have capacity for nitrogen filling of one pole in device (applicable reasonable time and shall be complete with all for hydraulically operated mechanisms) accessories for nitrogen charging at site.

## B. DISCONNECTING SWITCHES & EARTH SWITCHES

### 1.0.0 CODES AND STANDARDS

Disconnecting Switches And Earth Switches IEC : 62271-102, IS:9921

### 2.0.0 TYPE

Indoor, SF6 Gas Insulated

### 3.0.0 RATING

3.1.0 **Disconnecting Switches (DS)**

For 66 kV :

| | | |
|---|---|---|
| (i) | Rated continuous current | As required |
| (ii) | Short circuit making current | 100 kAp |
| (iii) | Rated Mechanical Terminal Load | As per Table III of IEC |
| (iv) | Operating time | Not more than 12 seconds |
| (v) | Auxiliary contacts | As required plus 8 NO + 8 NC per DS as spare. |
| (vi) | Temperature Rise | As per Table V of IEC 60694 for specified ambient |

3.2.0 **Earth Switch (ES)**

For 66 kV:

| | | |
|---|---|---|
| (i) | Short circuit making current | 100 kAp |
| (ii) | Operating time | Not more than 12 seconds |
| (iii) | Auxiliary contacts | As required plus 6 NO + 6 NC per ES as spare |

## 4.0.0 DESIGN AND CONSTRUCTIONAL FEATURES – DISCONNECTING SWITCHES

4.1.0 The three pole group operated disconnectors shall be operated by electric motor suitable for use on 110 V DC system and shall be equipped with a manual operating mechanism for emergency use. The motor shall be protected against over current and short circuit.

4.2.0 Disconnectors shall be designed as per relevant IEC. These shall be suitable to make and break the charging currents during their opening and closing. They shall also be able to make and break loop current which appears during transfer between bus bars. The contact shielding shall also be designed to prevent restrikes and high local stresses caused by transient recovery voltages when these currents are interrupted.

4.3.0 The disconnecting switches shall be arranged in such a way that all the three phases operate simultaneously. All the parts of the operating mechanism shall be able to withstand starting torque of the motor mechanism without damage until the motor overload protection operates.

4.4.0 It shall be possible to operate the disconnecting switches manually by cranks or handwheels. The contacts shall be both mechanically and electrically disconnected during the manual operation.

4.5.0 The operating mechanisms shall be complete with all necessary linkages, clamps, couplings, operating rods, support brackets and grounding devices. All the bearings shall be permanently lubricated or shall be of such a type that no lubrication or maintenance is required.

4.6.0 The opening and closing of the disconnectors shall be achieved by either local or remote control. The local operation shall be by means of a two-position control switch located in the bay module control cabinet.

4.7.0 Remote control of the disconnectors from the control room shall be made by means of remote/ local transfer switch.

4.8.0 The disconnector operations shall be inter-locked electrically with the associated circuit breakers in such a way that the disconnector control is inoperative if the circuit breaker is closed.

4.9.0 Each disconnector shall be supplied with auxiliary switch having six normally open and six normally closed contacts for future use over and above those required for switchgear interlocking and automation purposes. The auxiliary switch contacts are to be continuously adjustable such that, when required, they can be adjusted to make contact before the main switch contacts.

4.10.0 The signaling of the closed position of the disconnector shall not take place unless it is certain that the movable contacts will reach a position in which the rated normal current, peak withstand current and short-time withstand current can be carried safely.

4.11.0 The signaling of the open position of the disconnector shall not take place unless the movable contacts have reached such a position that the clearance between the contacts is at least 80 percent of the rated isolating distance.

4.12.0 All auxiliary switches and auxiliary circuits shall be capable of carrying a current of at least 10 A DC continuously.

4.13.0 The auxiliary switches shall be capable of breaking at least 2 A in a 110 V DC circuit with a time constant of not less than 20 milliseconds.

4.14.0 The disconnectors and safety grounding switches shall have a mechanical key (pad locking key) and electrical inter-locks to prevent closing of the grounding switches when isolator switches are in the closed position and to prevent closing of the disconnectors when the grounding switch is in the closed position.

4.15.0 The local control of the Isolator and high-speed grounding switches from the bay module control panel should be achieved from the individual control switches with the remote/local transfer switch set to local.

4.16.0 All electrical sequence interlocks will apply in both remote and local control modes.

4.17.0 Each disconnector shall have a clearly identifiable local, positively driven mechanical position indicator, together with position indicator on the bay module control cabinet and provisions for taking the signals to the control room. The details of the inscriptions and colouring for the indicator are given as under :

| | **SIGN** | **COLOUR** |
|---|---|---|
| **Open position** | Open | Green |
| **Closed position** | Closed | Red |

4.18.0 All the disconnecting switches shall have arrangement allowing easy visual inspection of the travel of the switch contacts in both open and close positions, from the outside of the enclosure.

4.19.0 The disconnecting switches shall be provided with rating plates and shall be accessible for inspection.

4.20.0 The disconnecting switches shall be capable of being padlocked in both the open and closed positions with the operating motor automatically disengaged. The padlocking device shall be suitable for a standard size lock with a 10 mm shank. The padlock must be visible and directly lock the final output shaft of the operating mechanism. Integrally mounted lock when provided shall be equipped with a unique key for such three phase group. Master key is not permitted.

## 5.0.0 DESIGN AND CONSTRUCTIONAL FEATURES FOR SAFETY EARTH SWITCHES

5.1.0 The three pole group operated disconnectors shall be operated by electric motor suitable for use on 110 V DC system and shall be equipped with a manual operating mechanism for emergency use. The motor shall be protected against over current and short circuit.

5.2.0 Each safety grounding switch shall be electrically interlocked with its associated disconnector and circuit breaker such that it can only be closed if both the circuit breaker and disconnector are in open position. Safety grounding switch shall also be mechanically key interlocked with its associated disconnector.

5.3.0 Each safety grounding switch shall have clearly identifiable local positive driven mechanical indicator together with position indicator on the bay module control cabinet and provision for taking the signal to control room.

5.4.0 The details of the inscriptions and colouring for the indicator are given as under :

| | **SIGN** | **COLOUR** |
|---|---|---|
| **Open position** | Open | Green |
| **Closed position** | Closed | Red |

5.5.0 Interlocks shall be provided so that manual operation of the switches or insertion of the manual operating device will disable the electrical control circuits.

5.6.0 Each earth switch shall be fitted with auxiliary switches having 6 NO & 6 NC contacts for use of Owner/Owner's representative over and above those required for local interlocking, position & indication purpose.

5.7.0 Provision shall be made for padlocking the earth switches in either the open position or closed position.

5.8.0 All portions of the Earth switch and operating mechanism required for grounding shall be connected together utilizing a flexible copper conductor having a minimum cross section area of 50 Sq.mm.

5.9.0 The main grounding connections on each grounding switch shall be rated to carry the full short circuit rating of the switch for 1 second and shall be equipped with a silver plated terminal connector suitable for steel strap of adequate rating for connection to the grounding grid.

5.10.0 The Safety Earth switches shall confirm to the requirement of IEC 622271-102.

5.11.0 Mechanical position indication shall be provided locally at each switch and remotely at each bay module control cabinet / substation automation system.

## C. HIGH SPEED EARTH SWITCHES

### 1.0.0 CODES AND STANDARDS

Disconnecting Switches And Earth Switches IEC : 62271-102, IS:9921

### 2.0.0 TYPE

Indoor, SF6 Gas Insulated

### 3.0.0 DESIGN & CONSTRUCTIONAL FEATURES

3.1.0 Earth switches located at the beginning of feeder module shall be of high speed, make proof type and will be used to discharge the respective charging currents, in addition to their safety grounding function. These grounding switches shall be capable of interrupting the inductive currents and to withstand the associated TRV.

3.2.0 Single phase switches shall be provided with operating mechanism suitable for 110 V DC.

3.3.0 The switches shall be fitted with a stored energy closing system to provide fault making capacity.

3.4.0 The short circuit making current rating of each ground switch shall be atleast equal to its peak withstand current rating of 100 kA. The switches shall have inductive/capacitive current switching capacity as per IEC-62271-102.

3.5.0 Each high speed make grounding switch shall have clearly identifiable local positive driven mechanical indicator together with position indicator on the bay module control cabinet and provision for taking the signal to control room.

3.6.0 The details of the inscriptions and colouring for the indicator are given as under :

| | **SIGN** | **COLOUR** |
|---|---|---|
| **Open position** | Open | Green |
| **Closed position** | Closed | Red |

3.7.0 High speed earth switch operation should be possible locally from the bay module control cabinet, or remotely from the control room in conjunction with opening of the associated disconnector.

3.8.0 These high speed grounding switches shall be electrically interlocked with their associated circuit breakers and disconnectors so that the grounding switches cannot be closed if the circuit breakers and disconnectors are closed.

3.9.0 Interlocks shall be provided so that the insertion of the manual operating devices will disable the electrical control circuits.

3.10.0 Each high speed earth switch shall be fitted with auxiliary switches having 6 NO & 6 NC auxiliary contacts for use by Owner/Owner's representative over and above those required for local interlocking, position & indication purpose. All contacts shall be wired to terminal blocks in the local bay control cabinet. Provision shall be made for padlocking the ground switches in their open or closed position.

3.11.0 The main grounding connections on each grounding switch shall be rated to carry the full short circuit rating of the switch for 1 second and shall be equipped with a silver plated terminal connector suitable for steel strap of adequate rating for connection to the grounding grid.

3.12.0 The main grounding connections on each grounding switch shall be rated to carry the full short circuit rating of the switch for 1 second and shall be equipped with a silver plated terminal connector suitable for steel strap of adequate rating for connection to the grounding grid.

3.13.0 The Safety Earth switches shall confirm to the requirement of IEC 622271-102.

**D. SF6 TO AIR TRANSITION BUSHINGS**

1.1.0 All bushings shall have an impulse and power frequency withstand level that is greater than or equal to the level specified for the switchgear.

1.2.0 Bushing shall be suitable for hot line washing and shall be provided with “water cut sheds”.

1.3.0 Puncture strength of bushings shall be greater than the dry flash-over value. When operating at normal rated voltage, there shall be no electric discharge between the conductors and bushing which would cause corrosion or injury to conductors, insulators or supports by the formation of substances produced by chemical action. No radio interference shall be caused by the bushing when operating at the normal rated voltage.

1.4.0 All hardware used for current carrying parts shall be SS 304 and other iron parts shall be hot dip galvanized.

1.5.0 All joints shall be air tight. Surface of the joints shall be turned up; porcelain parts by grinding and metal parts by machining. Bushing design shall be so as to ensure uniform compressive pressure on the joints.

1.6.0 All current carrying contact surface shall be silver faced.

1.7.0 BIDDER shall furnish details of precaution taken to prevent bimetallic corrosion wherever dissimilar materials (such as Copper, Aluminium) are used, including the following:

a) Aluminium conductor in the bus duct and the current carrying part in the bushing.

b) Terminal clamp and the current carrying part in the bushing if bushing stud is not of Copper.

1.8.0 A test tap shall be provided for measurement of Capacitance & Tan delta factor.

## E. INSTRUMENT TRANSFORMERS

### 1.0.0 CODES AND STANDARDS

| | |
|---|---|
| Current Transformers | IEC 60044, BS:3938, IS: 2705 |
| Voltage Transformers | IEC 186, IEC 186A, IEC 358, IS : 3156 |
| Insulating Oil | IS : 335 |
| Capacitive Voltage Transformers | IEC 60044-5 |

### 2.0.0 TYPE

| | |
|---|---|
| Current Transformers | Single primary internal mounted type with SF6 insulated or Resin cast |
| Voltage Transformers | Shall be metal enclosed gas insulated capacitor voltage divider type or electromagnetic type. |

### 3.0.0 RATING

3.1.0 Rated Insulation Levels for Instrument Transformers

| | | |
|---|---|---|
| i) | 1.2/50 micro-sec. impulse withstand Voltage | 325 kVp |
| (ii) | One minute power frequency withstand voltage. | 140 kV rms. |

3.2.0 **Current Transformers**

| | | |
|---|---|---|
| (i) | Rated primary current | - |
| (ii) | Rated dynamic current | 100 kA peak |
| (iii) | One minute power frequency withstand voltage between secondary terminal and earth | 5 kV |
| (v) | Temperature rise | ----------As per IEC---------- |

3.3.0 **Voltage transformers**

| | | |
|---|---|---|
| (i) | Rated primary voltage | 66 kV |
| (ii) | For secondary winding | 2 kV rms |

| | | |
|---|---|---|
| (iii) | Temp rise of electromagnetic unit | As per IEC:186 |
| (iv) | Rated voltage factor | 1.2 continuous ; 1.5 for 30 seconds |
| (v) | Phase angle error | +/- 20 minutes for metering |

**4.0.0 DESIGN AND CONSTRUCTION FEATURES**

4.1.0 **Current Transformers**

4.1.1 The current transformers and accessories shall conform to IEC: 60044-1 and other relevant standards except to the extent explicitly modified in the specification.

4.1.2 The current transformers shall have class B type insulation and shall be suitable for high speed auto reclosure.

4.1.3 The particulars of the various cores may change within reasonable limits as per the requirements of protection relay supplier. The manufacturer is required to have these values confirmed from the purchaser before proceeding with design of the cores. The other characteristics of CTs shall be as given in TECHNICAL PARAMETER of Current Transformer.

4.1.4 The number, rating, ratios, accuracy class, etc. for the individual current transformer secondary cores shall be in accordance with IEC. Where multi-ratio current transformers are required the various ratios shall be obtained by changing the effective number of turns on the secondary winding.

4.1.5 Rating and diagram plates shall be as specified in the IEC specification incorporating the year of manufacture. The rated extended current rating voltage and rated thermal current shall also be marked on the name plate.

4.1.6 The diagram plates shall show the terminal markings and the relative physical arrangement of the current transformer cores with respect to the primary terminals (P1 & P2).

4.1.7 The position of each primary terminal in the current transformer SF6 gas section shall be clearly marked by two plates fixed to the enclosure at each end of the current transformer.

4.1.8 The current transformers incorporated into the GIS will be used for protective relaying and metering and shall be of metal-enclosed type. The secondary windings shall be air insulated and mounted inside the metal enclosure. All the current transformers shall have effective electromagnetic shields to protect against high frequency transients.

4.1.9 Each current transformer shall be equipped with a marshalling box with terminals for the secondary circuits, which are connected to the local control cubicle. The star/delta configuration and the inter connection to the line protection panels will be done at the CT terminal block located in the local control cubicle.

4.1.10 Current transformers guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.

4.1.11 The rated extended primary current shall be 150% at all ratios and 200% at ratios other than highest ratios.

4.1.12 The instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have

to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably built in construction of the CTs.

4.1.13 The wiring diagram, for the interconnections of the three single phase CTs shall be provided inside the marshalling box.

4.1.14 Provisions shall be made for primary injection testing either within CT or outside.

**4.2.0 VOLTAGE TRANSFORMERS**

4.2.1 The voltage transformers shall conform to IEC 60044-2 and other relevant standards except to the extent explicitly modified in the specification.

4.2.2 Voltage transformers shall be of the electromagnetic type with SF6 gas insulated. The earth end of the high voltage winding and the ends of the secondary winding shall be brought out in the terminal box.

4.2.3 The rating, ratio, accuracy class, connection etc. for the voltage transformers shall be in accordance with IEC.

4.2.4 Rating and diagram plate shall be provided complying with the requirements of the IEC specification incorporating the year of manufacture and including turns ratio, voltage ratio, burden, connection diagram etc.

4.2.5 The beginning and end of each secondary winding shall be wired to suitable terminals accommodated in a terminal box mounted directly on the voltage transformer section of the SF6 switchgear.

4.2.6 All terminals shall be stamped or otherwise marked to correspond with the marking on the diagram plate. Provision shall be made for earthing of the secondary windings inside the terminal box.

4.2.7 The transformer shall be able to sustain full line to line voltage without saturation of transformer.

4.2.8 The accuracy class will be at maximum tap.

4. 2.9 The voltage transformers shall be located in a separate bay module on the bus and will be connected phase-to ground and shall be used for protection, metering and synchronization.

4.2.10 The voltage transformers shall be effectively shielded against high frequency electromagnetic transients. The voltage transformers shall have three secondary windings.

4.2.11 Voltage transformers secondary shall be protected by HRC cartridge type fuses for all the windings. In addition fuses shall be provided for the protection and metering windings for fuse monitoring scheme. The secondary terminals of the VT's shall be terminated to the stud type non-disconnecting terminal blocks in the secondary boxes via the fuse.

4.2.12 The voltage transformer should be thermally and dielectrically safe when the secondary terminals are loaded with the guaranteed thermal burdens.

4.2.13 The accuracy of 0.2 on secondary III should be maintained throughout the entire burden range up to 100 VA on all the three windings without any adjustments during operation.

4.2.14 The diagram for the interconnection of the VTs shall be provided inside the marshalling box.

## OUTDOOR SWITCHYARD EQUIPMENT

### F. SURGE ARRESTORS

**1.0.0 CODES AND STANDARDS** IEC 60099, IS 3070

**2.0.0 TYPE** Heavy duty station class and Gapless type without any series or shunt gaps

**3.0.0 RATING**

3.1.0 For 66 kV Surge Arrestor

| | |
|---|---|
| Nominal discharge current | 10KA of 8/20 microsec. Wave |
| Discharge current at which insulation coordination is done | 20 KA of 8/20 microsec. Wave. |

**4.0.0 OPERATIONAL REQUIREMENTS**

4.1.0 Shall protect power transformers, circuit breakers disconnecting switches, instrument transformers, shunt reactors, etc. with insulation levels specified in this specification.

4.2.0 Shall be suitable for circuit breaker duty cycle in the given system.

4.3.0 The reference current shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage. Values and calculations shall be furnished with offer.

4.4.0 Discharge capabilities.

4.4.1 Shall be fully stabilized thermally to give a life expectancy of one hundred (100) years under site conditions and take care of effect of direct solar radiation.

4.4.2 Shall be capable of discharging over-voltages occurring due to switching of unloaded transformers, reactors and long lines.

**5.0.0 OTHER PARAMETERS**

5.1.0 For 66kV Class Surge Arrestor

| | | |
|---|---|---|
| a) | Minimum discharge capability | 8 kJ/kV or corresponding to clause 5.01.02 at minimum discharge characteristics whichever is higher |
| b) | Long duration discharge class | II |
| c) | High current short duration test value (4/10 microsec.Wave) | 100kAp |
| d) | Current for pressure relief test | 40kA rms |

**6.0.0 DESIGN AND CONSTRUCTIONAL FEATURES**

6.1.0 **Insulation coordination**

6.1.1 The Bidder shall carry out the insulation coordination studies and design calculations for deciding the exact locate, energy capability, voltage levels of the SAs. The locations shown in the single line diagram is indicative only. If Bidder feels that at some more locations the surge arrestors are required same should be included in the offer.

6.1.2 The Bidder shall perform all necessary studies for insulation coordination and the report shall detail the characteristics of surge arrestor. The report shall also demonstrate that selected insulators comply with the requirements of the specification.

**6.2.0 Construction**

6.2.1 Shall be hermetically sealed single phase unit.

6.2.2 The non linear blocks shall be sintered metal oxide material.

6.2.3 Shall be robust with excellent mechanical and electrical properties.

6.2.4 Shall be capable of withstanding meteorological and short circuit forces under site conditions.

6.2.5 Each SA shall be complete with insulating base for mounting on structure.

6.2.6 SAs shall be provided with grading and/or corona rings as required.

**6.3.0 Pressure relief device**

6.3.1 Shall have pressure relief devices and arc diverting ports suitable for preventing shattering of porcelain housing and to provide path for flow of rated currents in the event of SA failure.

6.3.2 Shall not fail due to porcelain contamination.

6.3.3 Seals shall be effectively maintained even when SA discharges rated lightning current.

**6.4.0 Porcelain**

6.4.1 Porcelain shall be so coordinated that external flashover will not occur due to application of any impulse or switching surge voltage upto maximum design value for SA. The cantilever strength of the insulator shall be minimum 600kg.

6.4.2 The end fittings shall be non-magnetic and of corrosion proof material.

**6.5.0 The Bidder shall furnish the following** :

a) The heat treatment cycle details with necessary quality checks used for individual blocks along with insulation layer formed across each block.

b) Metalizing coating thickness for reduced resistance between adjacent discs along with procedure for checking the same.

c) Details of thermal stability test for uniform distribution of current on individual disc.

d) Detailed energy calculations to prove thermal capability of Discs.

e) The value of resistive current for each complete arrestor in factory test report and further suggest the values at which arrestor to be taken out of service.

**6.6.0 Discharge counters**

6.6.1 Self-contained discharge counters, suitably enclosed for outdoor use (IP-55 degree of protection) and requiring no auxiliary or battery supply shall be fitted with each SA along with necessary connection to SA and earth.

6.6.2 Suitable leakage current meters shall also be supplied in the same enclosure. The reading of milli - ammeter and counter shall be visible through an inspection glass panel to a man standing on ground. A pressure relief vent/suitable provision shall be made to prevent pressure build up.

6.6.3 The discharge counter shall be insulated from structure for measurement of resistive current.

**6.7.0 Maintenance Equipment**

The Contractor shall also supply micro-processor based portable maintenance equipment for monitoring resistive current of SA which is of proven design & make for the intended purpose. The Bidder shall demonstrate the operation of the equipment at site.

## G. INSULATORS

### 1.0.0 CODES AND STANDARDS

| | |
|---|---|
| Support & Hollow column insulators | IEC 137. IEC 168, IEC 233, IEC 273, IEC 815 |
| Bus post & Bushing Insulators | IEC 137. IEC 60168, IEC 233, IEC 273, IEC 60815 |
| String Insulators | IS 731, IEC:60815 |
| Composite Insulators | IEC 1109, IEC 507 |

**2.0.0 TYPE** Hollow/ Bushing / Bus post / String Insulators.

### 3.0.0 RATING

Dielectric Strength of Insulators

| Description | | Hollow & Bushing Insulators | Buspost Insulators & string Insulators |
|---|---|---|---|
| (i) | Dry & wet lightning impulse withstand voltage | 325 kVp | 325 kVp |
| (iii) | Dry and wet one minute power frequency withstand voltage | 140 kV | 140 kV |

### 4.0.0 OPERATIONAL REQUIREMENTS

4.1.0 There shall be no electric discharge between conductor and insulators, when operating at normal voltage, which would cause corrosion or injury to any of the material.

### 5.0.0 DESIGN AND CONSTRUCTIONAL FEATURES

5.1.0 Design of insulator shall avoid stresses due to expansion and contraction in any part of the insulator leading to deterioration.

5.1.1 All ferrous parts shall be hot dip galvanized. The associated metal part shall be permanently secured to the insulator, air tight and shall be designed to withstand all shocks and stresses to which they may be subjected to during operation and maintenance.

5.1.2 The design shall ensure uniform compressive pressure on the joints.

5.1.3 All insulators shall be of homogeneous glazed porcelain or composite type with silicon shed profile, free from laminations, cavities and other flaws or imperfections, and shall be thoroughly vitrified, tough and impervious to moisture.

5.1.4 Porcelain glazing shall be uniform brown in color, free from blisters, burns and other similar defects. Composite insulators can be of gray in color.

**5.2.0 Hollow Bushing Insulators**

5.2.1 Shall be provided for housing of various equipment i.e. circuit breakers, instrument transformer, surge arresters etc. & shall be robust and capable of withstanding internal pressures likely to occur in service.

**5.3.0 Bus Post Insulators (BPI)**

5.3.1 Shall be solid core type porcelain or composite insulators, and shall be used in disconnecting switches, support of bus conductor and line traps etc.

5.3.2 Parameters for BPI

| | | |
|---|---|---|
| (i) | Minimum cantilever strength | 800 kg |
| (ii) | Minimum torsional moment | 600 kg |

**5.4.0 Suspension and Tension Insulators**

(a) Suspension and tension strings. Shall be interchangeable between any type of strings.

(b) Shall be wet process porcelain or composite with ball and socket connections.

(c) Composite insulator as well as string insulators shall have electro mechanical strength of 120 KN per string and shall meet all the dielectric requirements for porcelain indicated.

**5.5.0 Disc Porcelain Insulators**

5.5.1 Parameters

| | | |
|---|---|---|
| (i) | Type of each disc. | Anti-fog |
| (ii) | Size of each disc | 255 x 145 mm |
| (iii) | Electro mechanical strength | 120 kN for each disc . |
| (iv) | Number of discs per string | As required to meet total creepage distance |
| (v) | Leakage distance per disc | 430 mm minimum |
| (vi) | Power freq. Withstand voltage for each disc | 85 kV – dry ; 50 kV – wet |

## H. MISCELANEOUS EQUIPMENT

### 1.0.0 CODES AND STANDARDS

| | |
|---|---|
| ALUMINIUM tubular Conductor | IS:5082 / IEC |
| ACSR conductor | IS : 398 / IEC |
| Clamps & connectors | IS : 617, IS : 5561 / IEC |
| Insulator string | IS : 731 / IEC |
| Hardware | IS : 2486, IEC : 433 |
| Spacers | IS : 10162 / IEC |
| Earthing conductor | IS : 2141 / IEC |
| Cabinets, boxes, kiosks, panel etc. | IS:5039, IS:8623 and IEC: 439 |

### 2.0.0 OPERATIONAL REQUIREMENTS

2.1.0 **Cabinets, boxes, kiosks, panels etc.**

The size of enclosure and the layout of equipment inside shall provide generous clearances. Each cabinet/box/kiosk/panel shall be provided with a 15A, 240V AC, 2 pole, 3 pin industrial grade receptacle with switch. For incoming supply, MCB of suitable rating shall be provided. Illumination of each compartment shall be with door operated incandescent lamp. All control switches shall be of rotary type.

### 3.0.0 DESIGN AND CONSTRUCTIONAL FEATURES

**3.1.0 Clamps and Connectors**

(i) Shall be Aluminium alloy casting conforming to designation A6 of IS:617 for connecting to equipment terminals and conductors of ALUMINIUM. In case the terminals are of copper, the same clamps/ connectors shall be used with 2mm thick bimetallic liner.

(ii) Shall be Galvanised mild steel for connecting to shield wire.

(iii) Bolts, nuts and plain washers shall be hot dip galvanized mild steel for sizes M12 and above. For sizes below M12, they shall be electro-galvanized mild steel.

(iv) The spring washers shall be electro-galvanized mild steel.

(v) All castings shall be free from blow holes, surface blisters, cracks and cavities.

(vi) All sharp edges and corners shall be rounded off to meet specified corona and radio interference requirements.

(vii) Shall have same current rating as that of the connected equipment with temperature rise limited to 35 deg.C over 50 deg.C.

(viii) All current carrying parts shall be at least 10 mm thick.

(ix) Shall be manufactured to have minimum contact resistance.

(x) Flexible connectors, braids or laminated strips shall be made up of copper/ ALUMINIUM.

(xi) Current rating and size of terminal/conductor for which connector is suitable shall be embossed/punched on each component.

**3.2.0 Insulator String Hardware**

i) Shall be of bolted type and forged steel except for insulator cap, which can be of malleable cast iron.

ii) Shall also generally meet the requirements of clamps and connectors as specified above.

iii) In one span, Tension string assembly at one end shall be supplied with suitable turn buckle.

iv) Suitable sag compensating spring shall be supplied in case the design calculations show excessive variation of the sag over the temperature range of 0 to 80 deg. C.

**3.3.0 ALUMINIUM ALLOY CONDUCTOR**

| | | |
|---|---|---|
| (i) | Code & standard | IEC |
| (ii) | Name | J Power corporation, Japan or equivalent |

**3.4.0 Spacers**

(i) Shall be non-magnetic material except nuts and bolts, which shall be of hot dip galvanized mild steel.

(ii) Shall generally meet the requirement of clamps and connectors specified above.

(iii) Design shall take care of fixing and removing during installation and maintenance.

(iv) Clamp slip test shall be conducted as follows :

In this test the sample shall be installed on test span of twin/quad bundle string at a tension of 44.2 kN (4500 kg.). One of the clamps when subjected to a longitudinal pull of 2.5 kN (250 kg) parallel to the axis of conductor shall not slip, i.e. permanent displacement between conductor and clamp after the test shall not exceed 1.0 mm.

This test shall be performed on all other clamps of the sample.

**3.5.0 Gantry Structure**

3.5.1 **Steel Structure**

Bidder shall furnish steel structure and other necessary materials like base plate/foundation bolts, anchor bolts etc. for all equipments supplied under this package.

3.5.2 **Gantry / LA, BPI Structures**

The steel structure shall be lattice truss construction made of Hot dip galvanized/shaped steel and assembled by bolts and nuts, except for a portion of welded parts.

**3.6.0 Cabinets, Boxes, Kiosks, Panels, etc.**

Control cabinets, junctions boxes, marshalling boxes, lighting panels, terminal boxes operating mechanism boxes, etc.

(i) Shall be of painted sheet steel or ALUMINIUM. However, the junction and switch boxes shall be of hot dip galvanized sheet steel of 1.6mm thickness.

(ii) Thickness of sheet steel shall be 2mm cold rolled or 2.5 mm hot rolled. The thickness of ALUMINIUM shall be 3mm and shall provide rigidity.

(iii) Top of the boxes shall be sloped towards rear.

(iv) The cabinets/ boxes / kiosks / panels shall be free standing or wall mounting or pedestal mounting type. They shall have hinged doors with padlocking arrangement. All doors, removable covers and plates shall be gasketed all around with neoprene gaskets.

(v) The cable entry shall be from bottom for which removable gasketed cable gland plates shall be provided. Suitable 240V, single phase 50Hz AC heaters with thermostats controlled by switch and fuse shall be provided to maintain inside temperature 10 deg. above the ambient.

(vi) Each cabinet / box / kiosk / panel shall be provided with two earthing pads to receive 75mmx 10mm GI flat. The connection shall be bolted type with two bolts per pad. The hinged door shall be connected to body using flexible wire.

(vii) The cabinets/boxes/kiosks/panels shall also be provided with danger plate, and internal wiring diagram shall be laminated and shall be installed inside of the door. The front label shall be on a 3 mm thick plastic plate with white letter engraved on black background.

**4.0.0 OPGW (COMPOSITE FIBRE OPTIC OVERHEAD GROUND WIRE) OPTICAL GROUND WIRE:**

4.1.0 **General**

The earth wire shall comprise a composite optical fibre cable and earth wire, with optical fibre cable links from each terminal support to the termination equipment installed in the sub-station buildings. Sectioning of aerial cable and jointing of optical fibres shall generally be arranged on tension supports or on suspension supports provided that such supports are designed for such condition.

The OPGW cable and its associated accessories shall be of a proven design with established satisfactory operating records / history.

The OPGW shall comprise an optical unit integral with the ground wire conductor. The OPGW design shall be mechanically and electrically compatible with the design of the transmission line. The OPGW shall be protected from Aeolian vibration by installation of vibration dampers.

The OPGW shall be earthed to the tower steel work at each tower. Approved clamps and bondings shall be used for earth connection.

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The composite earthwire shall conform to the requirements of the earthwires specified in this specification. The construction shall be such that tension in the earth wire can impose only negligible strain on the optical fibres.

The outer layer of OPGW shall be aluminium clad steel wire of smooth bodied construction. Optical fibre shall be of silicon type suitable to withstand temperature of about $80^0$C (Continuous) and upto 190 $^0$C under specified short circuit current for specified short circuit duration. Each fibre shall be jacketed by heat resistant material and stranded around central spongy rubber core. Considerations should be made on OPGW design to provide superior reliability on thermal resistance water proof, strain reduction to fibres, mechanical strength and corrosion resistance.

The OPGW shall also withstand lightning currents without degradation of optical attenuation of the fibres or mechanical damage to the ground wire strands.

The wire forming the outer strands of the OPGW shall be right hand lay and designed to prevent bird caging, strand popping and unravelling during normal handling and installation.

The OPGW shall be delivered with approved water proof end seal which shall not be removed until immediately prior to optical jointing.

No mid-span joints shall be allowed in the OPGW. All joints shall be performed in a tower joint box located 5.0 metre above the ground level.

It is not envisaged that repeater stations are required. The Bidder / Contractor is to conduct necessary investigation to demonstrate that repeaters are not required.

The following standards shall generally be applicable.

a. Aluminium Clad Steel wire (ASTM B 415, B 416).

b. Optical fibre (CCITT recommendation G 652 for single mode).

The Contractor shall furnish recommended procedure for stringing the OPGW together with sketches.

4.2.0 **Optical Fibre Requirement**

Based on the system short circuit current level specified, the contractor shall evaluate the split of the total system earth fault current between the actual earth, the optical fibre cable and the outer layer of earth wire on the tower. Necessary calculations to this effect shall be provided for the approval of the Owner/Owner's representative. Accordingly the sizing of the composite OPGW and its individual components shall be established.

# SECTION - 3

# DETAILED TECHNICAL SPECIFICATION - ELECTRICAL

## SUB-SECTION - 3.6.3

## 66 kV GIS SUBSTATION AUTOMATION SYSTEM (SAS) & PROTECTION

**VOLUME - III**

**SUB-SECTION - 3.6.3**
**66kV INDOOR GIS**
**SUBSTATION AUTOMATION SYSTEM (SAS) & PROTECTION**

1.0.0 **SCOPE**

1.1.1 The scope includes design engineering, software development, manufacturing, testing at works, supply, delivery, erection, configuring, on site testing and commissioning of a modern state of the art microprocessor based Substation automation system (SAS) associated with the new CCCPP. 66kV GIS and the station auxiliary electrical power HV & LV distribution switchgear circuits.

1.1.2 The SAS system shall provide controls and acquire real time data from the various circuits of the HV and LV electrical power system and present readily understood information to the electrical substation control engineer.

1.1.3 All elements of the SAS system shall be based on a real time multitasking operating system. The system shall be user friendly and allow easy access for maintenance, testing and repair.

1.1.4 The SAS system shall be based on a distributed architecture and all components shall be of approved and reliable design with highest attainable attributes for uniformity, interoperability and interchangeability. The design shall be modular to facilitate easy maintenance, fault diagnosis and repair of components and to support installation and incremental expansion. It shall be possible to alter, extend or upgrade any element of the substation by simple addition of hardware with necessary software augmentation and configuration. SAS shall be based on integrated automation solution which shall not just be limited to usual control and monitoring but shall be based on incorporation of features offering solution to serve as aid to operator in terms of automatic operation of normal functions and the other repeated security checked sequential switching, supply restoration after fault location and segregation of healthy and faulted sections.

1.1.5 Dual redundant servers with requisite software (MASTER STATION) connected by redundant communication links to distributed microprocessor based dual redundant Remote Terminal Units (RTU's – one for 66 kV GIS and other for the plant auxiliaries) with controllers for performing the required SAS functions including data collection, monitoring, operation, control, load shedding, events recording, energy management system for the 66 kV GIS, New CCCPP station auxiliary power distribution HV & LV circuits and existing three nos. GTGs, existing load connected to existing 11kV switchgear.

1.1.6 New SAS system shall have energy management & load shedding modules. For energy management purpose all the parameters of the existing gas turbine generator ( GTG-1,2 & 3) shall also be considered and for load shedding purpose all the existing & new 11kV switchgear outgoing plant feeders control & monitoring are to be considered in the SAS system. Any modifications/additions in the existing system for achieving this requirement like contact multiplication, providing digital multifunctional meters in the existing feeders (GTG-1, GTG-2, GTG-3, Grid transformer-1 & grid transformer-2) necessary cabling etc shall be considered in EPC contractor's scope. Logic to be adopted for load shedding purpose & feeders for load shedding shall be identified in consultation with ONGC during detailed engineering.

1.1.7 HMI at various locations in the form of dual Operator Console, Supervisory Console and each of their associated furniture's (desk with drawers and chair), plus Engineering Workstations (EWS). The consoles shall be PC based complete with colour monitors, industrial grade CPU, key board, mouse and printer.

1.1.8 The Engineering Work Station (EWS) shall be provided as one laptop PC that can be shared for use at each of the adjacent RTUs associated with the 66 kV GIS network along with a fixed EWS for all RTU.

1.1.9 Control Room Printers and Control room Video Copier.

1.1.10 Dual redundant distributed RTU for the GIS. The RTUs shall be designed as special purpose computers/controllers comprising control and data acquisition functions, analogue to digital converters (ADC), digital to analogue converters (DAC), and digital inputs (status) and output (controls). The RTU outputs shall be controlled by software's that shall be resident in the RTU as well as via remote command from the SAS system Master Computer. The RTU shall be complete with I/O module interface, interposing relays, I/O cards, processing units and communication processors as required.

1.1.11 Redundant Fibre optic links between SAS servers and various RTUs.

1.1.12 Clock and GPS satellite clock module with cable and antenna for time synchronization of the SAS.

1.1.13 SAS I/O or Marshalling Rack as required.

1.1.14 All control, protection cables and optical fiber / ethernet cable as a communication medium between the Numerical protection / control units, RTUs and the central components.

1.1.15 All software for functional completeness and integrity.

1.1.16 All special tools and tackles as required.

1.1.17 All necessary testing/diagnostic tools (including software) for comprehensive system (hardware and software) testing. On line and off line debugging aids shall be provided for software testing.

1.1.18 All necessary transducers, interposing relays, switches and indicators mounted in the interfacing cabinets to meet the requirements, including all other necessary hardware to make the system functionally complete in all respects.

1.1.19 The SAS shall utilize all features of the IEC 61850 standards that shall include:

a) **Data Modelling** -- Complete functionality of the substation shall be modelled into different standard logical nodes which can be grouped under different logical devices with logical nodes for data/functions related to the logical device (LLN0) and physical device (LPHD) and other functions as appropriate.

b) **Reporting Schemes** -- Various reporting schemes (BRCB & URCB) for reporting data from server through a server-client relationship which shall be triggered based on pre-defined trigger conditions.

c) **Fast Transfer of events** – Use of Generic Substation Event (GSE) for fast transfer of event data for a peer-to-peer communication mode, which is subdivided into GOOSE & GSSE.

d) **Setting Groups** – Use of the Setting Group Control Blocks (SGCB) defined to handle the setting groups so that user can switch to any active group according to the requirement.

e) **Sampled Data Transfer** – Adoption of schemes defined to handle transfer of sampled values using Sampled Value Control blocks (SVCB).

f) **Commands** -- Various command types shall be supported by IEC 61850 which include direct & SBO commands with normal and enhanced securities.

g) **Data Storage** — Adoption of SCL (Substation Configuration Language) for complete storage of configured data of the substation in specific formats.

## 2.0.0 LIST OF CONTROLS SIGNALS

In general the SAS interface with the switchgear circuits for the SAS control and data acquisition shall include the following that shall be wired to RTU's as minimum. However during detailed engg. it can be reworked.

### 2.1.0 Controls

- Control i.e. Trip or Close of circuit breaker of each of the 66 kV incoming + 66kV outgoing + bus coupler and outgoing transformer circuits, 11HV Switchgear incomer + outgoing + buscoupler, Black start DG breaker + LV PMCC incomer + Outgoing + bus coupler & All LV MCCs incomer + Outgoing + bus coupler circuits.
- Control i.e. Trip or Close of disconnectors of each of the 66 kV circuits.
- Raise or Lower taps of each transformer with on load tap changers.
- Resetting of electrically reset type trip relays, as applicable.

### 2.2.0 Circuit Wise Alarms And Annunciation

- Main protection trip.
- Back-up protection trip (over current, earth fault, connected to one common alarm circuit).
- Transformer Urgent trip (All Buchholz, Winding Temperature High, Oil Temperature High, Pressure Relief, Low Oil Level URGENT TRIP ALARMS)-Applicable only for transformers.
- Transformer Non-Urgent trip (All Buchholz, Winding Temperature High, Oil Temperature High, Pressure Relief, Low Oil Level ALARMS)-Applicable only for transformers.
- Auto relcose initiated (Applicable for Overhead lines where applicable only).
- Auto relcose lockout. (Applicable for Overhead lines where applicable only).
- Circuit breaker inoperative.
- Circuit breaker fail protection.
- Trip circuit 1 & 2 fail.
- VT fail (where applicable).
- Protection or SAS communication channel fail.
- Intertrip receive and send.
- Switchgear 110V DC supplies fail.
- SAS fail.
- Space for 5 future alarms.

2.3.0 **General Alarms and Annunciation**

- Main busbar protection trip.
- Transfer busbar protection trip.
- Busbar protections fail.
- LV AC supply to battery charger fail & LV AC supply fail.
- Alarm DC supply fail & Battery alarm.
- Under frequency scheme operated.
- Space for 5 future alarms.

**"ON / OFF" INDICATIONS FOR: -**

- Circuit breaker.
- Busbar disconnectors.
- Line disconnectors.
- Line earth switches.
- CP or SAS / supervisory control in service.
- Local or remote i.e. CP control in service
- Line fault locator fault location indication.

**FOR EACH TRANSFORMER**

- Control selection ( "master / follower" )
- Control selection ( "supervisory / remote" )
- Tap change in progress
- Tap change incomplete alarm
- Tap changer out-or-step
- Tap position indication ("Potential free" contacts on multi position stepping switch)
- Space for 5 future alarms or indications.

3.0.0 **GIS CONTROL AND MONITORING LEVELS**

- The GIS control and monitoring system shall allow for three levels of Human Machine Interface (HMI). The number of levels includes GIS level, substation level (control room) and SAS level. Provision shall be made for future implementation of a higher level of monitoring from grid/load dispatch control centre via SAS.

- In all cases, however, only one control point shall be capable of carrying out the control functions at any given time but it shall be possible to view the CCCPP GIS/station auxiliary power distribution system status, metering indications, control targets and other parameters from any of the control levels.

- Selection between bay or substation control shall be from the bay control point on an individual equipment basis. Selection between station or SAS control shall be from the station control panel location on a per circuit basis.

- The substation operator shall control and monitor the performance of the GIS/substation using the SAS system. However under emergency it shall be possible to open or trip circuit from the control panels (CP) irrespective of the SAS or CP mode of operation. All bay level monitoring shall be affected from SAS irrespective of the selection of any of the three levels of control.

- A GIS control and relay room to be established at appropriate location in the steam turbine generator control building shall accommodate protective relay panels, control panels, and the SAS panels. All SAS servers, printers shall be in this room.

- The SAS and the relay rooms will be air-conditioned. Additional space shall be provided in the electrical room for accommodating future extension of GIS. However, all the equipment shall be designed for successful trouble free continuous operation even if air conditioning system fails.

- The details of station control level HMI/Mimic/Alarm Annuciation shall be as specified in appropriate sections of this specification.

## 4.0.0 SAS EQUIPMENT ENCLOSURE

- The SAS equipment shall be installed in sheet steel cabinets. The equipment shall be rack mounted. The thickness of sheet steel shall be 1.6 mm (RITTAL Make). Enclosure material shall be cold rolled sheet steel. Cabinets shall be complete with all internal wiring and connections.

- All cables, wiring, lugs and terminals in the cabinets shall be tagged or identified with labels as per approved drawings of manufacturer. Wires shall be terminated using crimping type copper cable lugs. Wires shall be ferruled and colour coded. Terminals in cabinet shall be clip on type and shall be mounted on DIN Rail. DIN rail shall have a mechanical locking mechanism for holding terminals firmly at both ends of terminal strip. For termination of electronic wiring appropriate type of terminals with suitable markings shall be provided.

- Cabinet shall be naturally ventilated type. Each cabinet shall be provided with thermostatically controlled anti-condensation heaters and illumination lamp. However if enclosure cooling fans are employed then these shall be with replaceable filter units.

- All equipment in cabinets shall be clearly identified by means of nameplates as per approved drawings and documents.

- Enclosures shall have a degree of protection not less than IP 42. The degree of protection shall be in accordance with IEC 60529.

- The floor shall not be considered as forming a part of the enclosure.

5.0.0 **HARDWARE AND SOFTWARE**

5.1.0 **Hardware**

- The system shall be designed such that the failure or removal of a single component shall not result in inadvertent operation of the GIS switching devices.
- The SAS shall be provided with self supervision features. The system offered shall provide reliable, safe and efficient operation of the substation plant items at all times with an availability figure of 99.98 percent.
- The design in so far as concerns capacity and expandability, shall meet the following requirements:-
- Equipped capacity: - the equipment as initially supplied and installed shall be capable of performing all functions to the stated capacity. A further 10% spare capacity shall be supplied and installed.
- Extension capacity: - the equipment as initially supplied and installed shall be capable of 25% extension of all functions simply by addition of plug-in modules for which all necessary wiring shall be provided. The design shall allow expansion, modification and testing with the minimum of disruption.
- Terminations: - all input/output cables shall be terminated within the cubicle on terminal blocks which incorporate removable links.

5.2.0 **Software**

- The software shall be of modular construction and developed using structured design techniques, where possible standard library software modules shall be utilised.
- The software shall be pre-programmed and verified by simulation before despatch. There shall be facilities for on board re-programming. Reprogramming shall be carried out using a portable engineering PC.
- The programming language shall be graphical / user-friendly. The control programmes shall be modular in structure.
- The software shall guide the user, step-by-step, through each sequence by identifying, preferably via a visual technique on the workstation, the remaining valid entries.

**5.3.0 SAS Functionality 66kV System Control: - P & Q & Voltage Load Flow Monitoring & Analysis, Status Monitor/Control.**

These shall include:-

- Bus Voltage & Angle, Branch P & Q Load Flow Monitoring & Analysis.
- Fault Analysis.
- State Estimation From Real Time Measurements.
- Real Time Online study Mode (PAS i.e. Power Application Software) based on data originating from the network that will be utilized with results directly relate to actual situation & Offline Mode Analysis.
- Status Monitoring & Metering.
- Status Change & Violations Monitoring.

- Circuit Mode Monitoring Local, Remote Or Supervisory.
- 66 kV Electrical System Circuit Control.
- Contingency Analysis To Identify Overload & Load shedding/ Overload Monitoring.
- Each Branch Load Management With Demand Side Load Control.
- For each feeder variables such as bus voltage, transformer tap position and loading, voltage regulator status, feeder/transformer/branch amperage, loading, losses and voltage drops, cumulative voltage drops.
- Grid & Generator transformer & station transformer load management using data from transformer monitoring equipment to assess short term overload capability of transformers during emergences to allow evaluation of load balancing/allocation between transformers.

**SAS Main System Functions:**

These shall include:-

- HMI as per specification.
- Network Control & Monitoring as per specification.
- Disturbance Data Processing For Pre & Post Fault Analysis.
- Energy Accounting.
- Historical Data processing.
- Intelligent Alarm Management.
- Enhanced Information-Safety/ Permit To Work Tagging.
- Enhanced Presentation Of Network With Topology Network Colouring.
- Supervisory Control-Interlocking/Seq Switching / Select Before Operate.
- Advanced Monitoring-AVR, Governor & Relay Parameter Sets Handling For Checking/Changing/Uploading Or Downloading.
- Hand Dressing Or Manual Updating.
- Others As Per Spec,

**SAS Communication Functions:**

These shall have standardization with openness of Interfaces & Protocols with data rate, speed and band width suitable for data exchanges between,

Retrieving Data & Downloading Set Points/Data To All Circuit Numerical Control & Protection Devices,

- Retrieving Data & Downloading Set Points/Data to all Governors,
- Retrieving Data & Downloading Set Points/Data to all AVR's,
- Retrieving Data & Downloading Set Points/Data to all Transformer Tap Changer,

  Controllers Retrieving Data & Downloading Set Points/Data to all RTUs,
- Retrieving Data & Downloading Set Points/Data to all RIO's,

## 6.0.0 COMMUNICATION NETWORK

### 6.1.0 General

The physical media for the communication bus can be Ethernet cable (electrical) or fibre optic cable or a combination of both, based on the distances between various nodes. Procedure of data transmission, error control and recovery shall be as per acceptable standards. Connectors and splices as possible shall be used. Connectors shall only be used to connect equipment in patch panels.

### 6.2.0 Printers

Each workstation shall be provided with high performance hard copy Laser-jet colour printer along with additional black and white dot matrix type of robust construction suitable for continuous duty utilizing fanfold paper. The dot matrix printers shall support a minimum print carriage width of 80 columns with a minimum resolution of 360 dpi.

The devices shall contain off-line self-test systems that provide the capability of adjustment and maintenance without interfering with the remainder of the computer system.

Printer consumables shall be readily available.

The printing shall have a redundant facility, and in the event of a failure, the design should enable a switchover to a standby printer, both automatic and manual. The switchover shall provide both audible and visual alarms on the HMI's.

### 6.3.0 Digital and Analogue Annunciators

Standalone digital and analogue annunciators with a sufficient number of inputs (at least 64 windows) shall be provided for acquisition for general station alarms of the conventional type (e.g. fire fighting equipment operated, station ac/dc supply failure, HVAC failure, non-numerical devices, etc.), and for measuring transformer oil and winding temp, station outdoor and indoor temperature, dc system loads etc. the annunciators shall have the ability to time-stamp all the events with a resolution of 1 ms and shall be suitably integrated into the SAS system.

### 6.4.0 Global Positioning System (GPS) Receiver

GPS satellite receiver modules in redundant configuration with optical ports shall be provided with antenna cable. The module shall provide time synchronization of the SAS and protection equipment in order to guarantee a system wide accuracy of time related data of better than 1ms and also shall have facility for extending the GPS synchronization to other internal equipment clocks.

### 6.5.0 Substation Clock

A substation clock system shall be provided to update the substation control system with accurate date/time information. Updating shall take place automatically at start up and regularly thereafter to ensure that the error between the substation clock time and the substation control system does not exceed 1 ms. The equipment shall be supplied with sufficient outputs of the correct type to meet these operating requirements.

The clock system shall ensure connectivity to global time references such as GPS satellite receivers. The system shall receive UTC GPS time signals to provide accurate date/time information to maintain the crystal controlled.

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## 7.0.0 ISLANDING SCHEME

Islanding scheme shall be provided for the entire 66kV GIS as below :

The grid isolation relay shall operate based on either or all of the following principles:

- Multistage under frequency unit with adjustable time delay features.
- Multistage under voltage unit with adjustable time delay features.
- Voltage vector shift and / or rate change of frequency (df/dt) feature.

System shall have a separate dedicated islanding trip relay for each of the EHV breaker including future bays as per switchyard SLD.

The grid isolation relay shall be fast acting and shall be unaffected by harmonics.

System shall employ two out of three channels for high reliability.

Each of the three channels of islanding scheme shall be independent from each other, starting from the VT measuring core, control cables, DC supplies, under frequency or df / dt measuring relay, etc. till the islanding trip relay of the breaker.

Separately fused 110V DC supplies shall be employed.

# VOLUME - III

# SECTION - 3

# DETAILED TECHNICAL SPECIFICATION - ELECTRICAL

# SUB-SECTION - 3.7

# HT SWITCHGEAR

**VOLUME - III**

**SUB-SECTION - 3.7**

**HT SWITCHGEAR**

## 1.0.0 GENERAL

This specification covers, the design, manufacture, supply, erection, testing and commissioning of 11 kV Switchgear & 12 kV NGR.

It is not the intent to specify completely herein all details of the equipment, nevertheless, the equipment shall be complete and operative in all respects and shall conform to the highest standard of engineering, design and workmanship.

## 2.0.0 SCOPE OF WORK

The scope of work shall include but not limited to the following:

- 11 kV Switchgear.
- Fast Bus Transfer System (FBTS).
- 12 kV Neutral Grounding Resistor(NGR)
- List and supply of special maintenance tools and tackles
- All necessary base frame, channels and hardware
- One set of earthing trucks (for feeder and bus earthing)
- Mandatory spares as listed in Vol. II / Section-1.0 and recommended spares for two (2) years trouble free operation.

## 3.0.0 CODES & STANDARDS

11 kV switchgear shall conform to relevant IS/IEC standards. The major standards are listed below:

| | | |
|---|---|---|
| IS: 13118 | : | Specification for high voltage alternating current circuit breakers |
| IS: 12729 | : | Switchgear & control gear for voltages exceeding 1000V- General requirements |
| IS: 2705 | : | Current transformers. |
| IS: 3156 | : | Voltage transformers |
| IS: 4710 | : | Switches and switch isolators above 1.0 KV but not exceeding 11 KV. |
| IS: 5082 | : | Wrought aluminium and aluminium alloy bars, rods, tubes and sections for electrical purposes. |
| IEC 62271-200 | : | AC metal clad switchgear and control gear for rated voltage above 1kV up to and including 52kV. |

Other equipment and all components and accessories shall also conform to relevant IS/IEC standards amended up to date.

## 4.0.0 TECHNICAL REQUIREMENT

### 4.1.0 Design Features

i. Switchgear and its components and accessories shall conform to relevant IEC – 62271 – 100 / 200 Standards.

The switchgear shall have –

- Internal arc classification : IAC AFLR
- Loss of service continuity classification : LSC2B-PM

11 kV switchgear offered shall be fully arc resistant design and the switchgear shall be have an internal arc 40 kA for 1 second. Internal Arc testing procedure and certificate shall be furnished.

11 kV Switchgear shall comply with IEC 60298 with regards to mechanical strength in the event of an internal arc.

All internal arc tests shall be executed for all separate compartments within the functional unit containing HV equipment i.e. bus bar compartment, circuit breaker/contactor compartment and cable compartment.

All wiring space, bus bar areas and adjacent cubicles shall be shielded from one another by sheet barriers. Individual compartments shall be so designed and constructed as to limit the passage of flame from one compartment to another. Arc propagation barriers shall be provided to prevent flashover from auxiliary compartments to main bus bars. The switchgear assemblies shall be protected from internal arc in accordance with IEC 62271 – 200.

4.1.1 11 kV switchgears shall be of indoor, single front, single tier, metal clad, fully draw out type with vacuum circuit breaker.

4.1.2 11 kV switchgears shall have fault withstand capability of 44 kA (rms) for 3 sec.

4.1.3 Switching over voltage for 11 kV breakers shall be limited to 2.55p.u at breaker terminals. Surge limiters shall be provided in 11 kV vacuum switchgear for all motor feeders to take care of switching surges.

4.1.4 The circuit breakers shall be designed for natural air cooling.

4.1.5 The continuous rating of the main busbars shall be same as that of the incomer breaker and shall carry this continuous current without exceeding the temperature of 90°C considering an ambient of 50°C. For silver plated joints temperature shall not exceed 105°C considering an ambient of 50°C. For outgoing feeders the bus bar rating shall be same as that of the corresponding breaker.

4.1.6 Breakers shall be adequately de rated to account for electrical design ambient temperature of 50°C and temperature inside the cubicle. Incomer breaker fed from transformers shall be at least rated to carry the transformer full load current at minimum voltage within the enclosure at ambient the specified design ambient temperature. All circuit breakers shall be with natural cooling, in panel ratings shall be guaranteed with natural cooling only.

4.1.7 Equipment and component rating and quantities shall be suitably selected according to the requirements with adequate margin. 10% spare feeders with minimum one each of each rating and type shall be provided.

4.1.8 The incomer panel shall be suitable to receive 11kV segregated phase bus duct from Station Transformer. Suitable extension chamber shall be provided for the same. Bus duct entry shall be from top. Required current transformers shall be provided in the incomers for ST differential protection & restricted earth fault protection.

**4.2.0 Control Requirements & Changeover Scheme**

4.2.1 11kV switchboards shall be controlled (closing & tripping) from remote (SAS) only under service conditions.Only test closing shall be possible from switchgear. Breaker signals, protection relay operated condition and necessary current, voltage and power signals shall be routed to SAS in addition to local indication.

4.2.2 The control / interlock schemes for various types of feeders shall be commensurate with their application. Interlocks shall be hardwired in the switchboard itself. All switchboards shall be provided with redundant DC control supply with auto change over facility. Breaker spring charging motor shall be suitable for 110V DC. Isolating switch fuse units of adequate capacity shall be provided at each switchgear for the incoming supplies.

4.2.3 Switchgear shall be provided with one DC fail relay and DC fail indicating lamp for each DC incomer. Further a common DC failure alarm contact shall be wired up for remote annunciation to indicate failure of DC supply to any breaker panel.

4.2.4 For all remote operated feeders, interposing relays shall be provided in respective switchboard to receive open/close command from remote.

4.2.5 11kV switchgear shall be normally operated with two incomer breakers ON & the bus coupler OFF. Necessary auto changeover scheme and manual change over scheme shall be provided with necessary control, indications and interlocks. Momentary paralleling facility with check synchronizing relay shall also be provided in the manual change over scheme.

4.2.6 The switchgear shall be provided with automatic in phase (microprocessor based fast bus transfer scheme, FBTS) and manual live changeover scheme for emergency and planned changeover of supply from one source to the other and vice versa.

**Transfer Initiation**

Bus Transfer Initiation should be possible by following means:

- Manual Transfer

  Used for planned transfer during normal operations of the plant. This transfer shall be initiated from the front of the panel and shall be user friendly. Manual Transfer shall also be possible through remote command via the communication port.

- Auto Transfer

  The auto transfer shall be capable of intelligent auto transfers based on system healthiness monitoring algorithms performing analysis of bus under-voltage, bus under-frequency and bus [df/dt] in specified viable transfer directions.

**Transfer Modes**

The FBTS should have following transfer modes:

- Fast Transfer

The bus voltage and incoming source voltage should be monitored on a continuous basis for magnitude and phase angle to ensure that transfer operation is carried out under conditions conducive to fast bus transfer as per high speed sync-check supervision and ANSI C50.41 (1982) criterion.

- In Phase Transfer

  The breaker power contacts shall close when the decaying and drifting bus voltage synchronizes with the incoming source voltage within acceptable voltage and frequency parameters. The Bus transfer system shall continuously process the bus voltage and the drifting phase angle dynamics to determine in real-time the exact moment of sending a command to the breaker-closing coil to achieve the above.

- Slow Transfer

  The breaker power contacts shall close when the falling bus voltage shall reach an acceptable safe value. The auxiliary drives are selectively tripped simultaneously to limit the transformer inrush current.

- Momentary Paralleling Transfer

  This is a “Make before Break” transfer for a very short duration of the order of few cycles where, under supervision of the bus voltage and incoming source voltage for magnitude and phase angle, the new source breaker is closed before opening the old source breaker. Normally not recommended for unplanned transfers and auto/protective transfers from the system safety considerations.

**4.3.0 Enclosure**

4.3.1 The switchgear shall be indoor, single front, single tier, metal clad, compartmentalized, fully draw-out type comprising of minimum 2.0 mm thick cold rolled, sheet steel units, assembled to form a rigid, free standing structure.

4.3.2 Circuit breakers, instrument transformers, bus bars, cable compartments, LV chamber relays and instruments shall be housed in separate metal/ insulated partitioned compartments within the cubicles. Metal barriers where employed shall be effectively earthed and insulated barriers shall be arc proof to ensure operator safety. Power and control cable entry into the switchgear panel shall be totally segregated.

4.3.3 All relays, meters, switches and lamps shall be flush mounted on the respective cubicle door or on control cabinet built on the front of the cubicle.

4.3.4 Controls and interlocks as required for the safe switching, operation and maintenance of the switch gear shall be provided. Mechanical interlocks shall be provided in addition to electrical wherever possible.

**4.4.0 Circuit Breakers**

4.4.1 The Circuit Breaker shall be of vacuum type.

4.4.2 The circuit breakers shall be fully draw-out type, having SERVICE, TEST and DISCONNECTED positions with positive indicators for service & test positions.

4.4.3 The breakers shall have motor operated spring charged mechanism. It shall be possible to charge the springs manually. Breakers shall be trip free and shall have an anti-pumping device.

4.4.4 For motor wound mechanism, spring charging shall take place automatically after each breaker closing operation. One open-close-open operation of the circuit breaker shall be possible after failure of power supply to the motor.

4.4.5 Lockable emergency manual trip push buttons shall be provided for all breakers. Complete breaker assembly should have inter changeability with identical rating of breaker. Each breaker shall be provided with an operation counter, mechanical ON-OFF indicator and mechanical charge/discharge indicator clearly visible.

4.4.6 Automatic safety shutters shall be provided to ensure the inaccessibility of live parts after the breaker is drawn out. There shall be distinct overall door for the breaker compartment and shall be lockable.

4.4.7 The truck and breaker frame shall get earthed while the truck is being inserted in the panel and positive earthing of the truck and breaker frame shall be maintained in all positions.

4.4.8 Outgoing breakers shall be suitable for switching transformers and motors at any load. Motor feeders shall be suitable for frequent direct on-line starting of motor.

**4.5.0 Busbars**

4.5.1 All phase bus bars shall be of electrolytic grade copper with uniform cross- section sized to carry continuously, the specified current without exceeding temperature limits.

4.5.2 Bus insulator shall be flame-retardant, non-hygroscopic track resistant type with high creepage surface. This shall be of non-carbonizing material such as epoxy bonded fiberglass.

4.5.3 All horizontal & vertical bus bars and joints shall be covered by HT insulating shrouds.

4.5.4 The bus bar supports shall be able to withstand stresses due to maximum short circuit and also take care of any thermal expansion.

4.6.0 **CT & VT**

4.6.1 Bus VTs and line VTs for incomers shall be provided. The voltage transformers shall be of cast resin insulated, draw-out type and provided with HRC type primary and secondary fuses. Secondary voltage of voltage transformer shall be 110V AC. Fuse failure relay (97) shall be provided on the secondary side of all voltage transformers to monitor failure of LV fuses.

4.6.2 The CTs shall be of cast resin bar primary/wound primary type and of class-E or better insulation. CT secondary shall be rated for 1A. For earth fault protection core balance CTs shall be provided.

4.7.0 **Wiring, Indication lamps & Terminal block**

4.7.1 All wiring for control, signaling, protection and instrument circuits shall be done with 1.1kV grade PVC insulated copper wires. The minimum size for control circuit & PT circuits shall be 1.5sqmm. For CT circuits, cable size shall not be less than 2.5 mm¨ copper.

4.7.2 Electrical indications shall be provided as, Breaker `ON' - Red Lamp; Breaker `OFF'. Green Lamp; Breaker `Auto Trip' - Amber Lamp, Breaker Trip coil healthy - White lamp; DC fail - Blue Lamp. All indicating lamps shall be of LED type.

4.7.3 Sufficient terminals (1100V grade, stud type with marking strips) shall be provided on each terminal block to ensure that not more than two outgoing wires are connected per terminal. 10% spare terminals shall be provided on each terminal block. All spare contacts of auxiliary relays, timers etc.

shall be wired up to the terminals. Terminals for CT secondary leads shall have provision for easy shorting and earthing and shall be suitable for connecting 2 cables of 2.5 $mm^2$ copper.

4.8.0 **Measuring Instruments**

4.8.1 All the measuring instruments shall be digital multifunction type and shall be provided with suitable port for remote hook up to SAS.

4.8.2 All incomers and transformer feeders shall be provided with digital meter to read voltage, current, frequency, power factor, power and energy. Bus coupler shall be provided with digital ammeter.

4.8.3 All other outgoing feeders shall the facility to read current and power.

4.8.4 Energy measurement on the incomer shall be to the accuracy of 0.2S.

4.8.5 All the meters in a switchboard shall be daisy chained for remote hook up and wire break monitoring of these analog signals shall be provided.

4.9.0 **Control /Selector Switches and Push Buttons**

4.9.1 Circuit breaker control switches shall be 3- position (Trip/Neutral/Close) with spring return to `neutral'. Local/remote selector switch shall be of stay put lockable type.

4.9.2 Ammeter selector switches shall have make before break feature on its contacts. The selector switch shall have four positions.

4.9.3 All push buttons shall be heavy duty, spring return type suitable for flush mounting on sheet steel cubicle doors. The push buttons shall have two (2) Nos. `NO' and two (2) Nos. `NC' contacts. The continuous current and breaking capacity of the contacts shall be adequate for the duty involved.

4.10.0 **Earthing Connections**

4.10.1 11 kV cubicles shall be connected to an earth busbar of size 50 x 6 mm copper running throughout the length of the switchboard. All doors and movable parts shall be connected to the earth bus with flexible copper connections. Provision shall be made to connect the earthing busbar to the plant earthing grid at two distinctive ends.

4.10.2 CT & VT secondary neutrals shall be earthed through removable links.

4.10.3 Separate earthing trucks shall be provided suitable for earthing the switchgear busbars as well as outgoing cables. The trucks shall have a voltage transformer and an interlock to prevent earthing of any live connection. The trucks shall have in addition an audio-visual annunciation to warn the operator against earthing of live connections.

4.11.0 **Relays**

4.11.1 All relays excluding auxiliary relays shall be numerical microprocessor based only with IEC 61850 communications Protocol.

4.11.2 Microprocessor based numerical multifunction feeder management relays with facilities such as programmable scheme logic, programmable characteristics, comprehensive protection, measurement of electrical quantities, post fault analysis, communication ports and self diagnosis, etc. shall be provided for protection of MV switchgear incomers, bus couplers, outgoing motor & transformer feeders.

4.11.3 All protective relays shall be suitable for flush mounting and fitted with dust tight covers. All relays shall have built-in testing facilities.

4.11.4 Each breaker shall be provided with anti-pumping (94), lockout (86) and trip circuit supervision (74) relays. The lockout relay shall be hand reset type with flag indicators. Breaker auxiliary contacts used for interlocking purposes shall be multiplied contacts using electrically set/reset relay so that correct position of the breaker is represented.

4.11.5 For transformer feeder self reset auxiliary relays with hand reset flag indicator shall be provided for contact multiplication of :

- Transformer Buchholz alarm & trip contacts for main tank and OLTC compartment.
- Transformer winding temperature indicator alarm & trip contacts.
- Transformer oil temperature indicator alarm & trip contacts.
- Transformer pressure relief trip contacts.
- Transformer oil level low alarm contacts.
- Transformer oil surge relay for OLTC alarm & trip contacts

4.11.6 Under voltage / Over voltage relays with adjustable timer shall be provided in the bus VT & line VT circuit. VT fuse failure relay shall also be provided.

4.11.7 All protection relays shall have facilities for communication with SAS system. All hardware/software required for interfacing with the SAS system shall be supplied. Relay shall also have communication ports RS232 for direct access of data through laptop.

4.11.8 **Protections**

All necessary protections for the equipment offered shall be provided. The following minimum protection shall be provided for various feeders. Additional protection if any, to meet system requirements shall also be provided

**Transformer Feeders**

- Short circuit protection (50) on all the three phases.
- Over current protection (51) on all the three phases.
- Instantaneous earth fault protection (50 N).
- IDMT(51N)

**Incomer from ST**

- IDMT over current protection (51) on all the three phases.
- IDMT earth fault protection connected to neutral CT (51N).
- Earth fault protection (51N)
- Instantaneous(50 & 50N)
- Reverse current blocking

**Bus Coupler**

- IDMT over current protection (51) on all the three phases.
- Earth fault protection (51N)
- Instantaneous (50 & 50N) over current and earth fault protection.
- Complete Bus bar differential protection

**Motor Feeders**

- Comprehensive digital motor protection relay having comprehensive motor protection.
- Time delayed under voltage trip.
- Thermal over load protection (49)
- Short circuit protection (50/51)
- Excessive start time protection (48/51)
- Locked rotor protection (50/51 LR)
- Unbalanced load / single phasing ( 46)
- Earth fault (50N / 51N)
- Loss of load ((37)
- Differential protection and percentage differential protection for motor rated 1000 kW & above.
- All Outgoing Cable tie feeders and Motor feeders shall have CBCT for low earth fault current protection

4.12.0 **Space Heaters**

Each cubicle shall be provided with thermostat controlled space heaters suitable for operation from 240V ±10%, 1Ph, 50 Hz, +3%, -5% supply and 5A, 240V AC, 3 pin plug socket and cubicle lamp. The space heaters shall be located at the bottom of the switchboards. Cubicle heater, plug/socket/lamp circuits shall have individual switch fuse units.

4.13.0 **12kV Neutral Grounding Resistor ( NGR)**

4.13.1 The neutral grounding resistors shall be used to ground neutral of 12 kV Station Transformers. The NGR shall be rated for system having following system parameters.

- Nominal voltage : 12000 V
- Frequency : 50 HZ +3 % to -5%
- Power frequency withstand voltage : 28 kV
- Impulse withstand voltage : 75 kVp

4.13.2 The NGR rating shall be based on the electrical design ambient temperature specified in project information. The short time current rating of the NGR shall be such that it can allow 100A current for 30 seconds without exceeding the temperature rise of 300$^{o}$C over the electrical design ambient temperature.

4.13.3 The NGR shall be natural air-cooled type. The resistor shall be made of stainless steel grid. Degree o protection for NR enclosure shall be IP 33.

4.14.0 **Name Plates**

Black engraved perspex sheet / PVC of 3mm thick name plate with the switchgear designation shall be fixed at the top centre of the panel. A separate name plate giving feeder details shall be provided at front and both halves of rear for each panel. Name plates shall be provided for each equipment (lamps, PBs, switches, relays, auxiliary contactors etc.) mounted on the switchboard.

**5.0.0 TESTS**

5.1.0 11 kV switchgear shall be subjected to routine tests as per IEC/IS. Only type tested equipments are acceptable as per IEC 62271 – 200. If the equipments are not type tested then Bidder is bound to carry out the type test of each rating with no commercial implication. The type tested panels shall be of prototype and not to be used there after.

5.2.0 All tests shall be conducted as per relevant IS/IEC/IEEE standards and shall be performed in the presence of Owner/Owner's representative, if so desired by the Owner/Owner's representative.

5.3.0 Switchgear panels & it's components shall be of type tested & relevant type test certificates shall be furnished for Owner/Owner's representative's review. If relevant type test reports are not available the same shall be conducted without any cost implication.

5.4.0 Temperature rise test shall be conducted on the offered panel.

**6.0.0 PAINTING**

Equipment shall be finished with two (2) under coats of high quality epoxy based primer followed by two coats of epoxy painting. Painting shall be carried out by approved process.

## 7.0.0 SPECIFIED TECHNICAL DATA

| Sr.No | Description | Unit | Data |
|---|---|---|---|
| 1.0 | Type | | Totally enclosed, draw out type<br>Internal arc classification : IAC AFLR<br>Loss of service continuity classification :LSC2B-PI |
| 2.0 | Degree of protection | - | IP4X for HV compartment<br>IP52 for metering and relay compartment |
| | Internal arc classification | - | 40kA for 1 sec. |
| 3.0 | Nominal voltage | KV | 11 KV ±10% |
| 4.0 | Frequency | Hz | 50 Hz +5% -5% |
| 5.0 | One minute power frequency withstand voltage | kV (rms) | 28 |
| 6.0 | 1.2/50 micro sec. impulse withstand voltage | kV (peak) | 75 |
| 7.0 | Busbar | - | Copper |
| 8.0 | Circuit breaker | - | Vacuum Circuit Breaker |
| 9.0 | Breaker duty cycle | - | O-3 min - CO-3 min-CO |
| 10.0 | Control voltage | V | 110 V DC |
| 11.0 | Breaking capacity | kA | 44 kA |
| 12.0 | Short time rating | kA | 44 kA for 3 sec |
| 13.0 | Accuracy class of Current Transformer | | |
| | Metering | | Cl. 0.5 |
| | Energy meter(for incoming feeder) | | Cl. 0.2s |
| | Differential Protection | | PS Class |
| | Protection | | 5P20 |
| 14.0 | Accuracy class of Voltage Transformer | | |
| | Metering | | Cl.0.5 |
| | Energy meter(for incoming feeder) | | Cl. 0.2s |
| | Protection | | 3P |

| Sr.No | Description | Unit | Data |
|---|---|---|---|
| 15.0 | Breaker Control Switch | | Trip/Neutral/Close) with spring return to neutral'. |
| 16.0 | Local/remote selector switch | | Stay put lockable type |
| 17.0 | Aux contact for Push Button | | 2 NO+2NC |
| 18.0 | Earthing trucks for earthing the busbar | - | One of each type to be provided. |
| 19.0 | Earthing trucks for earthing outgoing cables | - | Two of each type to be provided. |

# VOLUME - III

# SECTION – 3

# DETAILED TECHNICAL SPECIFICATION - ELECTRICAL

# SUB-SECTION - 3.8

# LT SWITCHGEAR

**VOLUME - III**

**SUB-SECTION - 3.8**

**LT SWITCHGEAR**

## 1.0.0 GENERAL

This specification covers, the design, manufacture, supply, erection, testing & commissioning of complete LT Switchgears.

It is not the intent to specify completely herein all details of the equipment; nevertheless, the equipment shall be complete and operative in all respects and shall conform to the highest standard of engineering, design and workmanship.

Should the Bidder wish to deviate from this specification in any way, he shall draw specific attention to such deviation by listing the deviations in the deviation schedule without which his offer will be considered in conformity with the specification in all respects.

## 2.0.0 SCOPE OF WORK

The scope of work shall include but not limited to the following :

- 415 V Power Control Centres
- 415 V Motor Control Centres
- AC/DC Distribution Boards
- Normal AC/ Emergency AC / Emergency DC Lighting Distribution Boards
- DC Starter Panels
- Local Push Button Stations & Local Starters.
- List and supply of special maintenance tools and tackles
- All necessary base frame, channels, and erection hardwares.
- Mandatory spares as listed in Vol. II / Section-1.0 and recommended spares for two (2) years trouble free operation.

## 3.0.0 CODES & STANDARDS

LT switchgear shall conform to relevant IS / IEC standards. The major standards are listed below:

| | | |
|---|---|---|
| IS 8623 | : | Specification for low voltage switchgear and control gear Assemblies |
| IS 10118 | : | Code of practice for selection, installation and maintenance of switchgear and control gear |
| IS 12021 | : | Specification for control transformers for switchgear and control gear for voltages not exceeding 1000V |
| IS 13947 | : | Low-voltage switchgear and control gear- General rules |
| IS: 2705 | : | Specification for current transformers. |
| IS: 3156 | : | Specification for voltage transformers |
| IS: 3427 | : | Degree of protection provided for metal enclosed switchgear and control gear. |

IS: 5082 : Wrought aluminium and aluminium alloy bars, rods, tubes and sections for electrical purposes.

IS 11353 : Guide for uniform system of marking and identification of conductors and apparatus terminals.

IS 12063 : Classification of degrees of protection provided by enclosures of electrical equipment

IS: 2208 : HRC fuse cartridge, fuse links upto 650 V

IS 130321 : Miniature circuit breaker boards for voltages not exceeding 1kV

All components and accessories shall also conform to relevant IS/IEC standards, amended up to date.

In place of IS / IEC standards.

**4.0.0 TECHNICAL REQUIREMENT**

**4.1.0 Design Features**

4.1.1 The Power Control Centre (PCC), the Motor Control Centre (MCC) and Distribution Board (DB) shall be used to provide power, control, indication and protection for the 400 V/240 V drives/feeders and DC drives/feeders in the plant.

4.1.2 The Power Control Centre, Motor Control Centre & ACDB shall be suitable for 415 V ±10%, 50 Hz +5%, -5% and 3 phase, 4 wire solidly grounded system.

4.1.3 AC Emergency MCC shall be suitable for 415 V ±10%, 50 Hz +5% -5% and 3 phase, 4 wire solidly grounded system.

4.1.4 All switchgear offered shall be arc resistant design and the switchgear shall be tested for internal arc as per IEC. Internal Arc testing procedure and certificate shall be furnished. LT switchgears shall be fully type tested.

4.1.5 DCDB & DC lighting distribution boards shall be suitable for 110V DC + 10 to -15%, 2 wire ungrounded system. DCDB shall be suitably sized for DC system fault current for one sec. duration. Duplicate feeders shall be provided for all essential loads with change over arrangement at the receiving end.

4.1.6 All PCCs shall have two bus sections with separate incomers and bus coupler. Each incomer shall be rated for feeding the entire PCC and shall correspond to the transformer rating with 10% margin and rounded off to the next higher standard rating. Incomer breaker fed from transformers shall be at least rated to carry the transformer full load current at minimum voltage within the enclosure at ambient the specified design ambient temperature

4.1.7 All 415 V PCC's shall have two bus sections with separate incomers and a bus coupler. Incomer shall be rated for feeding the entire switchgear and shall be capable of delivering the full rated output from the transformer.

4.1.8 Under normal conditions, PCC incomer breakers are 'ON' with bus coupler 'OFF'. In case of one incomer outage, the other incomer shall feed the entire PCC. Necessary auto changeover scheme and manual changeover scheme shall be provided with necessary control indications and interlocks. Momentary paralleling with check synchronizing relay shall be provided in manual changeover scheme. Adequate interlocking shall be provided to prevent continuous parallel operation of the two incomers.

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4.1.9 During black out condition, Emergency DG set shall be automatically started and emergency bus section shall be energized after ensuring that the bus coupler between emergency bus and the main PCC is 'OFF'. Synchronization facility shall be provided for momentary paralleling of EDG with one of the PCC incomers after normal AC power is restored.

4.1.10 The MCC/Distribution Board incomer/bus rating shall have 15 % margin and shall not be less than the sum of the maximum load expected plus load on the spare feeders. 60% diversity may be considered for the load on spare feeders.

4.1.11 415V PCC/MCC/AC emergency MCC shall be rated for 50kA for 1sec. AC lighting distribution boards shall be rated for 10kA for 1 sec. DCDB shall be suitably sized for DC system fault current for one (1) sec. duration.

4.1.12 All PCCs and Emergency MCC shall be provided with air circuit breakers (ACBs) / Molded case circuit breakers (MCCBs) of suitable ratings.

4.1.13 All MCCs shall have two bus sections with two 100% rated incomers and bus coupler. All incomers, bus couplers and outgoing feeders of MCCs above 400A rating shall be ACB controlled. Fuse switch units shall be provided for 400A rating and below.

4.1.14 All AC motors shall be suitable for direct on line (DOL) starting. Motor feeders rated 90 kW and above shall be ACB controlled and connected to PCC. Motors less than 90 kW shall be provided with switch fuse, contactor and overload relay with SPPR protection.

4.1.15 The PCC/MCC incomer shall be provided with digital ammeter and voltmeter and power supply indicating lamps (R, Y, B). Motor feeders shall be provided with three indicating lamps for ON,OFF&TRIP and push buttons for START(in Test position), STOP and RESET. In MCC, motor feeders for essential auxiliaries shall have contactors with delayed drop out feature adjustable upto 3s and necessary auto restart facility.

4.1.16 20% spare feeders with minimum one each of each rating shall be provided on all PCCs, MCCs and distribution boards.

4.1.17 Redundant 110V DC control supply (from two different sources) with auto changeover facility shall be provided for breakers, numerical relays etc.

4.1.18 Breaker spring charging motor shall be suitable for 110 V DC.

4.1.19 All LT switchgears shall be of same make. All panels in every room shall have same height.

4.2.0 **Control Requirements**

4.2.1 All PCC /Emergency MCC breakers shall be controlled from SAS/DCS.

4.2.2 All interlocks shall be hardwired in the switchboard itself.

4.2.3 Local / Remote selector switch shall be provided in switchboard. Remote selection shall enable starting from DCS / SAS.

4.2.4 For all DCS operated feeders, interposing relays shall be provided in respective switchboard to receive start/stop command from DCS.

4.2.5 Only test closing shall be possible from switchgear.

4.2.6 Breaker signals, protection relay operated condition etc. shall be transmitted to remote in addition to local indication.

4.3.0 **Construction**

4.3.1 The PCC / MCC / DB shall be self-standing, floor mounted, compartmentalized, made of minimum 2 mm CRCA thick sheet steel cubicle with metal / insulating partitions between compartments. The thickness of doors / covers shall not be less than 1.6 mm.

4.3.2 The PCC and MCC shall be fully draw out type with self-aligning multifinger silver plated contacts for power termination. Similar modules of breakers shall be interchangeable. Other distribution boards shall be fixed type.

4.3.3 The enclosure shall conform to IP-52 degree of protection for the switchgears inside the switchgear rooms. The enclosure shall be IP54 for the switchgears located other than switchgear rooms but inside a building.

4.3.4 The operating height of the operating handle/switches shall be limited to a maximum of 1800 mm and a minimum of 300 mm.

4.3.5 PCC shall be of single front type. DB may be double / single front fixed type. MCC may be of double front type. The panels shall be extendible at both ends for the additions of vertical sections either by a breaker panel or a fuse switch panel. Ends of the bus bars shall be suitably drilled for this purpose. Cable termination to PCC/MCC shall be from bottom whereas bus duct termination shall be from top.

4.3.6 The individual module shall have rolled edges with neoprene rubber gaskets to form a dust proof structure. The doors shall have concealed hinges and shall be interlocked with the main switch operating handle so that it cannot be opened when the switch is `ON'. A feature for defeating the interlock shall also be provided for maintenance purpose.

4.3.7 The moving portion of the switchgear shall have locking arrangement in all the three positions, namely, SERVICE / TEST / ISOLATED. Arrangement for covering the power and control contacts with a shutter shall be provided when the moving carriage is withdrawn from the switchgear.

4.3.8 The MCC/DB modules shall be arranged in vertical sections with barriers between each module. The bus chamber as well as the breaker cubicles shall have inter panel fire barrier. A liberally sized vertical cable alley shall be provided to accommodate all cables.

4.3.9 All switches, indicating lamps, protective relays and indicating instruments shall be flush mounted on the respective module compartments and other auxiliary devices of the switchgear may be mounted inside the module.

4.3.10 It shall be possible to earth the enclosure at two places and suitable size of studs shall be provided.

4.3.11 Terminal blocks shall be provided at the side of the modules for cable terminations. The lowermost terminal block shall have minimum clearance of 200 mm from the bottom plate. The minimum clearance between adjacent rows of terminal blocks shall be minimum 100 mm.

4.3.12 The panels shall be rigid, vibration proof and free from bends and twists. Panel door and side doors shall have Allen head lock.

4.3.13 All boards shall be provided with removable gland plates.

4.3.14 Suitable lifting hooks shall be provided on each transportable section for ease of lifting of switchboard.

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4.4.0 **Air Circuit Breakers**

4.4.1 Circuit breakers shall be fully drawout, indoor, metal clad, air break and trip free type. Breakers of similar rating and duty shall be interchangeable both electrically and physically and shall be suitable for the corresponding duty. All the incoming and bus coupler breakers shall be 4 pole type.

4.4.2 Circuit breakers shall be provided with motor operated spring charged stored energy closing mechanism. Manual spring charging and closing mechanism shall also be provided. One open-close-open operation of the circuit breaker shall be possible after failure of power supply to the motor. Shunt trip coil shall also be provided.

4.4.3 The breaker shall have the following positions with positive indication for each of them:

| | | |
|---|---|---|
| Service position | : | Both power and control circuits are connected. |
| Test position | : | Power circuit is disconnected and the control circuit is connected. |
| Disconnected position | : | Power and control circuits disconnected. |

4.4.4 The earth connection must remain connected in "Test" position. The earth connection shall make before the main power/control contacts make and break after the main power/control contacts break. The breaker shall be suitable for operation from both remote as well as local while under "service" position. In "test" position the breaker shall be operated only from local.

4.4.5 Anti-pumping feature shall be provided to prevent automatic reclosure of the breaker, after tripping, in the event of sustained fault. The breaker shall not close unless the spring is fully charged.

4.4.6 Indicating lamps shall be of LED type. The red lamp shall indicate the breaker closed position, green lamp shall indicate breaker open position and amber lamp shall indicate breaker tripped condition in service position.

4.4.7 Telescopic trolley shall be provided for maintenance of circuit breaker module.

4.5.0 **Bus Bars**

4.5.1 The busbars shall be of high conductivity electrolytic Aluminium, liberally sized for continuous as well as short circuit current ratings and shall conform to relevant standards. The continuous current rating of the busbars shall be the same as that of the incoming feeder rating and shall carry this continuous current without exceeding the temperature of 90°C considering an ambient of 50°C.

4.5.2 The busbars shall be designed to carry a short circuit current 50 kA for 1 sec (minimum).

4.5.3 Three phase and neutral busbars shall be provided and a separate bus for earthing shall be provided.

4.5.4 Buses shall be spaced with adequate clearance of at least 25 mm.

4.5.5 The main horizontal busbars shall be placed in a separate enclosure at the top. Vertical busbars shall be used for connection to individual sections of the panels, fully shrouded with removable partitions. The busbar rating shall be same as that of the corresponding breaker and shall not be decided on the basis of CT ratios.

4.5.6 The main busbar supports shall be arc resistant, flame retardant and moulded from thermosetting FRP located at uniform intervals providing adequate support for the busbars and droppers.

4.5.7 Auxiliary supply busbars shall run horizontally in a separate enclosure within the power busbar compartment with necessary tee-off connectors for distributing auxiliary supply to each vertical panel. Rubber grommets shall be used for all wire entries to make the entries dust and vermin-proof.

4.6.0 **Instrument Transformers & Control Transformers**

4.6.1 The current and voltage transformers shall be cast resin insulated type, with primary and secondary terminals marked indelibly. Facility shall be provided for short circuiting and grounding each CT secondary. The CTs shall be capable of withstanding the peak momentary short circuit and the symmetrical short circuit current. The neutral side of the CT shall normally be earthed through a link. CT secondary shall be rated for 1A. Voltage transformers shall have fuses on both primary and secondary. For PCC, bus voltage transformer shall be provided housed in a separate compartment. Secondary of voltage transformer shall be rated for 110 V AC.

4.6.2 The control transformers shall be dry type with class F insulation with class B temperature rise. The transformer shall be complete with switch and fuse/MCBs. One control transformer shall be provided in each MCC module to provide control supply to respective feeders.

4.7.0 **Switches, Fuses, Contactors & Thermal Overload Relay**

4.7.1 The switches shall be TP/TPN heavy duty, air break mechanism operated by a suitable external handle with position indicator.

4.7.2 The live terminals shall be shrouded to avoid accidental contact. Combined fuse-switch of double-break type may be offered wherever practicable. Switches for motor circuits shall be of AC 23 category and of other circuits shall be of AC 22 category.

4.7.3 The fuses shall be of HRC link type with a breaking capacity of 80 kA. Visual indication shall be provided to indicate fuse failure. The motor fuse rating and characteristics shall be suitably chosen so that they do not operate during the starting period of the motor.

4.7.4 The main motor contactors shall be direct-on-line, air break triple pole AC3 duty for AC motors with minimum 2 NC and 2 NO auxiliary contacts. Reversing contactors shall have AC4 duty and shall be electrically and mechanically interlocked. DC contactors shall have minimum DC2 duty.

4.7.5 For motor feeders type II co-ordination shall be provided for switch fuse unit, contactor and overload relay.

4.7.6 Thermal over load relays shall be three element, ambient temperature compensated, time lagged, bimetal type. Each overload relay shall be provided with a built-in single phasing preventor. The relays shall be manually reset type with one changeover contact. Resetting of the relays shall be possible with the compartment door closed, with the resetting knob at the front.

4.8.0 **Protection Relay**

4.8.1 All relays excluding auxiliary relays shall be numerical microprocessor based only with IEC 61850 communications Protocol. They shall have facilities for communication with DCS / SAS system. All hardware/software required for interfacing with the DCS / SAS system shall be supplied. In addition, they shall have communication ports RS232 for direct access of data through laptop.

4.8.2 The relays shall be flush mounted on the front of the individual draw out module units. Indicating devices shall be so located that it can be seen when the relay has operated, without opening the door. The power supply for the protection relays shall be supplied from the two different (Redundant supply) 110V DC system.

4.8.3 The following protection as a minimum shall be provided for breaker operated feeders.

- 50 - Short circuit protection.
- 49 - Thermal over load
- 50N - Instantaneous earth fault
- 51 - IDMT overcurrent protection
- 51N - IDMT back-up earth fault protection. (Only for transformer incomers)
- 64R - Restricted earth fault protection (only for transformer incomers).
- 27 - Under voltage protection
- 94 - Electrical anti pumping feature
- 86 - Hand reset high speed lockout relay
- 74 - Trip circuit supervision relay
- 68 - VT supervision/ fuse fail

4.8.4 For breaker operated motor feeders, microprocessor based motor protection relay having comprehensive motor protection features described under MV motor protection shall be provided.

4.8.5 Required auxiliary relays/contactors/timers shall be provided for interlocking and multiplying contacts. Electrically set/reset relay shall be used for multiplying breaker auxiliary contacts wherever contacts are used for interlocking purposes.

4.8.6 Tripping relays shall be lock out with hand reset contacts and shall be suitable to operate at the DC voltage. These relays shall have self-coil-cut-off contacts and shall be provided with hand reset operation indicators.

4.8.7 Each switchgear shall be provided with one DC fail relay and DC fail indicating lamp for each DC incomer. Further, a common DC failure alarm contact shall be wired up for remote annunciation.

4.9.0 **Measuring Instruments**

4.9.1 All the measuring instruments shall be digital multifunction type with energy meters and shall be provided with suitable port for remote hook up to SAS / DCS.

4.9.2 All indicating instruments shall be provided with zero adjuster, accessible from the front.

4.9.3 Necessary current/voltage signals shall be routed to DCS in addition to local indications.

4.9.4 Ammeters shall be provided for all motors rated 15 kW and above and also for other important motors that are specifically required. Provision for remote and local ammeter shall also be given in the PCC / MCC panel. The ammeters in the motor feeders shall be CT operated having a spread out scale in the working range and compressed scale beyond the working range to read the starting current of 6-14 times the rated current of the circuit. A red mark at the rated current shall also be provided in the scale.

4.10.0 **Indicating Lamps**

Low wattage, LED cluster type indicating lamps shall be provided with the lamp assembly complete with holder and suitably coloured lens and a nameplate showing its function. Provision for connecting remote indicating lamps shall also be provided in the panel.

4.11.0 **Control Switch / Selector Switch**

Breaker control switches shall have Neutral-Close-Trip positions. Voltmeters and ammeters in the incomers / feeders shall be provided with a selector switch. The control and selector switches shall be rotary, back connected type having a cam operated contact mechanism.

4.12.0 **Starter Panels**

The starting resistors for the DC motors shall be enclosed in metal clad naturally ventilated self-standing panel (s) with sheet steel material of minimum 2.0 mm thick with degree of protection IP-33. It shall be dust and vermin- proof. The number of resistance steps shall be decided by the Bidder depending on application. The resistor elements shall be made of unbreakable, corrosion proof, joint less stainless steel grids or ferro-chrome aluminium alloy. The grids shall be in punched form and suitable for use in tropical climate.

4.13.0 **Local Push Button Station**

Required number of local push button station shall be supplied completely wired upto terminal block located inside. Enclosure shall have a degree of protection of IP - 55 for outdoor & IP 54 for indoor. The enclosure shall have cover/hinged door. Outdoor stations shall be provided with canopy. Push button station shall accommodate push buttons/terminal blocks as per system requirement.

4.14.0 **Other Auxiliaries**

All panels shall be provided with space heaters with thermostat and switch suitable for operating at 240V, 1 phase 50 Hz. AC. Motors rated 30 kW and above will be provided with motor contactor controlled space heaters, so that the space heaters are 'ON' only when the motor is 'OFF".

Cubicle lamp with door switch suitable for operating at 240V, 1 phase, 50 Hz. AC and 5/15A plug socket with switch and fuse shall also be provided for each panel.

4.15.0 **Cabling and Wiring**

4.15.1 Ample space for connection of cables shall be provided such that cable cores are not in contact with any metal part of the switchgear. All internal power connections shall be of copper.

4.15.2 The control wiring shall be done with 1100V grade, PVC insulated, stranded copper conductors of minimum 2.5 mm² size for CT circuits and 1.5 $mm^2$ for other circuits. The control wiring shall be terminated in terminal blocks on the side of each module. Each control cable shall be identified at either side by interlocking type PVC ferrules.

4.15.3 Power and control terminals shall be stud type, complete with crimping type connectors. Screw type terminals with screws directly impinging on conductors are not acceptable. Terminals for CTs shall be disconnecting type.

4.15.4 All spare contacts of relays and switches shall be wired up to the terminal board. At least 10% spare terminals shall be provided in each module.

4.16.0 **Earthing Connections**

All cubicles shall be connected to a copper earth busbar running throughout the length of the switchgear. All doors and movable parts shall be connected to the earth bus with flexible copper connections. Provisions shall be made to connect the earthing busbar to the plant earthing grids at two ends. All non-current carrying metallic parts of the mounted equipment shall be earthed.

4.17.0 **Name Plate**

A nameplate with the switchgear tag no. shall be fixed at the top of the central panel. A separate nameplate giving feeder details shall be fixed for each compartment also.

Nameplate shall be provided for each equipment /component and for each feeder mounted over each panel. Special warning labels shall also be provided wherever necessary inside or outside the switchboard.

Engraved nameplates shall preferably be of 3 ply (Black-White-Black) lamicoid sheets of anodised aluminium. Back engraved perspex sheet shall also be acceptable. Name plates shall be fastened by screws and not adhesives.

**5.0.0 TESTS**

All tests shall be conducted as per relevant IS/IEC/IEEE standards and shall be performed in the presence of Owner/Owner's representative, if so desired by the Owner/Owner's representative. All equipments shall be type tested as per the relevant standards. If relevant type test reports are not available the same shall be conducted without any cost implications.

**6.0.0 PAINTING**

Equipment shall be finished with two (2) under coats of high quality epoxy based primer followed by two coats of epoxy painting. Painting shall be carried out by approved process.

## 7.0.0 SPECIFIED TECHNICAL DATA

| Sr. No. | Description | Unit | Data |
|---|---|---|---|
| **1.0** | **General** | | |
| 1.1 | Rated service Voltage | V | 415 V ± 10% |
| 1.2 | Rated Current | A | As required with necessary margin |
| 1.3 | Rated frequency | Hz | 50 +5% -5% |
| 1.4 | System Earthing | - | Solidly grounded |
| 1.5 | Design ambient temperature | °C | 50°C |
| 1.6 | Enclosure protection | - | IP-52/IP 54 as specified |
| 1.7 | No. of poles | - | 4 Poles for all the incomer breakers and load breakers, The motor feeders breakers are of 3 pole. |
| **2.0** | **Bus Bar** | | |
| 2.1 | Material | - | Aluminium |
| 2.2 | Temperature (absolute) considering an ambient of 50°C | °C | 90° |
| 2.3 | Short circuit withstand capacity for 1 Sec | kA | 50 (rms) |
| 2.4 | Momentary short circuit current capacity | KA Peak | 110 |
| **3.0** | **CIRCUIT BREAKER** | | |
| 3.1 | Type | - | Air break |
| 3.2 | Rated short-time withstand current for 1 sec. | kA | 50 (rms) |
| 3.3 | Duty cycle | - | O-3 min-CO-3 min-CO |
| 3.4 | Operating mechanism | | |
| | - Closing | - | Stored energy type motor wound spring operated. |
| | - Opening | - | Shunt trip coil |
| | - Latching arrangement | - | Mechanically and electrically trip free. |
| 3.5 | Auxiliary voltage | | |
| | - Closing / Tripping / Spring charging Motor | V | 110 V DC |

| Sr. No. | Description | Unit | Data |
|---|---|---|---|
| | - Space heater and lamp | V | 240V ± 10%, AC to be derived from PCC/MCC. |
| 3.6 | Anti-pumping feature | - | Electrical type |
| 4.0 | Switch type | | AC 22/ AC 23 |
| 5.0 | Fuses | - | HRC, Link |
| 6.0 | AC Contactors | | AC3 / AC 4 |
| 7.0 | DC Contactors | | |
| | Number of poles | - | 2 |
| | System earthing | - | Ungrounded |
| | Utilization category | - | DC2 for shunt motors |
| 8.0 | Thermal Overload Relays | | Ambient temperature compensated bimetal type and hand reset type |
| | Single phasing protection | - | To be provided, (built-in unit of Thermal overload relays). |
| **9.0** | **Current Transformers** | | |
| 9.1 | Service/Type | - | Indoor/Cast Resin |
| 9.2 | Accuracy class | | |
| | Metering | | Cl.1.0 and 0.2s for incomer. |
| | Protection | | Cl.PS for differential protection & 5P20 for other protection. |
| 9.3 | Rated short-time withstand current for 1 sec. | kA | 50 (rms) |
| **10.0** | **Voltage Transformers** | | |
| 10.1 | Service/Type | - | Indoor/Cast Resin |
| 10.2 | Accuracy class | | |
| | Metering | | Cl.1.0 and 0.2 for incomer and tie feeder. |
| | Protection | | Cl.3P protection |
| 10.3 | Over voltage with stand capacity | | As per IS 3156 |

# VOLUME - III

# SECTION - 3

# DETAILED TECHNICAL SPECIFICATION - ELECTRICL

# SUB-SECTION - 3.9

# DC SYSTEM

**VOLUME - III**

**SUB-SECTION - 3.9**

**DC SYSTEM**

## 1.0.0 GENERAL

This specification covers the design, manufacture, supply, erection, testing & commissioning of complete DC system required.

It is not the intent to specify completely herein all details of the equipment, nevertheless, the equipment shall be complete and operative in all respects and shall conform to the highest standard of engineering, design and workmanship.

## 2.0.0 SCOPE OF WORK

The scope of work shall include but not limited to the following.

- **Batteries**
  - Two sets of 110V Ni-cd batteries ( 2x100%) for Power plant DC loads.
  - Two sets of 110V Ni-cd batteries ( 2x100%) for 66kV GIS loads.
  - Two sets of Ni-cd batteries (2x100%) for GTG & its auxiliaries (as per GTG Manufacturers recommendation).
- **Chargers**
  - 2x100% Float Cum Boost Charger (FCBC) & 110V DCDB for Power plant DC loads.
  - 2x100% Float Cum Boost Changer (FCBC) & 110V DCDB for 66kV GIS loads.
  - 2x100% Float Cum Boost Changer (FCBC) & DCDB for GTG & its auxiliaries (as per GTG Manufacturers recommendation).
- Complete set of accessories for the above batteries & chargers.
- List and supply of special maintenance tools and tackles as required.
- Mandatory spares as listed in Vol. II / Section-1.0 and recommended spares for two (2) years trouble free operation.

## 3.0.0 CODES & STANDARDS

IEEE: 1115 : Practice for sizing Ni-Cad batteries for stationary applications.

IEEE: 485 : Practice for sizing Large lead storage batteries for Generating Stations & Sub-stations.

IS: 10918 : Specification for vented type Nickel Cadmium batteries.

The Batteries, Chargers and other equipment / components shall conform to the other latest relevant IEC/IS standards as amended up to date.

## 4.0.0 TECHNCIAL REQUIREMENTS

### 4.1.0 Batteries

4.1.1 Batteries for the entire plant shall be Ni-cd type. Each battery shall be rated for 100% load with 15% design margin 110V DC Batteries shall be sized to meet the load duty cycle requirement as below.

4.1.2 The battery shall be sized for 2 hours back up in case of normal and emergency AC power failure. The batteries shall be sized for the required load taking into account approximate temperature correction, design margin and again compensation factors.

- Momentary loads for 1 minute. (Closing/tripping of breakers, starting of emergency loads etc.).
- Emergency loads for 2 hours. (Emergency DC drives, emergency lighting, etc.).
- Continuous loads for 2 hours. (Indication lamps, Annunciation, aux relays, etc.).

4.1.3 The battery shall be designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuation of load.

4.1.4 The Battery shall normally be permanently connected to the load in parallel with a charger and shall supply the load during emergency conditions when AC supply is lost. Batteries shall be suitable for a long life under continuous float operations and occasional discharges.

4.1.5 DC system shall operate as ungrounded system.

4.1.6 The maximum voltage variation allowed at the load end shall be + 10% to -15% at all operating conditions for 110V DC system.

4.1.7 The battery shall be sized in accordance with the IEEE 485-1983 considering temperature correction factor, contingency and ageing factors. Battery shall be suitable for being boost charged to fully charged condition from fully discharged condition within 8 hours.

4.1.8 Battery end voltage of cell shall be not less than 1.14V.

4.1.9 Nickel coated copper connectors shall be used for connecting up adjacent cells and rows. Bolts, nuts and washers shall be effectively Nickel coated to prevent corrosion.

4.1.10 All the terminals and cells interconnectors shall be fully insulated or have insulation shrouds. All connectors and lugs shall be capable of continuously carrying the 2 hours discharge current of the respective batteries and through fault short circuit current which the battery can produce and withstand for the period declared. Contractor shall furnish necessary sizing calculations to prove compliance to the same.

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4.1.11 The cells shall be supported on porcelain insulator fixed on to the rack with adequate clearance between adjacent cells considering the buldge allowed for two cells in accordance with IS:1146.

4.1.12 Containers shall be made of polypropylene plastic material. Electrolyte level lines shall be marked on container in case of transflucent containers.

4.1.13 Vent plugs shall be provided in each cells. They shall be anti-splash type, having more than one exit hole shall allow the gases to escape freely but shall prevent alkali from coming out. The design shall be such that the water loss due to evaporation is kept to minimum. In addition the ventilator shall be easily removed for topping up the cells and of such dimensions that the syringe type hydrometer can be inserted into the vent to take electrolyte samples.

4.1.14 The battery racks shall be constructed of MS. These battery racks shall be painted by the bidder with three coats of acid/ alkali resistance paint of approved make. The racks are single tier / two tier construction depending on the final layout based on space availability.

4.1.15 110V DCDB shall consist of two bus sections and a bus coupler. Each bus section shall have one incomer which receives 110VDC from the respective chargers. Incomers & bus coupler shall be contactor operated type. DCDB shall generally comply with the requirements specified in LT Switchgear section.

**4.2.0 Battery Charger**

4.2.1 The float cum boost charger shall be suitable for float charging as well as boost charging the battery. Each float cum boost charger shall be redundant to the other. Each battery charger shall be capable of float charging the battery while supplying the station normal DC load. The design shall be such that, in case the load exceeds the charger capacity, the excess load current shall be supplied by the battery.

4.2.2 During float charging of batteries the chargers shall feed the respective bus sections of DCDB. In case of one charger failure, the other charger shall feed both the bus section of DCDB and as well as float charge the batteries. On failure of station A.C. supply both float cum boost chargers will go out of service and battery will take over to supply station emergency loads automatically. It shall be possible that one charger can float charge both the batteries while supplying the station DC loads.

4.2.3 Interlock shall be provided such that when boost charger is selected in boost mode, the battery is boost charged and also supplying load current at 96% tap cell connection.

4.2.4 The battery charger shall be of solid state using silicon rectifiers with full wave, fully controlled bridge configuration and complete with automatic voltage regulator, current limiting circuitry, surge suppression network, smoothing filter circuits and soft-start feature.

4.2.5 The battery charger shall be suitable for 415V ± 10%, 3 phase, 50Hz +5%, -5% incoming supply and at least one charger per module shall be fed from Emergency section of PCC. The voltage regulation shall be within ± 1% for a 0-100% load variation and 10% combined input AC voltage and frequency variation on the AC side. The charger shall be provided with 2 x 100% capacity cooling fans.

4.2.6 The ripple content in charger output shall not exceed 1% (rms) without the battery in circuit.

4.2.7 The charger shall be self-protecting against all AC and DC transients and steady state abnormal currents and voltages.

4.2.8 The charger panel shall be mounted on anti-vibration pad.

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4.2.9 The battery charger shall be equipped with, but not limited to the following.

- Silicon type, rectifier circuits
- Dry type, double wound with copper conductor rectifier transformers with class F insulation with Class B temperature rise.
- Fully rated blocking diode with redundancy, for reliability, so that failure of one diode will not affect the system.
- Air break type incoming AC contactor with thermal overload relays
- Heavy duty, load-break type incoming isolating switches operated by a handle with padlocking facility in ON and OFF position.
- HRC and fast acting semi conducting fuses for float cum boost charger.
- LED type indicating lamps.
- Manual / Auto control for selection of float and boost charger.
- Voltage setters for setting the output of float/ boost charger independently.
- Current limit setters
- Alarm acknowledge, reset and test button
- Solid state surge protectors on both AC & DC side.
- DC earth fault and under voltage protection

4.2.10 Individual indicating meters with 96 sq.mm size, 240° scale, ± 1.5% accuracy and zero adjuster shall be provided on the front to read

- AC incoming voltage.
- DC output voltage of float cum boost charger.
- DC output current of float cum boost charger.
- DC charge/discharge current of battery.
- DC load voltage.
- DC load current.
- DC leakage current

4.2.11 In addition to above, metering provision shall be given for remote metering / recording at DCS.

- Battery Voltage low, high and normal
- DC voltage of float & Boost charger
- DC current of float & Boost charger

4.2.12 Each charger shall incorporate, but not limited to the following annunciations.

- SCR fuse failure.
- Filter capacitor fuse failure
- Charger overload
- Charger fail/trip
- DC output fuse failure
- Positive grounded
- Negative grounded
- AC input supply of float cum boost charger failure
- Battery fully discharged
- AC input supply failure
- AC input under voltage
- DC voltage low
- DC voltage high
- DC system earth fault

4.2.13 Necessary annunciations shall be taken to DCS. In case of switchyard DC system the required annunciation and metering shall be hooked up to SAS.

4.2.14 The annunciation system shall have audio-visual arrangement and shall incorporate acknowledge, reset and test push buttons. On occurrence of fault, the corresponding window lights up and stays in lighted condition until the fault is cleared and the reset push button is pressed. At least 20% spare annunciation windows with accessories shall be provided.

4.2.15 The panel shall be of sheet metal, enclosed, dust and vermin proof, confirming to IP 42 degree of protection. Battery charger shall be located in Air conditioned room.

**5.0.0 TESTS**

5.1.0 All routine & acceptance tests shall be conducted on the batteries, its chargers & all DCDBs as per applicable IS/IEC/IEEE standards. Batteries & chargers shall be of type tested as per relevant standards. If relevant type test reports are not available the same shall be conducted without any cost implications. Acceptance tests shall be performed in the presence of Owner/Owner's representative.

5.2.0 The acceptance tests shall also include all functional tests, HV test & IR test as a minimum.

**6.0.0 PAINTING**

Battery charger panel shall be finished with two (2) under coats of high quality epoxy based primer followed by two coats of epoxy painting. Painting shall be carried out by approved process. The batteries racks and other support structures in the battery room shall be coated with three (3) coats of anti-alkali paint of approved shade.

**7.0.0 SPECIFIED TECHNICAL DATA**

| Sr. No. | Description | Unit | Data |
|---|---|---|---|
| **A** | **Battery**<br>**Ni-cd** | | |
| 1.0 | Rated Voltage | V | 110V DC |
| 2.0 | Nominal system voltage | V | 110V, -15% to +10% |
| 4.0 | Total Load cycle duration | | 2 Hours |
| 5.0 | End Cell Voltage | V | 1.14V |
| 6.0 | Rated (Nominal) cell voltage | Volts/cell | 1.2 |
| 7.0 | Float charging (normal) | V/Cell | 1.42 |
| 8.0 | Boost charging (after complete discharge) | V/Cell | 1.54 to 1.7 |
| 9.0 | Mounting | - | MS racks |

| Sr. No. | Description | Unit | Data |
|---|---|---|---|
| 10.0 | Type | - | Ni -Cd |
| B | **Battery Charger (Float Cum Boost Mode)** | | |
| | Charger | | 2 x 100% FCBC |
| 1.0 | Type | - | Static SCR type full wave fully controlled sheet steel enclosure |
| 2.0 | Enclosure protection | | IP-42. |
| 3.0 | Input power supply | | |
| | - Voltage | V | 415 ±10%, 3 phase, 4 wire |
| | - Frequency | Hz | 50HZ +5% -5% |
| | - Combined frequency and voltage variation | % | 10% (absolute sum) |
| 4.0 | DC Output : | | |
| | - Float Charger | - | Continuous station DC loads + Float charging of battery. |
| | - Boost charger | - | Restoring fully discharged battery to fully charged condition in 8 hours. |
| 5.0 | Charger location | | Air-conditioned room |
| 6.0 | Permissible ripple content at rated continuous load | % | 1 (Max) |
| 7.0 | Voltage stabilisation for constant voltage regulator | | +1% of set DC voltage for + 10% voltage and +5% frequency variation in power supply<br>+ 5% during transients |
| 8.0 | DC current adjustment for boost charging | | 30% to 100% of maximum boost charging current |

# VOLUME- III

# SECTION - 3

# DETAILED TECHNICAL SPECIFICATION - ELECTRICAL

# SUB-SECTION - 3.10

# UPS SYSTEM

**VOLUME - III**

**SUB-SECTION - 3.10**

**UPS SYSTEM**

## 1.0.0 GENERAL

This specification covers the design, manufacture, supply, erection, testing and commissioning complete UPS System required at various areas of power plant.

It is not the intent to specify completely herein all details of the equipment, nevertheless, the equipment shall be complete and operative in all respects and shall conform to the highest standard of engineering, design and workmanship.

## 2.0.0 SCOPE OF WORK

The scope of work shall include one but not limited to the following:

- 2 x 100%, parallel redundant, 110 V AC single phase, 50 Hz UPS system, complete with float cum boost chargers, bypass stabilized supply and all other accessories
- 2x100% Ni-cad battery with MS racks, 2x100% Charger, 2x100% Inverter with racks and necessary accessories.
- UPS distribution panels/boards
- All necessary base frames, channels and erection hard wares.
- Mandatory spares as listed in Vol. II / Section-1.0. and recommended spares for two (2) years trouble free operation.

Any UPS requirement for Balance of Plant (BOP) equipments shall be fed from the above UPS.

## 3.0.0 CODES & STANDARDS

The UPS system and components shall conform to IEC 62040 & other relevant IEC/IS Standards amended up to date.

## 4.0.0 TECHNICAL REQUIREMENT

4.1.0 The UPS system shall have adequate capacity to supply clean power to the instrumentation control system & plant Communication system for a period of 2 hours in case of mains power failure. Voltage variation shall be limited to ± 1% and frequency variation to ± 2%.

4.2.0 UPS system shall comprise of 2 sets static type redundant converter-cum-chargers and Inverters, each capable of supplying 100% load with 15% design margin, connected in parallel, two Battery Banks with support time of two hours and an output AC Power distribution board.

4.3.0 UPS shall also consist of one by-pass regulating transformer along with surge suppression equipment, static switches, servo controlled voltage stabilizer, manual bypass arrangement and other power devices to supply power at constant output voltage in case of failure of both inverter system.

4.4.0 The transformers shall be of dry type copper wound with Class F insulation with Class-B temperature rise.

4.5.0 In the event of mains supply failure the floating battery bank shall be connected to the DC input of each inverter and maintain continuity of AC Power output without interruption, through inverters.

4.6.0 On failure of one set of Converter & Inverter, the other set will take-over the 100% load automatically without any interruption. On failure of both the sets, SCVS will take over the power supply distribution and will supply the power. The changeover from inverter to by-pass transformer shall not be more than 5 ms.

4.7.0 UPS may be provided with forced air cooling system as required. Fan cooling, if envisaged, shall be achieved with 2 x 100% cooling banks. In case of failure of running bank / one fan, the standby bank shall start automatically.

4.8.0 Battery charger shall be of automatic type having provision for boost and float charging of battery bank. However, provision shall be made for manual charging of battery banks, if required.

4.9.0 Inverter of UPS system shall synthesise AC wave form through pulse width modulation with at least 12 pulses/ half cycle to take care of the dynamic conditions (like switching on and off of the connected electrical loads).

4.10.0 The output frequency shall be controlled by a quartz crystal oscillator.

4.11.0 The UPS shall have an over load capacity of 125 % rated capacity for 10 minutes and 150 % rated capacity for 10 sec. The inverter shall have sufficient $I^2t$ capability to clear fault in the maximum rated branch circuit. The sizing of UPS shall be based on the power factor of the loads being fed subject to a maximum of 0.8.

4.12.0 The UPS shall be protected from over voltage, under voltage, overload and short circuits.

4.13.0 UPS shall be provided as shown in the enclosed key single line diagram Drg.No 00-5111168-E-201.

4.14.0 The UPS shall be tropicalised and shall have microprocessor based self-diagnostic feature.

4.15.0 24V DC required for Control & instrumentation shall be derived from UPS supply through converters.

4.16.0 The UPS shall have following alarm/status indications as a minimum:

- System normal (Green)
- AC input failure (phase wise)
- Battery discharge
- Low battery voltage
- Inverter failure (phase wise)
- Charger failure
- Over temperature
- Overload trip
- AC input over voltage
- AC input under voltage
- Static switch failure
- Stand-by on
- Fan failure
- Oscillator failure

4.17.0 The UPS shall have facilities for remote indication of the essential alarms and remote metering.

4.18.0 The design shall provide for high availability of equipment by ensuring high mean - time - between failures (MTBF) and low mean-time-to-repair (MTTR).

4.19.0 The storage battery shall be Ni-cd type and shall be kept in Non-Air-conditioned room .The battery storage unit shall be complete with all accessories and shall have adequate capacity so as to provide the rated DC current to the inverter unit for a period of two hours in case of mains failure. The recharging time of the unit shall not be more than 10Hours.

4.20.0 The overall efficiency of UPS system shall not be less than 90%.

4.21.0 The AC distribution board shall have switch fuse feeders. 20% spare feeders of each rating and each type with minimum one (1) feeder shall be provided. The output from UPS shall be taken to loads in redundant feeders with changeover arrangement at receiving panel.

4.22.0 All other requirements such as panels, distribution boards, painting and other auxiliaries shall be as per the specifications given in LT Switchgears. The degree of protection for cubicles shall be IP 42 and the UPS shall be located in air conditioned atmosphere.

4.23.0 Input voltage to UPS shall be from 3 different, 3 phase 3 wire source. Two supplies shall be normal supplies fed from essential switchboard bus section-A & B. In case of failure of both inverters, static transfer switch shall changeover within five (5) milliseconds to connect the alternate AC source to the load. UPS shall suitable for the voltage variation ±10% & frequency variation +5% to –5%.

4.24.0 Contractor shall furnish DBR (Design basis report). GTP (General technical Particulars) and sizing calculation of batteries /convectors/chargers for Owner/Owner's representative's review and approval.

**5.0.0 TESTS**

5.1.0 All routine tests covered under IEC-62040-3 shall be conducted on the UPS system in addition to the functional tests in presence of Owner/Owner's representative.

5.2.0 UPS and it's accessories shall be of type tested and proven type. If relevant type test certificates are not available the same shall be conducted without any cost implications.

5.3.0 All tests specified in battery section are applicable for UPS batteries also.

**6.0.0 PAINTING**

Equipment shall be finished with two (2) under coats of high quality epoxy based primer followed by two coats of epoxy painting. Painting shall be carried out by approved process.

## 7.0.0 SPECIFIED TECHNCIAL DATA

| Description | Unit | Data |
|---|---|---|
| **UPS system** | | 2X100 % ( HOT BACK UP ) + 100 % SCVS (bypass) |
| **Batteries** | | |
| Type | - | Ni-cd |
| Type of operation | - | Standby, parallel |
| Rated capacity | Ah | In accordance with the requirement for 100% load with 15% design margin for two hours. |
| **Charger** | | |
| Type | - | 2 sets of Static type full wave fully controlled |
| Input voltage | V | 415 ±10%, Three phase |
| Input frequency | Hz | 50 +5% -5% |
| Residual ripple | % | Limited to ±5% on resistive load |
| **Inverters** | | |
| Type | - | PWM technique |
| AC output voltage | V | 110 V, 1 Ph |
| Output voltage variation | % | ± 1%/To suit system requirement |
| Output frequency | Hz | 50 |
| Output frequency tolerance | % | ±2% To suit system requirement |
| Wave form | - | Sinusoidal |
| Mode of operation | - | Parallel with other inverter in synchronised mode |
| Frequency range for phase lock with alternate source | % | ± 3% |
| Correction time for voltage when 50% load change | m s | 50 |

| Description | Unit | Data |
|---|---|---|
| **Alternate Source** | | |
| Input | V | 400 ±10%, three phase |
| Frequency | Hz | 50 +5% -5% |
| Change over | - | By static transfer switch |
| Change over time when both invertors failed | ms | 5 (Max.) |
| Output : | | |
| Through | - | Servo controlled Voltage Stabilizer |
| Voltage | V | 110 V ,1Ph AC +-1% |
| Frequency | Hz | 50 ±2% |
| Type | - | Make before break |
| Radio interference suppression | - | In accordance with IEC |
| **Panels / Cubicles** | | |
| Degree of protection | - | IP 42, suitable for air conditioned atmosphere |
| Short circuit level | - | To match with the system fault level. |

# VOLUME - III

# SECTION - 3

# DETAILED TECHNICAL SPECIFICATION - ELECTRICAL

# SUB-SECTION - 3.11

# ELECTRIC MOTORS AND ACTUATORS

**VOLUME - III**

**SUB-SECTION - 3.11**

**ELECTRIC MOTORS AND ACTUATORS**

## 1.0.0 GENERAL

This specification covers the design, manufacture, supply, erection, testing and commissioning of Motors for various driven equipment and Actuators.

It is not the intent to specify completely herein all details of the equipment, nevertheless, the equipment shall be complete and operative in all respects and shall conform to the highest standard of engineering, design and workmanship.

## 2.0.0 SCOPE OF WORK

The scope of work shall include but not limited to the following:

- AC & DC Motors required for various application
- Actuators required for various applications.
- Mandatory spares as listed in Vol. II / Section-1.0 and recommended spares for two (2) years trouble free operation.

## 3.0.0 CODES AND STANDARDS

- IS 325 : Three phase induction motors.
- IS 12615 : Energy Efficient Induction Motors-Three Phase squirrel cage.
- IS 2148 : Specification for Flameproof enclosures of Electrical apparatus.
- IEC 60034 : Specification for rotating machines.
- IEC 60079 : Electrical apparatus for Explosive gas atmospheres
- ANSI/UL-674 : Electric Motors and Generators for use in Hazardous location, Class-I Groups C & D, Class-II, Groups E, F & G

Motors & Actuators shall also confirm to other applicable standards amended up to date.

## 4.0.0 TECHNCIAL REQUIREMENTS

### 4.1.0 Motors Design Features

4.1.1 All AC motors shall be squirrel cage three phase/ single phase induction motors. Lifts/Crane motors may be of slip ring type. DC motor shall generally be of shunt wound type rated for 110 V DC. All motors shall be rated for continuous duty. Crane motors shall be rated for intermittent duty.

4.1.2 Inching type motors as per the requirement shall be provided.

4.1.3 The motor rating shall be at least 10% over the maximum input power requirement of the driven equipment at rated point. Gas booster compressor motor & BFP shall have 15% design margin.

4.1.4 Motors shall be of High efficiency type IE3 for motors up to 55kW & IE2 for motors above 55kW with high power factor (at least 0.8).

4.1.5 Power supply for AC motors shall be as follows :

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- Up to 0.2 kW : 240 V, 1 Phase, 50 Hz.
- Above 0.2 kW up to 160kW : 415 V, 3 Phase, 50 Hz solidly grounded system.
- Above 160 kW : 11 kV, 3 Phase, 50 Hz resistance grounded system

4.1.6 Motors shall be capable of delivering the rated output with supply voltage variation of ±10% and frequency variation of ±5% and absolute sum of 10%.

4.1.7 The motor characteristics shall match the requirements of the driven equipment so that adequate starting, accelerating; pull up, breakdown and full load torques are available for the intended service.

4.1.8 Squirrel cage induction motors shall be designed for direct on line starting. Starting current shall not exceed as mentioned in IS 12615. The motor shall be capable of withstanding the stresses imposed if started at 110% rated voltage subject to tolerance given in IS 325 & IS 12615.

4.1.9 No load power factor for motors shall not be less than 0.8.

4.1.10 All motors shall be suitable for bi-directional rotation.

4.1.11 Double squirrel cage rotor shall be considered for all HT motors.

4.1.12 BFP motors shall be suitable for VFD application and accordingly derating margin in the above motor shall be considered w.r.t frame also. Class of insulation for VFD motor shall be class-F but temperature rise limited to class B.

4.1.13 The starting current of 110V DC motors shall be restricted to 200% of full load current whereas for 125V DC motors, the same shall be restricted to 160%.

4.1.14 The motor shall be capable of withstanding the stresses imposed if started at 110% rated voltage. Motor shall start with rated load and accelerate to full speed with 80% rated voltage at motor terminals. Permissible number of starts per hour for continuous duty motors shall be as follows:

| **Starts** | **No. of Starts** |
|---|---|
| No. of hourly startups uniformly distributed, starting from final steady working temperature (Hot) | **3** |
| No. of consecutive startups with initial temperature of motor at final steady working temperature (Hot) | **2** |

4.1.15 Motors subject to reverse rotation shall be designed to withstand the stresses encountered when starting with non-energized shaft rotating at 125% of rated speed in reverse direction.

4.1.16 The locked rotor withstand time under hot condition at 110% rated voltage shall be more than motor starting time by at least 2.5 seconds for motors with 20 seconds starting time and by 5 seconds for motor with more than 20 seconds starting time. Starting time shall be at the minimum permissible voltage of 80% rated voltage. If the above conditions cannot be met in unavoidable cases, special provisions such as motor shaft speed switch, etc. shall be provided.

4.1.17 The motor characteristics shall match the requirements of the driven equipment so that adequate starting, accelerating, pull up, breakdown and full load torques are available for the intended service.

### 4.2.0 Motor Constructional details

#### 4.2.1 Enclosure

a) Motors located indoor shall have IP 54 degree of protection and those located outdoor shall have IP 55 degree of protection for the enclosure. For vertical mounted outdoor motors a Canopy shall be provided. For hazardous areas, approved type of flameproof and increased safety enclosure shall be provided.

b) The motors shall generally be of self-ventilated type totally enclosed fan cooled (TEFC). Alternatively for large motors, closed air Circuit Air Cooled (CACA) System shall be adopted.

#### 4.2.2 Winding and Insulation

a) The winding for all the motors shall be of super enameled copper wire of suitable gauge or copper strip conductor depending on its rating. All motors shall be class F insulated limiting temperature rise to class B limit.

b) The windings, fittings and hardware shall be corrosion resistant. The windings shall be tropicalised and shall be impregnated to make them non-hygroscopic and oil resistant.

c) Main insulation and inter turn insulation of Motors shall be capable of withstanding switching surges as per IEC 34, Part 15.

d) Motors of rating 30 kW and above shall be provided with space heaters, suitably located for easy removal or replacement. The space heater shall be rated for 240 V, single phase, 50 Hz, and sized to maintain the motor internal temperature above dew point when the motor is idle. The space heater all the four terminals shall be brought out for termination facility.

e) All HT motors shall be provided with six (6) duplex type winding temperature detectors, two (2) per phase and the motor bearing shall be provided with 2 Nos. duplex type temperature detectors on driving end and non-driving end. These temperature detectors shall be resistance type, 3 wire, platinum wound, 100 ohms at 0°C. The temperature detectors shall be connected to the DCS system.

#### 4.2.3 Bearings

a) Motor shall be provided with antifriction bearings, unless sleeve bearings are required by the motor application. Vertical shaft motors shall be provided with thrust and guide bearings. Thrust bearing of tilting pad type are preferred.

b) Bearings shall be provided with seals to prevent leakage of lubricant or entrance of foreign matters like dirt, water etc., into the bearing area.

c) Lubricant shall not deteriorate under all service conditions. The lubricants shall be limited to normally available types in India.

d) Bearings shall be insulated as required to prevent shaft current and resultant bearing damage for a motor rating of above 1000 kW.

e) In case forced lubrication is adopted, a shaft driven oil pump shall be provided along with an electrical auxiliary pump. Alternatively, two motor driven pumps may be provided, one working and one standby. All necessary auxiliaries and accessories shall be provided to complete the system. A pressure gauge and pressure switch for low oil pressure warning and to start the

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standby oil pump automatically shall also be provided. A motor driven jacking oil pump may be provided, for heavy shaft loads.

4.2.4 **Indicator/Switch**

a) Dial type local indicator with alarm contacts shall be provided for the following:

- HT motor bearing temperature.
- Hot and cold air temperatures of the closed air circuit for CACA motors.

b) Flow switches shall be provided for monitoring oil flow of forced lubrication bearings, if used. Alarm switch contact rating shall be minimum 0.5 A at 110 V D.C. and 5A at 240 V A.C.

4.2.5 **Motor Terminal Box**

a) Motor terminal boxes shall be provided with a detachable extension box (cable core splitter box). Terminal box shall be capable of being turned 360° in steps of 90°, unless otherwise approved. The terminal boxes shall be split type with removable cover with access to connections and shall have the same degree of protection as motor. The terminal box shall have sufficient space inside for termination/connection of cables.

b) Terminals shall be of stud type, substantially constructed and thoroughly insulated from the frame. The terminals shall be clearly identified by phase markings, with corresponding direction of rotation marked on the non-driving end of the motor. The terminal box shall be capable of withstanding maximum system fault current for 0.25 sec for all breaker operated motors and shall be provided with explosion vent. However for contactor operated motors, the terminal box shall be capable of withstanding the fault current for let through time of the fuse preceding it.

c) For 11000 V motor, the terminal box shall be phase segregated type and neutral leads shall be brought out in a separate terminal box (not necessarily phase segregated type) with shorting links for star connection. For motors for 1000 kW and above, PS class current transformers shall be provided in the neutral side terminal box on all three connections for differential relay.

d) All accessory equipment such as space heater temperature detector, etc., shall be wired and terminated in a enclosure, separate from motor (power) terminal box. The degree of protection for accessory terminal box shall be same as that of motor. Terminal box shall be complete with double compression brass glands and stud type terminals and shall be suitably mounted on the side of the motor. If possible, the accessory terminal boxes shall be located on the same side of the motor as the main (power) terminal box.

4.2.6 The noise level and vibration limits shall not exceed the limits specified in relevant IEC/IS standards.

4.2.7 **Grounding**

The frame of each motor shall be provided with two separate and distinct grounding pads complete with tapped hole, GI bolts and washer. The cable terminal box shall have a separate grounding terminal. The grounding connection shall be suitable for accommodation of following sizes of earthing materials.

| | | |
|---|---|---|
| All HV motors & LV motors $\geq$ 90 kW | - | 75 x10 mm GI flat. |
| $\geq$ 30 kW up to 90 kW | - | 50 x 6 mm GI flat. |
| $\geq$ 5 kW to 30 kW | - | 25 x 6 mm GI flat. |
| < 5 kW | - | 8 SWG GI wires. |

**4.3.0 Actuators**

4.3.1 Duty cycle of actuators shall suit the system requirement. The actuators shall be capable of giving the required torque at the output shaft. The actuators shall be designed to take the full thrust.

4.3.2 Actuators shall be of totally enclosed weather proof and dust proof construction with IP 65 enclosure and shall be suitable for outdoor application without the necessity for a canopy. The actuator shall be suitable for mounting directly on the valve. The actuator shall be capable of giving the required torque, rpm and thrust without the help of any spur gear arrangement. The actuator shall be suitable for mounting in any position. Actuators shall be of non-integral type.

4.3.3 Each actuator shall have a hand wheel fitted on it for emergency operation. The hand wheel shall be designed such that it is declutched automatically when the power supply to the motor is restored. The material of the hand wheel shall be either malleable iron or steel. The hand wheel shall have adequate clearance from housing for each gripping and operation. Actuators offered shall be with self-locking worm.

4.3.4 Two number adjustable torque switches (one for open and one for close) each with 2 NO & 2 NC potential free contacts shall be provided. It is required to have calibration for the torque switches so that the switches can be easily set to any value desired.

4.3.5 Two numbers of position limit switches (one for open and one for close) each with 2 NO and 2 NC potential free contacts shall be provided. Two auxiliary limit switches (one for open and one for close) with 2 NO & 2 NC potential free contacts shall also be provided. The limit switches shall be of independently adjustable type. Limit switches and actuating mechanism shall be rust proof suitable for damp atmospheres. Limit switch compartment shall be weather proof and spacious enough for easy setting. The limit switches shall be suitable for the following ratings, both 240 Volts AC, 5 A and 110 V DC, 0.5 Amps.

4.3.6 Each actuator shall have a space heater in the limit switch compartment suitable for 240 V AC 50 Hz single phase supply.

4.3.7 The wiring from the limit switches, torque switches etc. shall be brought out in a separate terminal box of adequate size, so as to easily terminate the control cables.

**4.4.0 Variable Speed Drive Systems (VSDS)**

4.1.1 Some of the driven loads (Such as Boiler Feed Pumps) are proposed to be of the variable speed type.

4.1.2 All the motors rated for 415V shall be driven by atleast 12 Pulse VSDS drives.

4.1.3 For each of these machines, variable speed drives are normally provided for better speed response, range ability, control stability and for ease of control, and smooth, efficient and optimum speed operation of the machine drives.

4.1.4 These variable speed drives will preferably controlled AC electrical variable speed drive system (VSDS) with AC squirrel cage induction motor.

4.1.5 Each VSDS system will have most of the following features:-

- High input line-side power factor throughout the speed range.
- Built in dry type isolation transformer suitable for 415V input.
- In case of Inverter power stack failure built in advanced cell by pass contactor to be provided.

- Power conversion devices by LV IGBT preferred.
- Low harmonics on the input line-side, with the total and individual harmonic contents not exceeding the limits established in IEEE-519.
- Low load side harmonics with near sinusoidal current in the drive circuit.
- Suitable for regenerative operation as may be required for the drive application.
- Soft start and soft stop, with capability for bi-directional operation of the drive as may be required.
- Reduced shoot through faults.
- Integrated pf improvement facility shall be provided
- It should be permissible to use long cable without choke upto 2 kM.
- High starting torque as may be required for the drive application.
- Suitable for various drives operating with driven equipment having constant torque, constant power, or load torque varying with square or cube of speed.
- Faster response and have a wide speed range.
- Greater tolerance to load side drive machine parameter variations.
- Wide range of low frequency and super synchronous speed frequency range of operation as may be required.
- Low torque pulsations throughout the lowest & highest frequency range.
- Stability throughout the lowest and highest load range.
- Reduced voltage spikes inflicted on the motor / VSDS equipment that can occur during commutation.
- VSD shall be capable of flying restart.
- Frequency convertor output shall be directly connected without matching transformer
- VSD shall have dynamic breaking unit and resistor feature.
- In case of Inverter shut down DOL bypass to be provided.

4.1.6 The VSDS will comprise frequency converter, which will as a minimum be as follows:

- Voltage or Current Source DC link Pulse Width Modulated (PWM) Converter configuration suitable for operation at automatically produced fixed ratio of Voltage / Frequency (V / F) throughout the complete speed range of the motor; and for operation in constant torque and constant power mode as appropriate. The converter will comprise line commutated power converter connected to AC mains either directly or by a suitably rated converter transformer.

- Provided with suitable input transformer if required to transform the input system network voltage to the optimal voltage of the converter and to reduce the short circuit capacity and to reduce 'line notching' that can occur during commutation. The Input transformer will have appropriate phase shifting multiple windings to eliminate the 5th & 7th harmonics and their multiples.

- Suitable regulating equipment that will be so designed as to enable the drive motor system to respond to load change with good dynamic accuracy, excellent speed holding accuracy and fine speed setting resolution. From the instrumentation control system, isolated 4-20 mA dc controller output signal will be made available as a set point for the speed controller in the regulation system. The system will include as part of the speed controller any transducer/ converter that may be required to interface with the above signal. Facility for signal measurement at important points in the regulating system will also be provided.

- The VFD shall be capable of producing an variable AC voltage/frequency output to provide continuous operation over the normal system 30-100% speed range, The VFD must be capable of sustained operation at 1/10 speed to facilitate checkout and maintenance of the driven equipment. As a commissioning and troubleshooting feature, the VFD power circuit shall be capable of operating without a motor connected to the VFD output.

- Independently adjustable voltage boost for VSDS start up and operation at the lower end of the frequency.

- The VFD shall be capable of momentary overload of 110% for one minute for variable torque loads (centrifugal fans, pumps, etc.) and 150% for one minute for constant torque loads.

- Separately adjustable ramp up and ramp down time facilities.

- Voltage Harmonics: Individual or simultaneous operation of the VFD's shall not add more than 3% total harmonic voltage distortion.

- Current Harmonics: Maximum allowable total harmonic current distortion limits for each VFD shall not exceed 5% as calculated and measured at the point of common coupling.

- Compliance shall be verified by the VFD manufacturer with field measurements of harmonic distortion differences at point of common coupling with and without VFD's operating. The point of common coupling (PCC) for all harmonic calculations and field measurements for both voltage and current distortion shall be defined as the primary connection of each VFD input transformer.

- VFD output waveform shall be suitable for operating a squirrel cage induction motor without derating or requiring additional service factor. To ensure that there are no problems with motor heating, VFD output current waveform shall be inherently sinusoidal at all speeds, with a total harmonic current distortion not exceeding 3% between 10% and 100% speed regardless of loading VFD's utilizing output transformers/filters are not acceptable.

- The VFD output shall produce no electrically induced pulsating torques to the output shaft of the mechanical system eliminating the possibility of exciting a resonance caused by VFD induced torque pulsations. VFD systems or other types which produce torque pulsations in excess of 1%, will require a torsional analysis to be supplied by the VFD manufacturer as part of the scope of supply. The price of the torsional analysis shall be included in the base price of the VFD. If the torsional analysis shows that a special coupling is required, the VFD supplier shall be required.

- An input transformer shall be included to provide common mode voltage protection and allow the use of a standard motor. Use of reactor is not an acceptable method for protection against common mode voltages.

- Guaranteed minimum total VFD system efficiency (□sys) shall be a minimum 96% at 100% speed & 100% load and minimum 95% at 80% speed & 50% load. Efficiency evaluation shall include input transformer, harmonic filter and power factor correction (if applicable), VFD converter, and output filter, as indicated below. Auxiliary controls, such as internal VFD control boards, cooling fans or pumps, shall be included in all loss calculations.

- The VFD system efficiency is as follows: □sys = □VFD x □xfmr x □pfc x □harm x □filter.

  Converter/Inverter (VFD) □VFD

  Input Transformer □xfmr Total VFD System Efficiency (□sys)

  Power Factor Correction □pfc must be 96.0% at full load

  Input Harmonic Filter □harm and 95% at 50% load.

  Output Filter □filter

- VFD system shall maintain a 0.95 minimum true power factor from 30% to 100% speed.

- VFD system including power factor correction and/or harmonic filter shall never have a leading power factor under utility or generator operation. VFD manufacturer is to supply a power factor correction system, if required, to meet this requirement. Power factor correction unit shall include a separate input isolating contactor with fuses, power factor correction grade capacitors (5 KV class), and series harmonic decoupling reactors, all integrated into VFD system and mounted within the VFD enclosure.

- Complete features for drive soft start and soft or extended stop as required with features required for bi-directional operation of the drive as may be required for the particular application.

- Close loop control to keep output voltage unaffected by system voltage and load changes. Regulation of output voltage will not be more than plus 2% to minus 2% under steady state (zero to full load) and 8% under transient conditions.

- Maximum drift in set frequency will be plus 0.5% to minus 0.5%.

- All facilities as required for on site adjustments of current limits, trip time, maximum frequency, minimum frequency, start compensation, voltage boost, slip compensation, accuracy rate, deceleration rate and others as required.

- All internal firing signals and other communications which link operational controls with power components (such as status and diagnostic signals) must utilize fiber optic cables.

- The failure of any power switching device (SCR, GTO, diode, IGBT, IGCT, etc.) shall not prevent continued VFD operation. In the event of a device failure, the VFD shall annunciate and identify the specific location of the failed device and resume operation until such time as repairs can be scheduled.

- The VFD system must be capable of producing full rated torque in the event of a power loss of 5 cycles or less.

- The VFD system must be capable of automatically restarting in the event of a momentary loss of power, or a clearing of a drive trip. The VFD system shall provide the user with the choice of automatically restarting or not. The user shall be able to selectively apply this feature to some but not all conditions as appropriate for the specific application.

- In the event of a ground fault, the VFD shall capable of annunciating the ground fault condition, safely operating and, by user selection, either trip or continue operation. As a result of a ground fault trip, the VFD shall be capable of being reset and operating normally. There shall be no risk of fire or electric shock as a result of the ground fault.

- Comprehensive protection and fault display circuit including under / voltage (supply, over current, short circuit / earth fault due to inverter and / or motor fault , internal / external fault provisions for tripping unit. covering as a minimum Over current protection, fast acting short circuit & transient suppression circuits, Thermal overload protection, Phase sequence monitoring and protection, Single phase protection, Mains & Internally generated Transient Over Voltage Protection, Under Voltage and mains supply failure protection, Control supply failure, IGBT fuse failure, Gate suppression for output circuit faults, Thermistor protection relay for protection of windings of motors greater than or equal to 75 kW, necessary di/dt & dv/dt protection, Device / Cubicle overheating protection, Ventilation failure, and any other protection as required for the type of scheme provided.

- All power components in the converter sections shall be designed for rack-out accessibility.

- This provides the maximum safety during component repair or maintenance, as well as providing the required ease of access to minimize repair downtime. Alternate access options must be described in the proposal for purchaser's review and evaluation.

- All low voltage components, circuits and wiring shall be separated with physical barriers from any sources of medium voltage.

- Where closed loop dynamic and fast speed response is required for drives, necessary multi loop control system will be provided complete with tachometers provided in the drive shaft.

4.1.7 The control system will consist of a multi loop system having two internal loops. One loop is for speed control and the other is for the control of current. Each loop will have its own controller, along with an acceleration ramp function, which sets the desired value of the speed in accordance with a linear ramp function and thus prevents sudden variation in the controller input.

4.1.8 The primary controlled variable will be speed which will be measured by means of a tachometer, which will be provided on the drive shaft and compared with the reference speed input. The error in speed will actuate a speed controller to establish the reference current input. This reference value will be subtracted from the actual current value and the error signal actuates the current controller, the output of this should be connected to the gate control unit, which controls the firing of the IGBT.

4.1.9 The inner current loop is made more active than the speed control loop. The speed and current controllers will be capable of accepting the form and type of feed back signal provided by the error detector and must provide at its output a signal of the proper type to operate the IGBT.

- All necessary indication and monitoring equipment that will as a minimum include speed indicator for motors with a provision for repeat indication signal for use with DCS instrumentation system, speed reference, speed feedback, current reference, current feedback, regulated power supply voltages; voltmeter, ammeter, frequency, power factor meter, kW meter at mains input supply side, pulse output meter; voltmeter, ammeter, frequency, kW meter torque meter kW meter and speed indicator on the load side.

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- Audio visual Alarm annunciation (with visual and audio alarm acknowledge facilities) as required that will as a minimum include drive in monitoring mode, drive in regenerating mode, control electronic power supply, over temperature, motor over current, rectifier over current, motor thermal overload, any other motor / converter faults.

- The VFD system shall be supplied with the capability to operate the motor directly across the input power source in the event of a VFD malfunction. All switchgear necessary for this direct-on-line bypass of the VFD shall be supplied, including a VFD output isolating contactor and a fused full voltage starter in a common NEMA 1 enclosure with motor overload protection. Bypass must be separated from the VFD by a metal barrier. Contactors shall be draw-out, vacuum type. The contactors shall be easily removed from the front of the enclosure by loosening two bolts. Line and load cable terminations shall be completely accessible from the front. The VFD isolating contactor and starter are to be electrically isolated. Motor protection relaying shall be a Multilin 269 Plus, or Multilin SR469 if specified on the data sheet, or approved equal, to provide a complete motor management system that allows several motor related parameters to be monitored against user-selectable set points for protection during VFD bypass operation.

- Air-cooled VFDs shall be provided with 100% redundant fans and automatic switchover in the event of a fan failure for enhanced reliability. If a blower fails, the system must automatically switch to the alternate blower and generate an alarm to notify operator of initial blower system failure. Drive must have air flow detection switches to monitor proper operation of the system (using temperature detectors as the only protection against loss of blower system is not acceptable). If more than one blower is required for normal system operation, each blower must have its own 100% redundant backup. During normal operation, the system must periodically cycle between the two blower systems to “exercise” them and prevent drying out of bearings, seals, etc., and to ensure availability of both systems. VFD system manufacturer shall provide heat dissipation data necessary to design all auxiliary HVAC systems.

- Mechanical key interlocks shall be provided on all doors. Interlocking shall be fully coordinated to prevent access to all high voltage compartments, including transformer, filters or any switchgear that is part of the supply, when line power is applied to the VFD system. Interlocks must be mechanical to provide positive lock-out prevention and safety. Electrical interlock switches alone are not acceptable, due to the possibility of inadvertent shutdown and the ease with which such switches could be bypassed.

4.1.10 VSDS unit will be controlled from following 3 different locations

- VSDS panel
- Local Operator Panel or Local Control Station
- DCS

4.1.11 Following minimum control facilities will be provided on each of the VSDS Panel and the Local Operator Panel:-

- Incoming switch and HRC fuses.
- Start / Stop PBs to switch ON / OFF of the drive.
- All necessary contactors and switch with HRC fuses or current limiting circuit breakers for the drive control and protection along with thermal overload protection.
- Raise / Lower PBs for speed variation of the drive.
- Auto / Manual Selector Switch for selection of the mode of operation.

4.1.12 In Auto mode, frequency will be controlled from the instrument control PLC / DCS system by a 4 to 20 mA signal. For ON / OFF control of the motor in the Auto mode, 4-20 mA interlock signal from instrumentation PLC system will be wired to the VSDS panel.

4.1.13 In the Manual mode, the Selector Switch will be provided to select the motor control either from VSDS Panel or from the field.

- Drive Ready Indication and
- Speed Indicator
- DCS interface covering :-
- Wiring of 4-20 mA signal input from DCS/PLC for speed variation.
- Wiring of DCS / PLC ON / OFF input signal / contact for motor Start / Stop.
- Wiring of 4-20 mA signal output to DCS/PLC for speed indication.
- Wiring of contacts to remote for Drive Ready Indication.

## 5.0.0 TESTS

All tests shall be conducted as per relevant IS / IEC / IEEE standards and shall be performed in the presence of Owner/Owner's representative, if so desired by the Owner/Owner's representative. The Bidder shall give at least 15 days advance notice of the date when the tests are to be carried out.

## 6.0.0 PAINTING

All equipment shall be finished with two (2) under coats of high quality epoxy based primer followed by two coats of epoxy painting. Painting shall be carried out by approved process.

## 7.0.0 SPECIFIED TECHNICAL DATA

| Sr. No | DESCRIPTION | UNITS | REQUIREMENTS |
|---|---|---|---|
| A | **Motors** | | |
| 1.0 | **Rated Voltage** | | |
| 1.1 | Below 0.2 kW | V | 240 V, 1 Ph |
| 1.2 | From 0.2 kW and less than and equal to 160 kW | V | 415 |
| 1.3 | Above 160 kW | V | 11000 V |
| 2.0 | Rated Frequency | Hz | 50 |
| 3.0 | Voltage variation | | ±10% |
| 4.0 | Frequency Variation | | ±5% |
| 5.0 | Absolute sum of variation | | 10% |
| 6.0 | Rated Voltage for DC Motors | V | 110 ± 10% [125±10% If GTG supplier's standard] |
| 7.0 | Class of Insulation for all Motors | | Class `F' with temperature Limited to Class `B' |
| 8.0 | Starting Current | | As per Cl.4.1.8 & Cl.4.1.9 |
| 9.0 | Degree of protection | | IP 54/IP W 55 |
| 10.0 | Method of cooling | | TEFC/CACA |
| 11.0 | Fault withstand capability of terminal box | | Fault current for 0.25 sec. for breaker controlled motors |
| 12.0 | No. of consecutive hot starts with initial temperature of motor at final steady working temperature | | Two (2 ) |
| 13.0 | No. of hourly starts uniformly distributed from final temperature | | Three (3) |

# VOLUME - III

# SECTION - 3

# DETAILED TECHNICAL SPECIFICATION - ELECTRICAL

# SUB-SECTION - 3.12

# DIESEL GENERATOR SET

**VOLUME - III**

**SUB-SECTION - 3.12**

**DIESEL GENERATOR SET**

## 1.0.0 GENERAL

This specification covers the design, manufacture, supply, erection, testing and commissioning of Black start cum emergency Diesel Generator Set.

It is not the intent to specify completely herein all details of the equipment, nevertheless, the equipment shall be complete and operative in all respects and shall conform to the highest standard of engineering, design and workmanship.

## 2.0.0 SCOPE OF WORK

The diesel generator set (Black-start cum emergency) shall have sufficient capacity to fulfil the specified requirements, taking into account all mechanical and electrical losses and power needed for station auxiliaries. The diesel generator/s shall be installed in a closed shed and associated electrical and control panels shall be installed in the building.

***Bidder can offer separate Emergency DG set to cater the safe shut down of gas turbine & steam turbine and other emergency electrical loads. Same Emergency DG can be used to start the Black Start DG set.***

***The above arrangement is required so that during the period of starting of the black start DG set, the emergency loads are catered by the smaller capacity Emergency DG set.***

Diesel engine complete with integral air intake and exhaust manifold, speed regulation system, fuel injection system, lubricating oil system, jacket cooling water system etc. along with all necessary filters, valves, piping, fitting, etc.

The scope of work shall include but not limited to the following:

- Diesel Engine complete with all accessories
- AC generator (refer section 3.2 – Generator and accessories)
- Brushless excitation system complete with AVR (refer section 3.2 – Generator and accessories).
- AMF panel including Control cubicle and associated auxiliary devices, relay panel and synchronising panel.
- Complete starting arrangement; including necessary batteries & chargers (refer section 3.9 – DC system).
- Air inlet and outlet for generator cooling.
- Exhaust silencer package.
- Commercial type Acoustic Enclosure for silent type D.G. Set.
- 11kV DG switchgear with metering & protection (refer section 3.7 – HT switchgear for specification)
- Neutral earthing resistor.
- Foundation frame complete with foundation bolts and base frame.

- List and supply of Maintenance tools and tackles.
- Mandatory spares as listed in Vol. II / Section-1.0 and recommended spares for two (2) years trouble free operation.

**3.0.0 CODES & STANDARDS**

The design, manufacture and performance of equipment covered by this specification shall, conform to all relevant IEC/IS standards.

| | |
|---|---|
| ISO 3046 | Reciprocating internal combustion engines. |
| IEC 60034 | Rotating electrical machines. |
| BS:5514 | Diesel Engine. |

4.0.0 **TECHNICAL REQUIREMENTS**

**4.1.0 Design Criteria**

4.1.1 DG set (Black-start cum emergency) shall be rated for continuous duty. DG set shall be adequately sized for Black start condition of plant, for safe shut down of the units in the event of total black out and also to meet emergency loads such as emergency drives, lighting, control and indication etc. DG set shall come into operation in the event of total power failure in the station. A minimum of 15% margin shall be considered over the actual design requirement.

4.1.2 Manual control of engine speed and generator voltage shall be provided through raise / lower control switches on local control panel mounted on engine, at AMF panel located in engine room, at DG circuit breakers, control, relay & synchronising panels, SAS / DCS located in the plant control room.

4.1.3 The essential auxiliaries that are required to be catered by the DG set (Black-start cum emergency) shall be as listed below but not limited to:

- GT auxiliaries i.e. oil pumps, etc.
- GT starting loads like starting motor or Static frequency converter (SFC) etc.
- Air compressor-01 no.
- Auxiliary cooling water pump-01 no.
- Cooling tower fan-01 no.
- GT emergency loads
- STG emergency/safe shut down loads
- UPS loads
- Battery charger loads
- Emergency lighting loads
- Any other load required during black start of GT / safe shut down of the CCCPP

4.1.4 DG set shall be capable of starting the highest rated motor while supplying the other base loads.

4.1.5 Diesel engine shall be suitable for HSD oil. In the foundation, suitable drain off system for oil shall be provided.

4.1.6 DG set shall be installed indoor and housed in a separate closed shed. All DG control and switchgear panels shall be located in DG building.

4.1.7 DG set shall be supplied complete with required consumables.

4.1.8 DG set shall be provided with one channel for auto control and one channel for manual control. DG set shall have automatic starting sequence from the manually initiated command from remote/local. It shall also have auto initiation through a 'no volt relay'. D.G set is required to start up and come into operation whenever a remote starting impulse is received in the event of failure of normal supply.

4.1.9 Manual control of engine speed and generator voltage shall be provided through raise lower control switches on local control panel and also at central control room.

4.1.10 The governor shall be provided with motor operated speed gear for remote adjustment of generator frequency. The Governor/Excitation/Control Systems shall permit operation of DG set without exceeding the active and reactive power limitation of the Generator.

4.1.11 The generator shall be rated for 11kV, 3 phase, 50 Hz supply. Generator shall be connected to 11kV switchgear located in main plant building.

I. Medium speed diesel engine generator set complete with governing equipment, over-speed trip, excitation and control system.

II. Lubricating oil system including pumps, filters, heat exchangers and treatment.

III. Engine cooling system including air-blast coolers, heat exchangers, engine driven pumps, and thermostatic control valves as applicable.

IV. Exhaust system with silencers to meet the specified noise requirements, flexible bellows for fitting to the turbocharger outlet, stack with guided structure.

V. Meters in fuel oil supply line to engine and fuel oil return line from engine.

VI. Air inlet system including externally mounted filters and silencers to meet the specified noise level and flexible bellows at the turbocharger inlet.

VII. Synchronizing facilities for generator set. control, instrumentation and communication equipment including Engine Equipment Cabinets (EEC), Generator set Unit Control Panels (UCP), feeder Control Panels and monitoring facilities where incorporated in the suite of UCP's .

VIII. 110V DC systems for power supply for control and protection of all equipment supplied with necessary distribution.

IX. Foundation and holding down bolts for the engine and alternator and all equipment supplied, access ladders and platforms for the engine.

4.1.12 Diesel engine mounted on vibration dampening pads complete with integral air intake and exhaust system, speed regulation system, fuel injection system, lubricating oil system, jacket cooling water system, flywheel, barring gear, turbocharger etc. along with all necessary filters, silencer, exhaust piping, insulation, fittings, flexibles, valves etc.

4.1.13 Coupling between engine and generator with suitable coupling guard.

4.1.14 Complete fuel system consisting of day tank with float operated level control valve, Capacitance type level switch, Solenoid operated On/Off valve, oil pumps, filters, piping, valves etc.

4.1.15 Normal operation will be through float operated Level Control Valve. Incase the failure of Float operated Level Control Valve, Capacitance type Level switch will generate hi-hi alarm and close the On/Off valve. Capacitance type level switch will also generate Level Lo-Lo, Hi & Hi-Hi alarm.

4.1.16 Annunciator with each DG set installed in the control panel.

4.1.17 Complete water piping within the DG Building

4.1.18 Exhaust ducting including silencer and supports for silencer.

4.1.19 Exhaust pipe / chimney with guided structure.

4.1.20 Complete lubrication system, lube oil cooling system along with first fill of lubricants.

4.1.21 Any other part/accessories not specifically mentioned above but considered necessary for safe and reliable operation.

4.1.22 Statutory clearance required for fuel oil day tank.

**4.2.0 Diesel Engine**

4.2.1 **General**

The diesel engines shall be of the turbo-charged, charge-air cooled, four stroke compression ignition heavy duty type, suitably designed and constructed for operation on diesel fuel. The nominal speed of the engine shall be 1500 rev/min. The diesel engines shall conform to BS ISO 3046 and BS ISO 15550 with respect to rating, derating, governing, overspeed protection and testing. The diesel engine generating set shall conform to ISO 8528 with respect to rating, performance, protection and testing. The continuous output of each engine shall be sufficient to provide a net electrical output as specified in the schedules after deduction of all generating set auxiliary power requirements and station loads.

4.2.2 The continuous output shall take into account :-

i) The pressure drop in the engine inlet air ducting with filter and inlet silencer.

ii) The resistance in the exhaust gas ducting with silencer and chimney.

iii) The site ambient conditions.

4.2.3 Each engine shall be capable of operation at 110 per cent of the continuous power for a period of 15minutes, this to be demonstrated only at the Supplier's works. This additional power is for governing purposes (ISO 8528 refers).

4.2.4 Evidence shall be provided to show that the engines offered are capable of performing the duty specified in a reliable manner and with a minimum of routine or periodic maintenance. The power plant shall be capable of high availability under the prevailing operating conditions. Reliability will be of prime importance. The diesel engine shall be designed for a life of 25 years, for an operation time in excess of 8000 hours per year. The sets shall be able to be started at least twice a day and to be regulated from no load to full load. Engine platforms and guards to give access to all parts of the units shall be provided. The set shall be provided with all instruments and sensors required for local and remote control.

**4.3.0 Flywheel**

4.3.1 The flywheel shall be designed to ensure that the cyclic irregularities are damped to a minimum and in any case to less than the limits laid down in BS ISO 3046 or other approved National Standard. The flywheel and all moving parts shall be guarded to comply with BS 5304.

4.3.2 Motorized barring gear shall be provided to enable the engine crankshaft to be rotated. The device shall be such as to prevent the engine being started when the device is in use. Means shall be provided to indicate the angular position of the crankshaft relative to each cylinder. The engine shall drive a two-bearing alternator via a flexible coupling of the rubber block type.

**4.4.0 Crankcase**

4.4.1 Crankcase explosion relief valves shall be fitted. They shall open automatically in the event of abnormal pressure rise inside the crankcase space, and shall comply with Lloyd's Register of Shipping Rules and Regulations. Access to both sides of the crankcase shall be provided by large oil-tight doors. All crankcase and other breathers shall be vented to atmosphere. A warning sign shall be attached to each side of the crankcase advising of the hazard of removing crankcase doors after suspected overheating in the crankcase, to avoid explosion hazards.

4.4.2 A crankcase oil mist detector of Graviner or similar proven manufacture shall be fitted, in order to give early warning of abnormal temperatures within the crankcase. The mist detector shall trip the engine in the event of abnormal conditions. Care shall be taken to ensure that the mist detector power supply is taken from a source, which will not suffer from voltage dips in the event of electrical system faults, to prevent spurious tripping.

**4.5.0 Bearings**

4.5.1 The main bearings on the engine and generator shall be of the self aligning type split horizontally and so arranged that the bottom halves may be removed without appreciably raising the crankshaft. Any thrust bearing requiring periodic adjustment shall be so arranged as to facilitate such adjustment. In order to avoid damage to the main bearings due to induced currents, the bearings of the generator and associated oil pipes shall be insulated from the bedplate. A removable earthing strap shall be provided at the drive end of the generator.

4.5.2 The engine main bearings shall be fitted with temperature detectors to give alarm and trip signals to the engine control system in the event of high bearing temperatures.

**4.6.0 Governing**

4.6.1 The set shall be equipped with all necessary governing systems, protective devices, control and other instruments for reliable and efficient functioning under all operating conditions. The engine shall be fitted with a governor capable of governing to limits as laid down in ISO 8528 for class G1 of governing and suitable for parallel operation with other STG sets and also parallel with grid. Speed excursions within the governor limits shall not operate the over-speed trip mechanism. Means shall be provided at the engine via the Engine Equipment Cabinet (EEC) to adjust engine speed for commissioning purposes. Synchronizing and load control shall be achieved at the Unit Control Panels in the Control Room. The governor shall permit the engine speed to be adjusted over the range given in BS ISO3046: Part 4 at any load. The governor shall have controls whereby the droop can be varied within the limits given in BS ISO3046.

4.6.2 The generator sets shall be capable of being operated in either droop or isochronous governing modes, with the Unit Control Panel (UCP) providing both manual and automatic synchronising facilities.

4.6.3 The governor shall be arranged to shut down the engine by cutting off all fuel in the event of the operation of a mechanical or electrical shut down device. The system shall be able to control the speed and the power, in a stable way, between zero and maximum load, when operating in parallel with other generators and with STG. The dynamic stability of the entire governing system shall be ensured and shall be guaranteed by the Supplier. Means shall be provided for varying the engine speed under no load for testing the over-speed protection. Variations in speed under constant load

and during island operation shall be as low as possible. In the case of a loss of the load, the governing system shall prevent response of the over-speed protection trip. The governor power supply shall be from a battery backed DC power source. In the event of loss of power or failure of the governor, the governor shall fail-safe and shut down the engine.

**4.7.0 Overspeed protection**

4.7.1 The engine governor shall provide the first level of overspeed protection at a setting of 9% above the nominal speed. A two-stage separate overspeed protection (through the PLC) independent of the governor control shall be provided. The trip control logic shall contain electrical contacts for the tripping of the generator and initiating of overspeed alarms in the control room. The PLC based controls shall include two levels of overspeed protection:

4.7.2 The first stage shall operate at 10% overspeed.

4.7.3 The second stage shall operate at 15% overspeed.

4.7.4 The diesel engine and connected apparatus shall be mechanically designed for an over-speed of 15 per cent.

**4.8.0 Torsional vibration damper**

4.8.1 A vibration damper shall be fitted to the free end of the crankshaft to limit the torsional vibrations in the crankshaft/alternator rotor system to an acceptable level. There shall be no critical speeds within the normal operating speed range of the engine.

**4.9.0 Lubricating oil system**

4.9.1 The diesel engine shall be of integral wet sump design. The diesel engine shall be provided with self-contained and independent pressurized lubrication systems operated by positive displacement pumps and serving the lubrication requirements of the engine including the crankshaft and connecting rod bearings, shaft gears, camshafts, pistons, valve gear, fuel injection pumps and turbocharger. The oil shall be circulated from the sump via a water cooled heat exchanger and filters to the engine by a pump driven from the engine crankshaft. A strainer shall be installed at the suction of the lubricating oil pump. Manual lubrication of any part of the engine will not be acceptable. The system shall incorporate duplex oil filters and shall be complete with pipe work, relief valves, valves and instrumentation.

4.9.2 Lubricating oil shall be cooled in a shell and tube heat exchanger for which a standalone cooling water system consisting of cooling water pumps, cooling tower, etc is to be provided. The full flow duplex oil filters, which shall be provided with manual change-over, shall have a nominal size of 15 microns. The design shall be such that the lubricating oil supply to the engine is not interrupted during change over. It shall not be possible for both sides of the filter to be shut-off at the same time. Each filter shall be suitable for the discharge pressure of the pumps and shall be capable of dealing with the full lubricating oil requirements of the engine. The filter units shall be complete with a differential pressure gauge and a differential pressure switch to initiate an alarm.

4.9.3 A self-actuating wax element mixing type thermo-static control valve and oil cooler by pass arrangement shall be installed in the lubricating oil circuit to maintain the lubricating oil within the desired temperature range throughout the range of operating loads and ambient temperature. The diesel engine shall be provided with an electric motor driven priming pump, which shall be adequately sized to allow for priming of the engine when the oil is hot. All lubricating oil system components shall be installed either on the engine or on a 'filter/cooler' module which shall be pre-piped and wired to reduce installation time on site. Rubber components (eg flexible connectors or hoses) shall not be used in the lubricating oil system under any circumstances. The recommended type and grade of the lubricating oil shall be stated in Schedule F3. The first fill of lubricating oil and

oil required for flushing will be provided by others as per the lube oil specification to be furnished by the Supplier.

**4.10.0 Foundation**

4.10.1 The engine foundation will consist of a substantial concrete block of sufficient stiffness and strength to support the weight of the engine and the generator, and to withstand external couples from the engine. The detailed civil design will be done by others. The engine manufacturer shall provide a foundation block outline drawing and all data necessary for the detailed design. Each engine and alternator shall be installed on a fabricated steel base-frame designed for solidly mounting on a mass concrete foundation block. If fabricated bases are used they shall be fully stress relieved prior to machining. Fastening of the engine onto the foundation shall be such that all parts can expand freely and alignment is maintained. Foundation and holding down bolts, shims and packers and any special grouting materials required for the attachment of the generator set to its foundation shall be supplied with each engine as defined in the Scope of Supply

**4.11.0 Engine Piping and ducting**

4.11.1 The engine shall be complete with all necessary integral piping, ducting and manifolds for exhaust gas, charge air, control air, fuel oil, lubricating oil and jacket cooling water. The exhaust manifolds shall be lagged and enclosed in light sheet metal coverings. Suitable terminal connections shall be provided on each engine system for connecting with the various off engine fluid systems pipe work. Mating flanges for welding to field pipe work shall be provided for each non-standard (BS, DIN, ANSI) connection. The connections shall be blanked off prior to shipment.

The Supplier shall provide separate commissioning filters for the engine fuel inlet connection.

**4.12.0 Engine Operating Regime**

4.12.1 The Engine shall be provided to operate continuously for upto 8000hours per year in accordance with the maintenance regime recommended by the Supplier.

4.12.2 Hot start of a Unit (Engine having run on HFO and being stopped and subsequently restarted within 12 hours – rest of the station running)

**4.13.0 Ramp-up Rate**

Once the Facility has been synchronised and brought to its minimum operating level, its Net Electrical Output maybe increased at the maximum rate of 3%MCR per minute during a cold start of a Unit and at the maximum rate of 15% MCR per minute during a hot start of a Unit.

**4.14.0 Ramp-down rate**

If the Facility is operating above its minimum operating level, its Net Electrical Output may be reduced at the maximum rate of 15% MCR per minute down to the minimum operating level.

**5.0.0 COOLING SYSTEMS**

5.1.0 **General**

5.1.1 Cooling of the engines shall be by means of air blast radiators ( if applicable) with electric motor driven fans. Automatic air eliminator valves shall be provided at either at the highest point in the systems or high points on the radiators. All low points shall be provided with drain valves. If indicated in the Scope of Supply, a quantity of scale and corrosion inhibitor for the cooling systems, suitable for one-year operation of the engines shall be supplied. The Contractor shall be responsible

for initial dosing of the system and for the provision of test kits for checking the concentration of the inhibitor in the cooling water systems.

**5.2.0 Jacket cooling system**

5.2.1 The jacket cooling water shall be circulated through the jacket water radiator by a centrifugal pump driven from the engine crankshaft (if applicable). A self actuating wax element diverting type control valve and air blast cooler by-pass arrangement shall be installed to maintain the desired constant engine outlet temperature throughout the range of operating loads and ambient temperature.

**5.3.0 Charge air cooler system**

5.3.1 Each engine shall be fitted with water cooled charge air coolers to cool the charge air before admission into the engine cylinders. The charge air coolers shall be cooled by closed water circuit(s) with engine driven circulating pump, and cooled by the air blast coolers. The water flow through the charge air cooler shall be provided to ensure a steady charge air temperature under all conditions of load and ambient temperature. The charge air cooler ductwork shall be equipped with manual drain valves on the cold air side to remove condensate from the system. Either vapour vents or manual drain valves shall be provided on the engine charge air manifolds.

**5.4.0 Air Blast Coolers**

5.4.1 At least one cooling radiator per engine shall be provided. Each radiator shall have a minimum of two 50 per cent capacity motor driven induced draft fans. The radiators shall be rated for engine operation at 100 per cent load in the maximum ambient temperature expected on site and shall incorporate a design margin of 15%. In addition, a fouling factor of at least 10 per cent shall be applied to offset the effect of fouling in service.

5.4.2 Radiators shall be of the horizontal type with vertical airflow. Materials used in radiators shall withstand the environment stated in the schedules. The radiator support structures shall be hot dip galvanized after fabrication. Plastics are not allowed as material for the radiators. The cooling radiators shall be erected close to the power station. The coolers shall be constructed such that caking of dust is prevented as much as possible. The cooling units shall be located such that inhalation of heated air from the coolers into the air inlet of the engine is prevented. It shall be possible to clean the air side of the coolers easily and thoroughly. The radiators shall be designed to ensure that the noise levels specified in the schedules are not exceeded. O&M manuals shall include cleaning methods.

6.0.0 **FUEL SYSTEM**

6.1.0 **General**

6.1.1 The DG set shall be designed to operate on diesel fuel (DFO).

6.1.2 Fuel will be delivered to the by road tankers.

6.1.3 2 x 100% unloading pumps to be provided along with 2 x 100% forwarding pumps.

6.1.4 Day oil tank of required capacity to be provided. The capacity of tank to be mentioned in the bid along with the criteria.

6.2.0 **Inlet and exhaust system**

6.2.1 **Air intake system**

Combustion air shall be drawn from outside the building through a combustion air intake filter suitable for the environmental conditions as set out in the Schedules. The filter shall be sized for the engine load under site conditions and shall be equipped with a differential pressure gauge.

An air intake silencer shall be provided for installation in the intake ducting of each engine. The attenuation provided shall be such that the noise level specified in the schedules will not be exceeded. The silencer internal coatings shall be chosen and applied to ensure long term corrosion resistance and good adhesion. Suitable flexible bellows for installation at each engine shall be supplied under this Contract.

6.2.2 **Exhaust system**

The exhaust system shall include the following items to be supplied under this contract:-

i) Exhaust silencer(s) for each engine

ii) Flexible bellows for installing at the Turbocharger Outlet.

iii) A 'Y' piece to give a single exhaust outlet for each engine or single silencer with two inlet connection.

iv) Ducting and duct supports

6.2.3 **Exhaust silencers**

The exhaust silencers shall be thoroughly cleaned externally after manufacture and coated with two coats of high temperature silicone aluminium paint suitable for temperatures up to 500°C. Any damage shall be made good after installation and immediately prior to start up of the engines. The silencers shall be arranged for horizontal / vertical mounting (as applicable) on support structures to be provided by others. Integral mounting feet shall be provided. Each silencer compartment shall be fitted with a drain plug to allow for drainage of collected moisture.

6.2.4 **Exhaust bellows**

Where specified in the Scope of Supply stainless steel expansion bellows shall be supplied, to cater for the expansion anticipated in the engine exhaust system, reduce the possibility of engine vibrations being transmitted to the building and other equipment, and to prevent unacceptable loads being imposed on the turbocharger casings. The bellows shall be fitted with lining sleeves to prevent accumulation of carbon in the convolutions and shall be clearly marked with the direction of flow. The bellows shall be supplied with tie-bars fitted between the flanges to ensure that they are installed at the correct fitted length. The tie bars shall be readily removed after installation.

6.2.5 **Chimney**

Where it is necessary to meet project requirements, refer to schedules, the diesel engine exhaust gases shall be discharged via silencers to the chimney. The height of the chimney shall be decided during detail engineering and shall be as per statutory norms.

6.3.0 **Generator (refer section 3.2 – Generator and accessories for specification)**

Generator shall be mounted on a common base frame together with the prime mover.

The Generator shall be totally enclosed air cooled type. The Generator shall be star connected. The generator shall have a degree of protection of not less than IP 54.

6.3.1 **System Operation**

DG Sets shall serve both continuous base load and auto main failure start standby operation. When DG sets selected for standby AMF operation shall be scheduled from SAS.

The DG set shall normally be in an unattended area and suitable for base load operation. The control system shall be suitable for unattended operation. The control system shall operate in fail-safe mode and shall include all controls and protection necessary for the operation of the package. The generator sets shall function as per the following schemes.

- Auto Main Failure Scheme (AMF)
- Manual start in service mode
- Manual test mode

6.3.2 **Automatic Mains Failure Scheme (AMF)**

This shall be effective in auto position of Auto / manual selector switch located in control panel. The generator set shall normally be at rest. Upon failure of plant normal supply, an impulse shall be extended from DCS / SAS. Upon receipt of this impulse, generator set shall be started automatically and voltage brought to rated speed and generator voltage brought to rated value. All accessories required for starting and completion of various sequences of operation for the above purpose shall be provided.

Immediately after the generator set reaches rated speed and rated voltage, voltage and frequency monitoring relays located in control panel shall extend an impulse for closing generator breaker.

DG shall start automatically on mains failure & shall be synchronised at the same time or in sequence.

6.3.3 **Manual start in service mode**

This shall be effective in manual position of Auto / manual switch and service position of service / test selector switch located in control panel. The scheme of operation shall be same as auto mode except that starting impulse shall be extended manually through the push button in local control panel or through power management system.

6.3.4 **Manual test mode**

This shall be effective in test position of service / test selector switch. The scheme of operation shall be same as that if manual start in service mode except that the closing impulse for generator breaker shall not be extended automatically.

6.3.5 **Stop**

Stopping of the generator set in all cases for a normal shut down shall only be done manually by means of push button in either local control panel or automatically through the SAS / DCS.

6.3.6 **Starting time**

The total time from the receipt of the starting impulse for the generator set till set reaches rated speed and generator reaches rated voltage shall not be more than 10 seconds. If this time is

exceeded, and annunciation in the local control panel shall be provided with a facility for repeat annunciation in DCS / SAS.

6.3.7 **Black Start facility**

The generating unit shall be provided with all necessary 'black start' facilities. All DC supplies and chargers including batteries for start-up of prime mover shall be supplied along with the generator set.

All auxiliary motor shall be three phase, 415 V, 50 Hz squirrel cage type suitable for DOL starting or DC motor operating at 110 V. Insulation class of motors shall be class F with temperature rise limited to class-B. All motors shall have IP-55 enclosure.

7.0.0 **SYNCHRONISING**

7.1.0 The generator set shall be capable of being operated in either droop or isochronous or MW control governing modes, with the Unit Control Panel (UCP) providing both manual and automatic synchronising facilities.

7.2.0 The manual mode will allow the operator to adjust engine speed and generator voltage in order to match voltage, phase and frequency. When synchronism has been achieved, as indicated on the synchroscope, the generator circuit breaker can be manually closed. If the set is selected to droop mode it will be the responsibility of the operator to manually load the genset. If selected to isochronous the genset will be automatically ramped up to take up its share of the available load. For automatic synchronising, the operator will be required to depress an auto-synchronising 'initiate' pushbutton in order to activate the synchronising process. Engine speed and generator voltage will automatically be adjusted and, when conditions are correct, the generator circuit breaker will automatically be closed. If the set is selected to droop mode it will be the responsibility of the operator to manually load the genset. If selected to isochronous the genset will be automatically ramped up to take up its share of the available load.

7.3.0 Synchronising schemes shall be provided for the black start and emergency diesel generators circuit breakers, which will include the use of auto/off/check synchronizing selector switches on the diesel generator control panels.

7.4.0 **General**

Each generator set shall be provided with a Engine Equipment Cubicle (EEC), which is designed to operate in conjunction with the generator set UCP functions and also interfaces with various other auxiliary equipment.

7.5.0 **Engine Equipment Cubicle (EEC)**

7.5.1 An EEC shall be a 'low line' enclosure with a sloping top surface and contains that equipment, which for technical reasons must remain local to the engine (eg. the engine governor equipment), the generator set sequence control PLC, digital and analogue I/O, signal conditioning and hard wired trip circuits. The EEC shall incorporate a full colour touch sensitive LCD Operator Interface unit which will provide a comprehensive display of generator set operating parameters, sequence control and alarms together with fault reset facilities.

7.5.2 Control of the generating sets shall be from the UCP in the control room, control features in the EEC local to the engine are limited to start / stop / emergency stop / fuel selection and speed control.

7.5.3 The EEC will include a relay based (hard wired) shutdown system which will shut the engine down via the governor and trip the generator circuit breaker. This system will function independently of the

PLC and will shut the set down in the event of PLC failure. An audible and visual alarm is provided with full reset facilities.

7.6.0 **Unit Control Panel (UCP)**

7.6.1 **UCP Control Combination**

7.6.2 The Supplier may where design dictates combine the UCP with feeder/circuit breaker control and indication to form an integrated panel. The front panel shall be fitted with a touch sensitive LCD Operator Interface unit identical in appearance and function to that fitted to the EEC. Full engine control and monitoring shall be available at the UCP, where required all of the associated circuitry, sequencing and shutdown systems shall be located within the EEC. Internally the UCP includes the generator AVR, Diode Failure Monitor, Remote PLC I/O Expansion Cards, Transducers, AC and DC MCBs/ Fuses/Relays, Fluorescent Lamp. As a minimum the following panel controls and indicators shall be provided: -

| Panel | Controls | Instruments |
|---|---|---|
| Engine Equipment cubicas(EEC) | Maintenance/Local (control location) Key Switch.<br>Engine Start Pushbutton.<br>Engine Stop Pushbutton.<br>Emergency Stop Pushbutton.<br>Illuminated Push Button - Droop Control.<br>Illuminated Pushbutton – Isochronous Control. | MMI – Colour unit with touch sensitive screen.<br>Engine Speed Indicator 0-900 RPM.<br>Audible and visual alarm indication. |
| Generator Set Unit Control Panel (UCP) | Speed Raise/N/Lower Switch.<br>Voltage Raise/N/Lower Switch.<br>Circuit Breaker Trip/N/Close Switch.<br>Manual/Off/Auto Sync Switch.<br>'Initiate Auto Sync' Pushbutton.<br>Deadbar Override Pushbutton. | Meters suitable for unbalanced loads, complete with repeat output to the PLC / MMI, displaying as a minimum the following parameters:<br>Kilowatts Kilovars<br>Line Volts x 3 Line Amps x 3<br>Power factor Frequency<br>Generator Circuit Breaker Open Indication Lamp.<br>Generator Circuit Breaker Closed Indication Lamp. |
| Synchronising Panel (On Trolley ) | Synchronising Selector Switch (ON/OFF– key trapped in Off). Commen synchronizing check relay. | 360º Synchroscope.<br>Incoming & Running Voltmeter.<br>Incoming & Running Frequency Indicator. |

An audible and visual alarm is provided with full reset facilities.

7.7.0 **Tests**

7.7.1 DG sets shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished.

7.7.2 Routine tests shall be carried out for all the equipment (Generator, AVR, Exciter etc) as per applicable standards. Copies of certified reports of all tests carried out at the works shall be furnished.

7.7.3 The following acceptance test shall be carried out on DG set at Shop and as well at Site. Load bank with resistive load should be in 4 steps (Load bank should be installed permanently) and fuel for testing shall be supplied by the Bidder without any extra cost.

- Load test
- 10% Over load test for one hour after the full load test
- Voltage and speed Regulation test
- Insulation resistance test
- High voltage test
- Functional test
- Measurement of vibration level
- Performance of DG set
- Any other any special/Statutory test as laid down by CPCB.

7.8.0 **Painting**

All metal surfaces shall be thoroughly cleaned of scale, rust and grease etc. prior to painting. Cleaned surfaces shall be given two coats of primer and prepared for final painting. Final shade shall be of approved colour which will decided during detailed engg. Final finish shall be free from all sorts of blemish.

8.0.0 **SPECIFIED TECHNICAL DATA**

**A DIESEL GENERATOR**

| | | |
|---|---|---|
| 1 | Cycle | 4 stroke |
| 2 | Turbo-charging type | Pulse with air cooled after-cooler |
| 3 | Circulating lube oil tank | 3 minute storage of total flow of oil for cooling and lubrication |
| 4 | Aftercooler fan | 1 Engine driven + 1 A.C. motor operated during standby |
| 5 | Fuel oil filter (Duplex type) | 2 sets (1 installed + 1 stored)<br>Filter element: SS310 |
| 6 | Lube oil filter (Duplex type) | 2 sets (1 installed + 1 stored)<br>Filter element: SS310 |
| 7 | Fuel feed pump | 1 Engine driven + 1 A.C. motor operated during standby<br>MOC: Impeller, Shaft – SS310 |
| 8 | Fuel pressure pump (if applicable) | 1 Engine driven + 1 A.C. motor operated during standby<br>MOC: Impeller, Shaft – SS310 |
| 9 | Lube oil pump | 1 Engine driven + 1 A.C. motor operated during standby<br>MOC: Impeller, Shaft – SS310 |
| 10 | Cooling medium circulating pumps | 2 x 100% A.C. motor driven<br>Material of Construction<br>MOC: Impeller, Shaft – SS310 |
| | Heat Exchanger | MOC: SS tubes |
| 11 | Air cooler | 1. Finned tube construction, of SS (tube + fins) OR SS tubes + 300 µm epoxy coated aluminium fins.<br>2. 1 $m^3$ (1000 litre) make-up tank integral to air cooler, mounted above the cooling oil pumps.<br>3. Capacity: 150% of total heat capacity. |
| 12 | Inlet air filter | 2 sets (1 installed + 1 stored)<br>Filter element: SS310, Canister type |
| 13 | Exhaust Duct & Silencer | MOC: SS. |

| | | |
|---|---|---|
| 14 | HSD Storage tank | Design Standard: API 650.<br>MOC: SA 516 Grade 70.<br>Internal coating:<br><br>a). Top of bottom plate to 1 metre of bottom shell: Fibre glass with reinforcement epoxy with 1600 microns thick.<br>b). Rest of the surface, including top shell: Primer – Amine adduct cured HD coal-tar epoxy.<br>c). Internal Floating suction |
| | HSD forwarding pump | 2 x 100% A.C. motor driven,<br>MOC of Impeller & Shaft : SS304/SS310,<br>Body: SA 516 Gr.70<br>Motor: IP54 |
| | HSD unloading/fill pumps | 2 x 100% A.C. motor driven,<br>MOC of Impeller & Shaft : SS304/SS310,<br>Body: SA 516 Gr.70<br>Motor: IP54 |

# VOLUME - III

# SECTION - 3

# DETAILED TECHNICAL SPECIFICATION - ELECTRICAL

# SUB-SECTION - 3.13

# ILLUMINATION SYSTEM

**VOLUME - III**

**SUB-SECTION - 3.13**

# ILLUMINATION SYSTEM

## 1.0.0 GENERAL

This specification covers the design, manufacture, supply, erection, testing and commissioning of Illumination System required for the entire power plant and its offsites. Temporary Illumination System for construction site is also included.

It is not the intent to specify completely herein all details of the equipment, nevertheless, the equipment shall be complete and operative in all respects and shall conform to the highest standard of engineering, design and workmanship.

## 2.0.0 SCOPE OF WORK

The scope of work shall include but not limited to the following:

- Lighting fixtures with lamps and accessories for normal and emergency lighting.
- Lighting panels & receptacle panels
- Lighting poles / towers
- Temporary Illumination system for construction site
- Required quantity of conduits, wires, lighting cables, switch boards, junction boxes, supports and other accessories.
- Mandatory spares as listed in Vol. II / Section-1.0 and recommended spares for two (2) years trouble free operation.

## 3.0.0 CODES & STANDARDS

- IS : 6665 : CODE OF PRACTICE FOR INDUSTRIAL LIGHTING
- IS : 3646 : CODE OF PRACTICE FOR INTERIOR ILLUMINATION
- IS : 1944 : LIGHTING FOR ROADS WITH SPECIAL REQUIREMENTS.

## 4.0.0 TECHNICAL REQUIRREMNET

### 4.1.0 Design features

4.1.1 The Plant Illumination System shall consist of the following:

- Normal AC Lighting
- Emergency AC Lighting
- Emergency DC Lighting

4.1.2 The illumination system shall provide lighting supply to all plant areas. In addition, it shall also provide emergency lighting to selected areas during plant emergency conditions.

4.1.3 Normal AC lighting shall be provided by AC lighting fixtures distributed throughout the plant. AC lighting fixtures shall be fed from respective area lighting panels, which in turn shall be connected to main lighting distribution board. The lighting distribution board is fed through 1 : 1 lighting transformer.

4.1.4 Normal AC lighting and emergency AC lighting together shall provide 100% lighting to the plant. At least 25% of the total lighting in a particular area shall be fed from AC emergency lighting distribution board. Emergency lighting distribution board shall receive supply from the emergency bus section of Station Switchgear through 1:1 lighting transformer.

4.1.5 For control rooms, other strategic locations and exit/entry points, DC emergency lighting shall be provided. Emergency DC lighting shall be fed by station battery and shall switch on automatically on AC supply failure.

**4.2.0 Illumination level**

4.2.1 The Contractor shall design the lighting system such that the average lux level specified is achieved. The average level of illumination at different locations of the power plant shall be as under:

| Location | | Illumination level (lux) |
|---|---|---|
| Control room, control equipment room, testing laboratories | : | 400 |
| Office rooms, Relay rooms | : | 300 |
| Switchgear rooms, MCC room | : | 300 |
| Turbine hall | : | 200 |
| Air compressor house, Pump house and water treatment plant. | : | 150 |
| Battery room | : | 200 |
| Basement floors, boiler house including platforms, cable galleries, passages, stairs, and toilets. | : | 100 |
| Gas conditioning area (outdoors) | : | 50 |
| Outdoor transformer yard & switchyard | : | 30 to 50 |
| General yard lighting | : | 20 |
| Street lighting: | | |
| Main roads | : | 20 |
| Secondary roads | : | 10 |

4.2.2 In illumination design, lamp ageing factor and maintenance factor shall be suitably considered. The maintenance factor shall not be more than 0.8 for control room/ office area and 0.7 for other areas.

4.2.3 The minimum illumination level at any point shall not be less than 75% of the average levels mentioned.

4.2.4 The illumination levels for different areas shall be guaranteed. While measuring the illumination levels for this purpose, aging factor and maintenance factor considered in the design will be applied (i.e) the illumination levels measured for the new installation have to be that much higher than the

illumination levels specified. The illumination level shall be at the working plane for office areas, control room and laboratories and at floor level for other areas.

4.2.5 All the lamps shall be of energy efficient type. Antiglare type fitting shall be provided for control room.

**4.3.0 Lighting Controls**

4.3.1 All indoor lighting fixtures shall be provided with selective switch control or group control as per layout requirements. Generally the lighting load in an individual MCB circuit shall be limited to about 1500 watts. For all outdoor lighting, control shall be automatic using photo cells/timer.

**4.4.0 Lighting fixtures and lamps**

4.4.1 The lighting fittings shall be designed for an operating voltage of 240 V ± 10%, 50 Hz, ±5%, 1 phase AC supply.

4.4.2 Fluorescent fixtures with electronic ballast shall be generally provided for a room height upto 5m. Fluorescent fixtures shall be of high efficiency T5 lamp type. Type of fixture shall be industrial trough type with vitreous enamelled reflector or decorative type to suit the aesthetics. For corrosive areas, corrosion proof lighting fixture shall be provided and for hazardous areas flame proof type equipment shall be used for lighting fixtures and associated equipment.

4.4.3 Medium bay type of lighting fixture with HPMV lamps shall be used depending on the mounting heights for indoor areas having room height more than 5m and upto 10 m. For heights greater than 10 m high bay HPMV fixture shall be used.

4.4.4 For outdoor areas such as roads, street, Transformer area and open yards, HPSV lighting fixtures shall be used. Metal halide lighting fixtures shall be used for HRSG area.

4.4.5 For areas like HRSG and outdoor areas such as roads, street, Transformer area and open yards, HPSV lighting fixtures shall be used.

4.4.6 Peripheral lighting through 150W HPSV lamps at a spacing of not more than 50 m shall be provided through out the plant boundary. Alternate lighting switching arrangement shall be provided for energy conservation. Peripheral lighting shall be designed so as to cover all corner areas of plant boundary.

4.4.7 For false ceiling areas recessed mounted decorative fixtures with mirror optic louvres shall be used. For areas like boiler platforms well glass type HPSV fixtures shall be used.

4.4.8 DC lighting fixtures shall have fluorescent lamps rated for 110V DC +10% -15%. 125V DC emergency lighting shall be provided in GTG area, if required.

4.4.9 Flood lighting shall be provided for general area illumination.

4.4.10 The lighting fixtures shall be designed for minimum glare and the finish shall be smooth and scratch resistant. In control room area lighting shall be by means of concealed diffusion fluorescent strip lighting with antiglare features giving a good light distribution in the control room.

4.4.11 The fixtures shall be suitable for cable / conduit entry. High bay fixtures shall have provision for vibration damper in turbine hall to ensure rated lamp life. The fittings shall be of high power factor type.

4.4.12 Lighting fixtures shall be complete with lamps, holders, ballast, capacitor, starter, ignitors, cable glands etc.

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4.4.13 The fixtures shall be fully wired upto respective terminal blocks, suitable for connection of PVC wires of size 2.5 mm¨ copper. All fixtures shall have provision for earth wire connection.

4.4.14 In multi lamp-fixtures, each lamp shall be provided with individual electronic ballast. Ballast for mercury vapour shall be of copper wound provided with suitable tappings to set the voltage within range specified.

4.4.15 Lighting fixtures shall not be mounted on switchyard towers.

4.4.16 All lighting fixtures and accessories shall confirm to applicable Indian Standards and shall be of the type readily replaceable by the available Indian make.

4.4.17 Degree of protection for flood light fixtures shall be IP 55. Street light fixtures and all outdoor fixtures shall be weather proof.

**4.5.0 Lighting DB, Lighting transformer & Lighting Panel**

4.5.1 The main and emergency AC lighting distribution boards and emergency DC lighting distribution boards shall be as per specification given in LT Switchgears.

4.5.2 The transformer for AC ELDB / MLDB shall be dry type, 415 / 433V rated, AN cooled, Dyn11 type. It shall be used to feed power to the lighting loads and suitable for mounting inside the lighting distribution board. The windings shall be provided with class - F insulation limiting temperature rise to class 'B' limits. Transformer shall be provided with off circuit tap changer with + 5% to -5% range in steps of 2.5%.

4.5.3 The lighting panels shall be rated for 415 V, 3 phase, 4 wire, AC with neutral bus and suitable for either wall/column mounting. Indoor panels shall have degree of protection of IP 54 and the outdoor panels shall be weather proof with canopy, IP 55.

4.5.4 The panel bus bar shall be of electrolytic grade copper, sized for a maximum temperature of 90°C colour coded for easy identification of phase and neutral bus bars.

4.5.5 The cable/conduit entry shall be either from the top or bottom with removable cable gland plates and shall be terminated in suitable separate terminal blocks.

4.5.6 Provision shall be made for grounding the panel at two points. A copper earth bus shall be run along the length of the panel. The front access door of the panels shall have padlocking arrangement.

4.5.7 The incoming to each Normal and Emergency AC lighting panel shall be provided with a triple pole MCB with neutral isolating facility and one earth leakage circuit breaker. Combined type triple pole MCB and earth leakage circuit breaker are also acceptable for incomers to lighting panels.

4.5.8 Normal and Emergency AC lighting panels shall have outgoing MCBs having thermal elements for overload protection and an instantaneous magnetic trip to protect against severe faults. All MCBs provided shall be suitable for breaking capacity of 10 kA (minimum) at 240 V AC. ELCB of suitable sensitivity shall be provided.

4.5.9 The Emergency DC lighting panels shall have Incoming and outgoings feeders with HRC Switch fuse units or MCB units with back up fuse as required.

4.5.10 The Lighting panels shall be of double door type with the outer enclosure made of sheet steel having minimum thickness 2 mm with a hinged door and suitable locking arrangement.

**4.6.0 Cables / Wires**

4.6.1 The cables shall conform to the specification given in Power and Control Cables.

4.6.2 The lighting wires in conduit shall be 1100 V grade, PVC insulated stranded copper conductors of minimum size 2.5 mm². These shall be colour coded as per relevant IS standards.

4.6.3 The wiring from lighting panels to lighting fixtures/switch boards/junction boxes/ receptacles etc. shall be done by PVC copper wires in GI conduit and PVC insulated cables as per the requirement for indoor and outdoor areas respectively.

4.6.4 The cables from main lighting distribution boards to lighting panels, street lighting, area lighting shall be by 1100V grade armoured power cables with stranded aluminium / copper conductor.

4.6.5 The wiring in hazardous areas shall be by flame proof junction boxes & armoured cables.

**4.7.0 Switch and switch boards**

4.7.1 The switch boards shall be of surface/flush mounting type with bent steel construction, fabricated with 14 SWG MS sheet with sheet steel cover. The switch boards shall have conduit knock out on the sides. Each switch board shall be provided with one (1) no. 5 A flush type receptacle with the plug projecting outside. The switches shall be of quick make and quick break type and shall be of plate type.

4.7.2 The conduits, switch box etc. shall be flush mounted in places such as office rooms, false ceiling areas.

**4.8.0 Lighting Junction box**

4.8.1 The junction boxes shall be of cast iron or die cast aluminium (LM 6) dust and weather proof. The junction boxes shall be complete with gasketted inspection cover, conduit knock out/ threaded hub/ cable entry and terminal blocks.

4.8.2 Multiway terminal blocks complete with screws, nuts, washers and marking strips shall be furnished for connection of incoming/outgoing wires in the junction boxes. Each terminal shall be suitable for connection upto two (2) nos. 2.5 mm² copper conductors.

**4.9.0 Lighting poles and towers**

4.9.1 Lighting poles shall be swaged type tubular poles of suitable height as per relevant standards complete with, weather proof junction box and all other accessories. The pole shall be coated with bituminous compound paint on inside as well as outside for the embedded portion. Outside shall be coated with one coat of red- oxide primer and finished with two coats of aluminium paint.

4.9.2 Lighting towers shall be of hot dip galvanised steel lattice structure with platforms or of raising lowering type steel tubular structure.

4.9.3 A weather proof marshaling box with water tight hinged door and suitable locking arrangement shall be provided at the bottom of the each flood lighting pole/ tower. This box shall contain HRC fuses, neutral links, terminal blocks, ground studs etc. GI conduits shall be embedded in muff for incoming and outgoing cables.

### 4.10.0 Conduits and Accessories

4.10.1 Conduits shall be of rigid steel, hot-dip galvanized, furnished in standard lengths threaded at both ends. Minimum diameter of conduits shall be 20 mm. All conduits shall be heavy duty suitable for electrical installation. Sizing of conduit shall be based on maximum 40% fill criteria. Conduits shall be complete with all accessories such as bends, ties, couples, inspection box, etc.

4.10.2 Flexible conduits where required, near equipment terminations, shall be made with bright, cold rolled, annealed and electro-galvanized mild steel strips. In corrosive areas, epoxy coated conduits shall be provided.

### 4.11.0 Flush type indoor receptacles

Flush type receptacles shall be provided for office rooms, control rooms and wherever false ceiling has been adopted. These shall be so located that only the plug projects outside and shall be rated for 5/15 A, 240V, AC. The receptacle shall be complete with switch housed in sheet steel enclosure.

# VOLUME - III

# SECTION - 3

# DETAILED TECHNICAL SPECIFICATION - ELECTRICAL

# SUB-SECTION - 3.14

# COMMUNICATION SYSTEM

**VOLUME - III**

**SUB-SECTION - 3.14**

**COMMUNICATION SYSTEM**

## 1.0.0 GENERAL

This specification covers the design, manufacture, supply, erection, testing and commissioning of complete Communication System.

It is not the intent to specify completely herein all details of the equipment, nevertheless, the equipment shall be complete and operative in all respects and shall conform to the highest standard of engineering, design and workmanship.

## 2.0.0 SCOPE OF WORK

The scope of work shall include but not limited to the following :

- Page and Party System with Master station & Slave Station.
- Telephone system shall be extended from existing exchange and new telephone sets to be considered for the Power Plant.
- Power, Communication and Telephone cables.
- Conduit, conduit accessories, junction and pull boxes, as required.
- Grounding materials and connections.
- Mandatory spares as listed in Vol. II / Section-1.0. and recommended spares for two (2) years trouble free operation.

## 3.0.0 CODES & STANDARDS

The communication system shall be designed, manufactured in accordance to the latest relevant IEC/IS as amended up to date and Indian Telephone Department (ITD) standards.

## 4.0.0 TECHNICAL REQUIREMENTS

### 4.1.0 Page and Party System

4.1.1 The system shall provide for quick and reliable communication between plant personnel located in different areas. The design shall be such as to provide two-channel communication.

4.1.2 The Plant Communication System is an open line communication system which comprises Master control stations, Field Handset stations and Speakers with amplifiers controlled by a Central Control Exchange. Master control stations shall be located at various control rooms which control the communication among the field handset stations. Field handset stations are spread all over the plant.

4.1.3 The design shall be such as to provide highly intelligible two-channel voice communication even in areas of high background noise (50 db to 100 db).

4.1.4 The Plant UPS power supply shall be utilized for the Plant Communication System. Alternatively independent battery backed up system shall be provided.

4.1.5 Equipment shall be sturdy, impact resistant, dust and damp-proof generally conforming to IP:54 degree of protection. Equipment for outdoor shall be weather proof type conforming to IP-55 and shall be provided with canopy. All equipment and accessories shall be given tropical protection against fungus, insects and corrosion. Equipment shall be made tamper-proof by use of non-standard screws which can be opened only by means of special keys. Solid state components shall be used throughout and assembled in plug-in type modules.

4.1.6 Page and party system shall comprise of one channel for paging and preferably 4 channels for party talks to enable 4 individual parties to talk simultaneously and independently in party mode without any interference.

4.1.7 On the private mode, conversation should not be heard over the loudspeaker but it shall be carried out on the telephone handsets. This mode shall be used for actual conversation, exchange of information and issue of all specific instructions to the concerned personnel.

4.1.8 This system shall essentially comprise of a number of communication stations each of which shall be provided with a telephone handset, loudspeaker amplifier, a hook, micro switch (spring return to normal), a loudspeaker muting switch, volume control, etc.

4.1.9 It shall be possible to make a paging call by lifting the handset, off the hook switch and pressing the "press to page" switch. This shall initiate a call attention sound to be transmitted to all the speakers to ensure that the initial part of the announcement should not be missed and gets off automatically after a preset time. The paging message can then be transmitted over the loud speakers when the paging person shall speak in the microphone of the handset.

4.1.10 While paging under this system it shall automatically mute the loud speaker near the paging handset to eliminate the acoustic feedback.

4.1.11 The above system shall be distributed type i.e. each handset station/loudspeaker shall have its own pre-amplifiers, line amplifiers suitable for long line signal transmission and power amplifier to suit loudspeaker capacity etc.

4.1.12 The master station shall be desk mountable, complete with microphone, speaker, selector switches (one for each communication station), call registering device, LED indication for each communication station, ,'ALL CALL' switch, Emergency hooter switch, loud speaker mute switch, and all other associated auxiliaries and accessories.

4.1.13 The master station shall be provided with the following modes of operation.

- Paging (selection of communication station or 'ALL CALL').
- Private talk and talk back facility.
- Conference facility, etc.

4.1.14 The slave station shall be wall/column/structure mounted conventional telephone type complete with sensitive microphone ear piece, coiled cord retractable cable of atleast 2 m length and loud speaker. It shall have push button feedback switches on the front panel for two independent channel namely page and private channel operation along with function switch and necessary control and indication facilities. Each station shall be complete with its own pre-amplifier, signal processing and power amplifier. For hazardous area flame proof sets are to be installed.

4.2.0 **Telephone System**

4.2.1 Telephone system shall be extended from existing system located in existing CPP control room.

4.2.2 The telephone sets are to be installed in various areas of power plant.

4.2.3 All telephone sets shall be of modern attractive design. Shell and handset shall be made of high impact-resistant, dust tight and temperature resistant plastic. The push button set design shall be supplied. All kinds of sets shall be equipped with snap-in modules for the push-button units, tone signal source, handset and signaling buttons. The tone signal source shall be infinitely adjustable in volume.

4.2.4 The handset shall be equipped with high quality transmitter and receiver insets. The push button mechanism shall be compatible with all dial systems according to ITD recommendations.

4.2.5 The Telephone system shall be provided with all modern features such as, extension features, intrusion, call waiting, internal add-on conference, external add-on conference, abbreviated dialing, call division, intercept calls, call monitoring and billing etc.

4.2.6 In hazard areas such as oil storage, wall telephone sets with explosion proof and corrosion resistant metal cases shall be provided.

**4.3.0 Cables**

4.3.1 The power supply to all the subscriber stations shall be through multicore annealed, tinned, stranded copper conductor, PVC insulated, PVC sheathed, GI round wire armoured, overall FRLS PVC sheathed power cable.

4.3.2 The signal cable shall be twisted pair, annealed tinned, stranded Copper conductor, PVC insulated, PVC sheathed with electrostatic screening and GI round wire armoured with overall FRLS PVC sheath.

4.3.3 Conductor size and no. of pairs/cores shall be chosen to suit the application.

**4.4.0 Junction box/Telephone Tag box**

The Junction boxes/Telephone tag boxes shall be of galvanized steel or die-cast aluminium alloy construction with IP-55 degree of protection. It shall be complete with double compression type cable glands suitable for terminating or looping armoured signal/power cables and earthing stud. It shall be suitable for wall/column/structure mounting.

# VOLUME - III

# SECTION - 3

# DETAILED TECHNICAL SPECIFICATION - ELECTRICAL

# SUB-SECTION - 3.15

# POWER AND CONTROL CABLES

**VOLUME - III**

**SUB-SECTION - 3.15**

**POWER AND CONTROL CABLES**

## 1.0.0 GENERAL

This specification covers the design, manufacture, supply, erection, testing and commissioning of Power and Control Cables.

It is not the intent to specify completely herein all details of the equipment, nevertheless, the equipment shall be complete and operative in all respects and shall conform to the highest standard of engineering, design and workmanship.

## 2.0.0 SCOPE OF WORK

The scope of work shall include but not limited to the following:

- 66 kV, XLPE power cables
- 11 kV, XLPE unearthed grade power cables
- 1.1kV, PVC power cables
- 1.1kV grade PVC control cables
- Special cables for excitation system etc.
- Special cables for cranes, hoists, etc.
- Heat resistant cables.
- Fire proof cables

## 3.0.0 CODES & STANDARDS

- IS 1554 : PVC insulated (heavy duty) electric cables.
- IS 7098 : Cross-linked polyethylene insulated PVC sheathed cables for working voltages upto and including 33 kV.
- IS -3961 : Recommended current ratings for cables.
- IS -3975 : Specification for Mild steel wires, formed wires & tapes for armouring of cables.
- IS -8130 : Specification for conductors for insulated electric cables & flexible cords.

Cables shall also conform to other relevant IS /IEC standards amended up to date.

## 4.0.0 TECHNICAL REQUIREMENT

### 4.1.0 Design Criteria

4.1.1 Power cables shall be sized to satisfy the following Criteria:

- System short circuit current.
- Derating factors due to higher ambient temperature and grouping of cables.
- Continuous current rating.
- Voltage drop during starting and continuous operation.
- Standardisation of the cable size to minimise too many sizes of cables.

4.1.2 Power cables shall withstand the fault current of the circuit for the duration not less than the max. time taken by the primary protective system to isolate the fault. Cables shall be sized for the following short circuit rating.

| | | |
|---|---|---|
| Cables from 11kV Switchboard to LT transformers | : | 40 kA for 0.16 sec. |
| Cables from 11kV Switchboard to Motors | : | 40 KA for 0.16 sec |
| Incoming cables to 415 V PMCC (Breaker operated) | : | 50 kA for 1 sec. |
| Cables from 415 V PMCC to Motors | : | 50 kA for 0.16 sec ACB operated |
| Tie / Incomer feeders at 11kV if any | : | 40kA for 1 sec |

4.1.3 To maintain voltage at motor terminals /equipment end with in desirable limit, it is proposed to limit the voltage drop in the cables with in the following limits:

| | |
|---|---|
| Steady state Voltage drop (Continuous running condition) | : 3% |
| Transient state voltage drop (During Motor Starting) | : 10 % |

4.1.4 Following design ambient shall be considered while sizing the cables.

| | | |
|---|---|---|
| Design Ambient Air Temperature | : | 50 degree C |
| Ground Temperature | : | 40 degree C |

4.1.5 Cables installed in hot areas shall be specially designed for that ambient temperature.

4.1.6 Cables shall be adequately sized to take care of any derating due to fire stop cable sealing/fire resistant coating.

4.1.7 Separate cables shall be provided for circuit of different plant and auxiliaries for different voltage levels and for circuits fused separately. Power, control and instrumentation circuits shall be taken through separate cables.

### 4.2.0 Constructional requirement

4.2.1 Power Cables up to 300sqmm size shall be of Multicore cables. For above 300sqmm size single core cables shall be considered. All 11kV power cables shall be XLPE insulated. LV power cables shall be XLPE insulated type.

4.2.2 XLPE insulation shall be suitable for continuous conductor temperature of 90 °C and short circuit conductor temperature of 250°C.

4.2.3 66 kV cables will be of stranded copper conductor, Triple extruded insulation with field limiting layers of cross linked polyethylene, bedding tapes, copper screen in longitudinally water tight embedding, crepe paper, copolymer coated aluminum tape.

4.2.4 11kV cables shall be 11/6.35kV (UE) grade (suitable for 11 kV unearthed system) multi stranded compacted copper conductor, XLPE insulated, screened, extruded PVC inner sheathed, armoured, overall FRLS PVC sheathed cables conforming to IS 7098.

4.2.5 LV Power cables shall be of 1.1 kV grade, XLPE insulated, PVC inner sheathed (extruded), armoured, FRLS PVC outer sheathed, compacted Copper conductor upto 10 sq.mm and above 10 sq.mm aluminium conductor. LT XLPE cables shall be conforming to IS 7098-Part- & LT PVC cables shall be conforming to IS 1554.

4.2.6 Control cables shall be of 1.1 kV grade, multicore, XLPE insulated, PVC inner sheathed, armoured, FRLS PVC outer sheathed stranded copper conductor conforming to IS: 1554.

4.2.7 The signal cables shall be of 650 / 1100V grade, 0.5 sq. mm, single pair / multipair, stranded copper conductor, PVC insulated, cores laid up, extruded PVC inner sheathed, armoured and extruded FRLS PVC outer sheathed.

4.2.8 For single core armoured cables, armouring shall be of aluminium wire. For multicore armoured cables, armouring shall be of galvanised steel strip/wire as per applicable IS.

4.2.9 The cable cores shall be laid up with fillers between the cores wherever necessary. All the cables shall have distinct extruded PVC inner sheath.

4.2.10 Conductor of Copper cables shall have plain annealed copper. All the conductors shall be multi-stranded.

4.2.11 Cables shall be suitable for laying on racks, in ducts, trenches with chances of flooding by water and shall also be suitable for directly buried installation. All the cables shall be flame retardant low smoke (FRLS) type designed to withstand mechanical, electrical and thermal stresses developed under steady state and transient operating conditions.

4.2.12 Outer sheath shall be of PVC black in colour having following FRLS properties.

- Oxygen index of not less than 29.
- Acid gas emission of max. 20%.
- Smoke density of not more than 60%.

4.2.13 The cables shall meet flammability test as per IEEE – 383.

4.2.14 All the cables shall be protected against rodent and termite attack. Necessary chemicals shall be added in to the PVC compound of the outer sheath.

4.2.15 Cables shall be supplied in wooden or steel drums of heavy construction. Wooden drums shall comply with IS 10418.

**5.0.0 TESTS**

Cables offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished. Routine tests, Acceptance tests and all special tests for FRLS properties shall be carried out for all the cables as per applicable standards. The sample shall be drawn at the rate of one per type and size for every lot offered for inspection.

# SECTION - 3

# DETAILED TECHNICAL SPECIFICATION - ELECTRICAL

## SUB-SECTION - 3.16

## EARTHING & LIGHTNING PROTECTION SYSTEM

**VOLUME - III**

**SUB-SECTION - 3.16**

**EARTHING & LIGHTNING PROTECTION SYSTEM**

## 1.0.0 GENERAL

This specification covers the design, manufacture, supply, erection, testing and commissioning of earthing and lightning protection system of the complete plant.

It is not the intent to specify completely herein all details of the equipment, nevertheless, the equipment shall be complete and operative in all respects and shall conform to the highest standard of engineering, design and workmanship.

## 2.0.0 CODES & STANDARDS

| Code No | : | Description |
|---|---|---|
| • IS 3043 | : | CODE OF PRACTICE FOR EARTHING |
| • BS 7430 | : | CODE OF PRACTICE FOR EARTHING |
| • IEEE 142 | : | IEEE RECOMMENDED PRACTICE FOR GROUNDING OF INDUSTRIAL AND COMMERCIAL POWER SYSTEMS |
| • IEEE 80 | : | IEEE GUIDE FOR SAFETY IN AC SUBSTATION GROUNDING |
| • EEE 665 | : | STANDARD FOR GENERATING STATION GROUNDING |
| • IS 2309 | : | CODE OF PRACTICE FOR LIGHTNING |
| • CBIP MANUAL | : | DESIGN OF EARTHING MAT FOR HIGH ON SUBSTATION VOLTAGE SUBSTATION |

## 3.0.0 EARTHING SYSTEM

The Earthing & bonding system at each electrical installation will be provided in accordance with IS 3043 / BS 7430 and IEE wiring regulations.

In order to avoid risk of serious electric shock due to hand touch potentials it is important to provide a direct path for earth leakage currents to operate the circuit protection, and to maintain all installation metalwork at equal potential. Earthing system will be in line with the 'TN-S'. The 'TN-S' system of Earthing that will be adopted will employ direct connection of the supply system neutral earth, with connection of the each equipment to the earthed neutral of the power source via protective conductors formed by combination of earth mat and earth branch conductor connection to the mat for each equipment.

Plant earthing at each of the different locations will be formed by means of buried earth conductors arranged in a ringed mesh to form a earth mat along with earth pits and Earthing electrodes. All building floors will also be provided with earth conductor flats embedded in each of the floor with 50 mm concrete cover on the floor conductors. Necessary riser conductors will be provided at each sites / building floors to bond electrical equipment enclosures to earth and to both all non electric metallic structures, pipes, process equipment to the earth mat.

The earth resistance of each site will be as low as is practicable, but will in any event be such that the electrical resistance between the earth grid and the general mass of earth ensures the operation of all electrical protective devices. The overall earth resistance at each site will be less than 1.0 ohm.

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The main Earthing mat/ring conductors at each plant site will be G.I Flats having a minimum cross sectional area of 75x10mm. The plant site earth grid will be connected to the remote power source end neutral Earthing system by 2 numbers of 75x10 mm bare G.I flats or by appropriate Al/PVC earth return cables. The earth electrodes driven vertically into the soil will be formed preferably by 32 mm or 40 mm dia GI earth electrode rods. The earth rods will be as long as possible with couplings provided to obtain the necessary overall depth of the driving rod required. The connections between electrode heads and conductors will be so executed that easy inspection and testing of the earth resistance of individual electrodes is possible, without disconnecting the Earthing conductors from one another.

The Earthing of cable trays / pipe conveyor / pipe racks will be effected by running 2 runs of at least 50 x 6 mm GI flats laid along the full length of the trays/racks with the earth flats connected to the GI earth electrodes at regular interval of 25 mm along the route by means of suitable vertical droppers.

All Earthing terminals will be made with compression cable lugs. Interconnections will be directly made using thermo weld or compression branch connectors.

Branch earth conductors connected to individual switchgear and control gear assemblies will be sized so that their total cross sectional area is capable of carrying the short circuit current capacity of that particular assembly.

Substation switch boards, motors, sub DB's & other main electrical equipment will be connected to earth bar by two Earthing conductors, and electrical auxiliary panels by a single Earthing conductor.

The metallic enclosures of all items of electrical equipment will be bonded to the main earth mat. The metallic enclosures of non-electrical equipment shall also be bonded to the main earth ring.

The cross sectional area of branch GI conductors connecting equipment and structures to the main earth ring will be:-

- Generator / NGTR - 75 x 10 mm GI flat.
- Metallic structures / column, Mechanical tanks/Vessels etc. - 50 x 10 mm GI flat.
- Transformer / NGR - 75 x 10 mm GI flat.
- HV Motor - 50 x 10 mm GI flat.
- HV Switchgear 75 x 10 mm GI flat.
- PCC / MCC - 75 x 10 mm GI flat.
- Cable Trays/Risers - 75 x 10 mm GI flat.
- LV Motors :-
  - $\geq$ 90 kW - 50 x10 mm GI flat.
  - $\geq$ 30 kW up to 90 kW - 50 x 6 mm GI flat.
  - $\geq$ 5 kW to 30 kW - 25 x 6 mm GI flat.
  - < 5 kW - 8 SWG GI wires.
- Lighting panels/poles/ Local control station/ Miscellaneous equipment. - 8 SWG GI wires.

All machine package equipment, vessels, tanks, exchangers etc in which static charges are liable to be generated will be effectively earthed.

### Testing Requirements

The resistance measurement of the grounding system shall be made in accordance with IS standard after installation and periodically thereafter.

## 4.0.0 LIGHTNING PROTECTION SYSTEM

Lightning protection installation will be in accordance with BS 6651.

The lightning protection system for each building will comprise adequate horizontal roof conductors with appropriate number of down conductors connected to station earth via test points as per BS 6651.

Vertical Air Terminations rods will be provided to project 2.0 metre above the tallest item of the projected structure. The protective angle of the vertical terminations will be 30 degrees instead of the normal value of 45 degree to provide high degree of protection.

For facilitating a low impedance lighting path to earth, earth electrodes will be provided at the base of building. These electrodes will be connected to the building lightning protection system and will be interconnected with the station main buried earth mat by suitably sized earth conductors.

The metal works of the building structures, including steel reinforcement structures, including steel reinforcement in concrete will form part of the Earthing and bonding as per BS 6651. In order to avoid flashovers during lightning, all metallic structures in the vicinity of the lightning conductors will be bonded together.

| | Subject | Doc. No. | Rev. | Vol. / Sec. |
|---|---|---|---|---|
| | **BID PACKAGE FOR COMBINED CYCLE CAPTIVE POWER PLANT AT HAZIRA PLANT,GUJARAT** | **5111168-ME-SPC-100-001** | **R1** | **III / 3.17** |
| | | | | **Sheet No.** |
| | | | | **539** |

# VOLUME - III

# SECTION - 3

# DETAILED TECHNICAL SPECIFICATION - ELECTRICAL

# SUB-SECTION - 3.17

# CLOSED CIRCUIT TELEVISION (CCTV)

**VOLUME - III**

**SUB-SECTION - 3.17**

**CLOSED CIRCUIT TELEVISION (CCTV)**

## 1.0.0 GENERAL

The intent of the specification is to define the functional & design requirements for the CCTV System meant for gathering video information from the various operational areas of the power plant. The Tenderer shall be responsible for selection, design, engineering, manufacture, testing at manufacturer's works/ site, installation and commissioning of the system to the satisfaction of Owner/Owner's representative. All the cables, cable trays, power packs, erection hardwares etc. are also included in Tenderer's scope.

## 2.0.0 SCOPE OF WORK

The intent of the specification is to define the functional & design requirements for the CCTV System meant for gathering video information from the various areas of the power plant. The Contractor shall be responsible for selection, design, engineering, manufacture, testing at manufacturer's works/site, installation conforming to IS:1881, IS:1882 of all the equipments supplied as covered in this specification and commissioning of the system to the satisfaction of Employer meeting the intent & functional requirements of the specification. All the cables, cable trays, power packs, erection hardware (viz. junction boxes, brackets glands, nut-bolts, conducts etc.) are also included in CCTV Vendor scope .

Scope shall also include successful demonstration of performance testing specified herein complete in all respects. All equipment, accessories and facilities required for completeness of this system shall be furnished by the Contractor within the quoted price, whether these are specifically mentioned herein or not.

Submission of all drawings and documents required document data sheet.

## 3.0.0 CCTV SPECIFICATION

**The System Major Components**

1 Fixed cameras at strategic locations in the plant.

2 Remote-controllable PTZ cameras for site surveillance.
(Additional cameras should be added if required to cover the overall plant

3 Telephone jacks at each camera.

4 2 no. video monitors to be installed in the central control room. 1 no. video monitors in Security Building / Gate house .

5 Video Switches/Controller and DVR 30 days (720 hours) of real time recording

6 Two identical consoles one for central control room , one for Security Building / Gate House

7 Camera enclosures suitable for the environment.

8 All cabling from cameras to the central control room including telephone wiring.

9 Camera supports for CCTV

10 Sound powered phones for setting-up and maintenance communication.

11 Miscellaneous hardware necessary to complete installation of the above items.

PTZ cameras will be digital colored with motorized zoom lenses.

The cameras will be furnished in pan and tilt weather proof outdoor corrosion resistant housing units.

The housing units will include sun shade and wiping system with following specifications :

1) Protection class IP-66 weather proof system.
2) Operating environment: 0°C to 75°C.
3) Humidity 0-100%
4) Accepts AC & DC voltages.
5) Outdoor applications.

Camera will automatically adjust to set optimum contrast, high sensitivity, high resolution.

Two color monitors (24 inch diagonally) will be installed in Central Control rooms on the control consoles and one color monitors will be installed in security building.

Simultaneous remote centralized surveillance & selection of any cameras from both CCR & Security room is required.

Display of images shall be in multiplexed fashion.

Recording of images shall be in Real time fashion & playback facility of images required .

All camera images shall be continuously recorded . System offered shall allow to record & hold camera images for minimum period of 30 days . facility for transferring camera images to separate recorders. data storage devices & play back facility of the same shall be provided.

CCTV System shall be designed to operate for 24 hours a day and capable in night operation.

## 4.0.0 STANDARDS & REFERENCES

A. American National Standards Institute (ANSI)

CI National Electrical Code.

B. Electronic Industries Associations Standards (EIA)

RS – 312 Engineering Specification Outline for Monochrome CCTV Camera Equipment.

RS – 330 Electrical Performance Standards for Closed Circuit Television Camera 525/60 Interlaced 2:1

## 5.0.0 DESIGN REQUIREMENTS

5.1.1 The CCTV System offered by the Bidder shall be from reputed manufacturer who shall have designed, manufactured, tested and commissioned a distributed type CCTV systems as specified in large industrial installation as on the date of bid opening. All major equipment such as Cameras, Video Switcher/Control System, Key Boards, Receiver Drivers, Pan/Tilt Units, Post equalization Video amplifiers, Digital Video Recorder, (DVR) Archiving System etc. shall of the same make. In case the bidder wants to offer Dome type cameras for all applications are also acceptable.

5.1.2 The Contractor shall guarantee satisfactory performance of the equipment under stipulated variations of voltage and frequency.

5.1.3 The design and manufacture shall be such that equipment / components of same type and rating are interchangeable.

5.1.4 The number of camera units and their locations are included here in specification. All the above listed cameras shall be connected to respective microprocessor based video switcher/control system.

5.1.5 Any other equipment, module required for the safe and satisfactory operation, control, protection, monitoring, testing and maintenance of the system shall also be included by the Bidder within the lump sum quoted price.

5.1.6 The equipment furnished under this section shall meet the requirements of all the applicable codes and standards or their amendment International Codes and Standards.

6.0.0 **POWER SUPPLY ARRANGEMENT**

6.1.1 The CCTV System shall be powered from UPS system for microprocessor based switching / control unit, monitor, Digital Video recorder, etc. in the control room as well as for cameras to be located in the main plant areas and auxiliary plant areas.

6.1.2 For cameras to be located in the areas where the UPS power supply cannot be extended due to voltage drop etc., then 230V AC, 1 phase, 50 Hz power supplies shall be arranged by the Contractor from the respective area power supply system. In case the cameras cannot operate with the normal 230V AC, 1 phase, 50 Hz power supply system, mini UPS are to be provided by the contractor within his quoted lumpsum price.

6.1.3 If the offered equipment is operating at voltage level other than what has been specified in Sub-Section above, the Contractor shall provide all required hardware, within lump sum quoted price to make the offered system compatible with specified power supply arrangement.

7.0.0 **DESIGN AND TECHNICAL REQUIREMENTS**

7.1.1 The CCTV system shall be able to provide surveillance of different locations in the plant as listed at Appendix-1. Contractor to note that the locations indicated therein are tentative only. The exact locations shall be decided during detailed engineering.

7.1.2 The complete system shall be divided into the following zones:-

(1) One Zone For Each Of The Generating Unit.

(2) One Zone For Common Plant System.

8.0.0 **DETAILED DESCRIPTION OF THE SYSTEM COMPONENTS**

8.1.1 **Video Switcher/Control System**

a) The Video Switcher/Control System shall be Microprocessor based and modular in construction. The system shall have all required Controller Units, power supply system, input/output cards etc. It shall offer full matrix switching capability, i.e. the system shall be programmable to display the video from any camera on any monitor, either manually or via independent automatic switching sequences.

b) The Video switcher/Control System shall have provision for controlling all the associated camera units, monitors, keyboards, Digital Video Recorders, integral signal distribution unit and all other hardware/software including master/slave software etc. that may be required to make the system complete. The system shall also have 20 % spare provision for future expansion. Suitable wired in space in racks and corresponding handling capability in switcher/control system for 20% additional cameras shall be provided.

c) The Video Switcher/Control System shall be programmable with at least 50 sequences that can run independently of each other in either forward or reverse direction.

d) The video switcher/control system shall have easy provision for integral signal distribution ports, connections to on-site receiver/drivers. It shall have built-in alarm interface capability. Any monitor or group of monitors could be set to display cameras under alarm conditions. In addition, at least 16-character alarm title could be selected to appear instead of the camera title during alarm conditions.

e) The video switcher/control system shall include on screen display for time-date, camera number/camera ID, and status information. The system shall have provision for logging through printer output port, which provided permanent record of system status showing time and date of changes such as: incoming alarms, acknowledgement of alarms, loading of sequences, user long-on to key board, transfer of system tables and sequence, video loss messages, and a power up reset message, thus hard copy of the system's configuration tables and sequences can be obtained.

f) The video switcher/control system shall permit the design of a distributed matrix video switching system with control at one central location and individual control at the local sites. The main control site could view/control local cameras plus cameras located at any of the remotely distributed sites.

g) The video switcher/control system shall also have provision for connection to Large Video Screens (LVS) of each of the units. All the related hardware and software shall be provided by the Contractor. The unit level video switcher/control system shall be connected to at least one no monitor, one no. key board and requisite number of DVRs and cameras. The system shall also have the following provisions:

h) User friendly spread sheet/ equivalent format providing the ability to enter camera titles, operator name, timely events, change system parameters, program camera sequences and lockouts. It shall provide high performance programming, control and monitoring of all the system functions by using on-screen icons to reflect real time status of the devices being controlled by the system. Software shall also provide the ability to monitor system status events. Systems alarms, switching functions, sequence events, keyboard actions, and video loss information.

i) The video switcher/control system shall be able to provide complete system diagnostics. All the Station locations, where additional monitors and keyboards are to be provided for controlling all

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the station cameras shall be connected to this central video switcher/control system. The central archiving unit shall be connected to the video switcher/control system of the common plant zone.

j) The CCTV system shall have an interface to the Station LAN either through video switcher or DVR.

8.1.2 **Cameras**

a) The cameras shall be rugged, 1/4 inch / *1/3 inch* image format fully performance colour CCD cameras. These cameras shall provide high resolution and high sensitivity suitable for operation in a power plant, both in natural and artificial sighted areas.

b) The cameras shall have features as mentioned below :

- Suitable for night-time surveillance(Day/Night type)
- Manual or Automatic Colour/Black and White switching
- Automatic picture enhancement to give a balanced picture where there is too little/too much light.
- On screen menu display
- Back light compensation
- Automatic white balance, with mode selection options
- Synchronization selection for line lock and internal free-running.

c) Detailed technical specifications are as under :

- Imager Interline transfer CCD, 1/4 inch image format.
- Horizontal resolution 480 TVL in PAL B mode or better
- Sensitivity (at f1/4, 6dB) Scene illumination 0.7 Lux ( at 50 IRE colour) Signal-to-noise >50 dB.
- Automatic Gain Compensation Up to 18 dB.
- Shutter Speed 1/50-1/1, 00,000 sec or equivalent.
- Lens Mount Video Iris/DC Drive Iris.
- Day Night selection ON / OFF / Forced.
- Power Supply As per manufacturers standard practice, to be arranged by the contractor.

8.1.3 **Lens**

The lens shall be Auto-iris lens to be mounted on the above camera. It shall be zoom lens with CS-Mount. The details are as under:

Focal Length : 6 – 90 mm zoom lens or equivalent.
Iris range : 1.6 to 360

8.1.4 **Camera Housing**

- All the cameras and accessories are to be housed in Weather Proof IP 66 environmental housing made of aluminum and Sun shroud. The housing, with heater and blower installed, shall provide protection for camera/lens assemblies in the ambient temperature range of - 0 deg. C to 50 deg. C.

- For Non Dome type cameras; The housing shall also have thermostatically controlled heater kit. Continuous duty blower kit (with suitable filters) for purge air arrangement / Window wipers shall be available within the housing for cameras as indicated against each application.

8.1.5 **Pan and Tilt Unit**

- The Pan and Tilt unit shall be weather proof (IP-65) designed to meet the rigorous requirement and shall be constructed with corrosion resistant hardware.
- They shall be capable of handling the intended loads and shall have at least 50% duty cycle motors to permit continuous operation.
- The pan & tilt shall comply with the following :

Power supply Power Supply As per Contractor's standard practice, to be arranged by Contractor.
Pan ranges 15 Deg to 345 Deg movements in horizontal plane.

Pan speed At least 6 deg. /sec.

Tilt 120 deg movement in vertical plane

Tilt speed At least 3 deg./sec.

Construction Cast aluminum based and yoke, corrosion resistant cover.

8.1.6 **On-site Receiver/Driver Unit**

- The on-site receiver/drive unit shall be able to control the motor drives for pan/tilt and cameras for zoom and auxiliary control. These would be used in conjunction with the video switcher/controller systems.
- The on-site receiver/driver unit shall have features like focus/zoom/iris controls, with minimum 50 numbers of prepositions, lockable enclosure latches, with integral local test facilities and IP 65 rated environmental enclosure.
- Contractor shall arrange the power supply for On-site receiver/driver unit. It shall be possible to locate the on-site receiver/driver unit within hazardous are in the vicinity of the camera and pan tilt unit. The cable from the receiver drive unit to the pan/tilt unit and the camera is to be provided to the cable being used. All the Receiver Driver units shall be compatible. All the required hardware and software shall be provided for the same.

8.1.7 **Keyboard and Monitor**

**a) Keyboard & Joystick**

Keyboard shall have full function used for system control and programming for selection of various video switcher / camera functions including pan/tilt and zoom lens controls and shall be ergonomically designed. The Key board(s) shall be able to access DVR (in case of Integrated DVR-video switcher) and video switcher as per the standard practice of the Contractor. Joystick shall be provided for achieving all control functions.

**b) Colour Video Monitor**

The monitors shall be versatile and aesthetic units It shall also be S-VHS/composite video compatible and shall have built in audio. Monitors are to be operable at 230V AC, 50 Hz (Power supply from Contractor's UPS is to be arranged by contractor).
They shall comply to the following specifications:

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- General Automatic degaussing, Fast warm up time Display tube 51 cm diagonal, integral implosion protection.

- Resolution 450 TVL minimum Controls Colour system select, volume, colour, brightness, contrast, power, video input select and Y/C termination.

8.1.8 **Digital Video Recorder**

- Parameter Specification Horizontal Resolution 720x570 lines for NTSC 704X576 for PAL Color system PAL/ NSTC, compatible with the CCTV system being proposed by the contractor.

- Recording system Applied JPEG, MPEG, Wavelet or better with Motion detection-Hi performance system.

- Recording speed 400 frames per second ( fps) , programmable Inputs 16 channel with Inbuilt Multiplexer and storage for minimum eight days on HDD for all the connected camera signals.

- Characters generation Date, hours, minutes and seconds.
- Record time by alarm Minimum range from 5 sec. To 3 min, to be finalized during detailed engineering stage.

- Input signal Compatible with the finally selected cameras/ network View Multiple, 2x2, 4x4, single to be finalised during detailed engineering stage.

- Power supply Manufacturer's standard.

- Search By date, time or cameras.

- Alarm Inputs Minimum 8.

- Video I/P 1V p-p 75 Ohm to be finalised during detailed engineering stage.

- Video O/P 1 V p-p 75 Ohm to be finalised during detailed engineering stage.

- Zones Minimum 5 User Customizable Zones per camera.

- Archiving The recorder shall be fully compatible with any standard 10/100 Base FO full Duplex Ethernet port for networking to a central DVD or AIT or Hard Disk Arrays after seven days of recording is over on the HDD. All or selected portions of the recorder material shall be shifted on to AIT or DVD and archived. The Archiving unit shall be common for the stations.

**9.0.0 OPERATIONAL REQUIREMENTS**

The CCTV system shall comply with the following operational requirement

- From all the Keyboards / monitors connected to the video switcher / control unit for common plant zone, it shall be possible to access / control / display all the common plant and unit zone cameras. From the Keyboards / monitors connected to the video switcher / control unit for unit zones, it shall be possible to select any associated camera and display the picture on any of the associated monitors.

- Commands from the video switcher/control unit are sent via an onsite receiver/drive unit to the camera which in turn controls the pan/tilt zoom etc., functions.

- Operator shall be able to control all the cameras, pan / tilt and zoom functions manually.

- The video recorder shall record the activities of all the places where alarms have been alerted and as decided during detailed engineering.

**10.0.0 CABLES**

- Cables shall be of FRLS PVC sheathed cables for use in CCTV and shall conform to latest edition of Indian/International standards. Fiber optic cables are to be provided wherever required. The remaining cables can be as per CCTV supplier's standard. All the cables and the hardware required for powering the system are also in the scope of Contractor.

- For estimation of cable quantities, erection hardware etc., the Bidder shall refer to General Layout Plant and Equipment Location Plans drawings which are enclosed with this specifications .All the cables are to be provided by the Contractor on as required basis within his quoted lump sump price.

**11.0.0 CONSOLES**

- DCS standards to match the same consoles.

**12.0.0 CAMERA SUPPORT**

- Cameras shall preferably be mounted on or to concrete structures (by others) in order to avoid vibrations. Mounting locations shall be easily accessible for servicing purposes.

- Where structures are not available the contractor shall supply rigid vibration – proof triangle type structures, suitably protected against corrosion. They shall be fitted with climbing and relevant safety facilities. No stay wires shall be used.

- Camera structures shall have a top platform with hand-railing, hoisting facilities, fixing facilities for cables along the whole structure and for the cameras to be installed with ample space for servicing purposes.

The outdoor cameras shall be provided on the tower of suitable height & proper maintenance accessibility.

**13.0.0 CCTV MONITORING SHALL BE PROVIDED FOR FOLLOWING PLANT EQUIPMENT / AREAS**

**PTZ Cameras**

1. GTG AREA
2. HRSG Area
3. Steam Turbine Area
4. Switchyard
5. Cable cellar Room
6. Boiler Feed Pumps
7. Condensate Extraction Pumps
8. CW/ ACW Pump House
9. DM plant Building
10. Cooling Towers
11. Fire Water Pump House
12. Spare Application- 4 nos. ( to be identified during execution phase )

**Fixed Cameras**

1. Security Gate(s) – 2 nos.
2. Plant Boundaries – 4 nos.
3. Spare Application- 2 nos. ( to be identified during execution phase )

**14.0.0 FACTORY ACCEPTANCE TEST (FAT) AND INSPECTION**

The Owner/Owner's representative shall have the right to inspect design, materials and workmanship and to report thereon at any time during the progress of design and/or fabrication.

The Contractor shall perform all tests necessary to ensure that the materials and workmanship are of the required degree of excellence, and that the entire systems furnished by the Contractor will perform as specified and guaranteed.

The test shall include the following:

- Complete functional tests on the systems using simulated inputs.
- A visual inspection of the equipment to ensure good workmanship and compliance with this specification and the manufacturer's drawings.

The Contractor shall provide equipment, instruments and tools and personnel and shall bear all expenses incidental to the foregoing tests, including replacement of damaged parts and material.

**15.0.0 SPARE PARTS**

The bidder shall include in his offer complete list of spare parts for start-up and two (2) years operation.

# VOLUME - III

# SECTION – 3

# DETAILED TECHNICAL SPECIFICATION - ELECTRICAL

# SUB-SECTION - 3.18

# ELECTRICAL INSTALLATION

**VOLUME - III**

**SUB-SECTION - 3.18**

**ELECTRICAL INSTALLATION**

## 1.0.0 GENERAL

This specification covers Erection, Testing and Commissioning of the all electrical equipments.

It is not the intent to specify completely herein all details of the equipment, nevertheless, the equipment shall be complete and operative in all respects and shall conform to the highest standard of engineering, design and workmanship.

## 2.0.0 SCOPE OF WORK

The scope of work shall include but not limited to the following:

Installation of Generator, Transformers, Switchgears, Buducts, Motors, Control and Relay Panels, Battery and Chargers, Cables, Push button stations, Cable trays and accessories, DG Set, UPS system, Communication system, Illumination system, Earthing and lightning protection system, GIS etc.

The scope of work shall also include but not limited to the following:

- Cable Trays and Accessories
- Cable termination and jointing kits.
- Cable ties, clamps and markers
- Conduits and accessories.
- Junction boxes.
- 3-phase power Receptacles.
- Cable glands and cable lugs.
- Fire stop cable sealing system.
- Electrical Lab equipments / Components
- List and supply of Maintenance tools and tackles.
- Danger Boards
- Rubber Mats
- 30 nos. first aid charts shall be provided for display in the plant area.
- Minimum 20 nos. first aid boxes shall be provided at various locations in the plant.
- Sufficient quantity of gas masks shall be provided in line with rule no 43 of I E rules.
- Marshalling Boxes (MBs) as required for the power plant shall be supplied as required for marshalling cables of devices located in an area/ equipment.
- Name Plates indicating the identification of all equipments/systems/plants/etc. for entire plant

All accessories, fittings, supports, anchor bolts etc. which form part of the equipment or which are necessary for safe and satisfactory installation and operation of all the equipments/ all electrical system of entire plant shall be furnished.

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## 3.0.0 CODES AND STANDARDS

**Code No** : **Description**

- IS: 1255 : Code of practice for installation and maintenance of power cables up to and including 33 kV rating.
- IS:732 : Electrical wiring installation (system voltage not exceeding 650 V).
- IS 10028 : Code of Practice for selection, Installation & maintenance of Transformers.
- IS 10118 : Code of practice for selection, installation & maintenance of Switchgear & control gear.
- IS:5216 : Guide for safety procedures and practices in electrical works.
- IS 2551 : Danger notice plates
- IS 2309 : Code of practice for the protection of buildings and allied structures against lightning
- IS 3043 : Code of practice for earthing

All the items shall conform to latest edition of relevant IEC/IS standards amended up to date. Equivalent ANSI standards are also acceptable.

Bidder shall comply with Indian statutory Regulations.

## 4.0.0 INSTALLATION REQUIREMENTS

### 4.1.0 General

All electrical installation work are to be carried out in accordance with this tender document and in conformity with the requirement of Indian Electricity Act, and Indian Electricity Rules as amended up to date and relevant standards, codes and statutory regulations. Manufacturers recommendation are also to be followed. The installation shall be carried out by a licensed and approved electrical contractor. The electrical installation must be got approved by the State Electrical inspector.

Site testing of all electrical equipment are to be carried out as per relevant standards and manufacturer's recommendation.

### 4.2.0 Switchgears and Control Gears

4.2.1 The foundations shall be designed to carry the dead weight of panels and additional impact loads imposed. The equipment shall be installed correctly and leveled properly. The floor level in front of the equipment shall be such as to facilitate easy drawout of breakers.

4.2.2 For storage batteries the floor shall be chemically resistant type and walls shall have chemically resistant tiles upto a suitable height. Alternatively chemical resistant paints are also acceptable.

4.2.3 All openings shall be closed to avoid entry of foreign particles.

4.2.4 Should the Switchgear or part of it be having a low IR value, the entire switchgear shall be dried up, with special care, to avoid direct local heating of surrounding insulation.

**4.3.0 Transformers**

4.3.1 The level of the transformer base should be higher than the highest flood and storm water level of that area.

4.3.2 High rating transformer shall be placed after grouting channels or rails over concrete foundations, leveled, aligned & checked for free movement on the rails. Other transformers shall be placed directly on concrete beds. Stoppers to wheels shall be clamped immediately to prevent any movement.

4.3.3 Adequate clearance shall be maintained on sides and over the highest point of transformers.

4.3.4 Fire barrier walls shall be provided as per requirements.

4.3.5 Oil soak pit/drain pit of adequate capacity with necessary drain pipes shall be provided for draining of oil, away from the transformer.

4.3.6 Fire protection with sprinkler system shall be provided for higher rating of transformers as required.

4.3.7 Samples of oil shall be taken from the bottom of the tank and tested for proper dielectric strength and acidity. It should be ensured that the oil is free from dust and moisture during filling-in operation.

4.3.8 Drying out of the transformer shall be carried out to attain the required insulation levels as required.

**4.4.0 Busducts**

4.4.1 The insulators in busducts shall be inspected for any possible damage during transit and the defective ones shall be replaced. Contact surface of busbars, busbar bolts and nuts shall be thoroughly cleaned. The busduct run shall be properly aligned and leveled and shall be suitably supported.

4.4.2 The opening in the wall where the busduct enters OUTSIDE TO INSIDE room shall be completely sealed off so that entry of rain water and foreign materials are prevented. Expansion joints, flexible connectors inspection on openings, shall be checked for proper tightness.

4.4.3 The Generator busduct enclosure shall be checked for earth continuity and then properly earthed.

**4.5.0 Illumination Systems**

4.5.1 The location of the lighting panels shall be such that the same shall be operated easily.

4.5.2 The location of the light fittings, receptacles, switches, etc. shall be such as to avoid interference with piping or other equipment and to avoid objectionable shadows and glare.

4.5.3 Lighting panels shall be suitable for wall / column mounting. Outdoor lighting panel may be floor mounted. Fixtures shall be firmly supported from structures. Clamps may be bolted or welded to the steelworks. In case of concrete structures, fixtures may be fixed with the help of anchor fasteners. In false ceiling areas fixtures shall be supported from the true ceiling.

4.5.4 All hardware shall be galvanized or zinc passivated. Wherever 90° bending on conduit routes are involved inspection elbows or smooth bends shall be used. All wires in conduit shall be colour coded. Each circuit shall have independent phase and neutral wire. Earth wire shall run in all conduits. Conduit size shall be chosen considering 40% maximum fill.

4.5.5 For street lighting, fixtures shall be mounted on steel poles. Each pole shall be grounded by connecting it to the plant ground grid or by using individual 3 m length ground rod.

4.5.6 In false ceiling areas the switchboards and the conduits shall be recess mounted below the false ceiling.

**4.6.0 Cables / Conduits**

4.6.1 Cable shall be laid above ground in overhead cable trays or shall be laid in cable trays in cable trenches. For interplant cabling separate cable rack/cable duct bank or combined pipe cum cable rack shall be used.

4.6.2 Cable spreader room shall be provided below switchgear rooms and it shall be provided with easy access for inspection and maintenance.

4.6.3 In transformer yard and switchyard cables shall be laid in cable trays in RCC concrete trenches with RCC covers.

4.6.4 Proper slope shall be ensured in the cable trenches for draining of water. Cable entry to the building from cable trench shall preferably be overhead (above plinth level) to avoid water entry into the building. Depth of cable trenches shall be adequate to provide the required bending of the largest sized cable at the terminating ends.

4.6.5 For remote areas of the Plant cable may be buried directly in ground. Method and depth of burying shall be as given in I.S. 1255. Route markers shall be provided at an interval of 30 m and at each change of route direction.

4.6.6 Where a cable route crosses a permanent road/railway line cables shall be drawn through hume pipes or G.I. pipes. Pipes should be laid in a straight configuration. Filling criteria in any pipe shall not be more than 40%.

4.6.7 The cable layout shall be so designed that a fire in one route affecting certain equipment shall have minimum effect on other equipment.

4.6.8 Separate cable trays shall be used for the following:

- HT Power
- LT Power
- Control
- Instrumentation/communication cables
- Fire survival cables

4.6.9 HT Power cables shall be laid with adequate spacing between each cable. For LT Power Cables also spacing between the cables shall be preferably provided. In any case HT and LT Power

Cables shall not be laid in more than one layer. Control and Instrumentation cables shall not be laid in more than two layers.

4.6.10 Contractor shall provide necessary embedded steel inserts in wall/floor/ceiling surfaces for supporting cable trays. The cable racks shall be secured to the rack/tray supports by welding to those inserts or other available building steel surfaces. In case of non-availability of embedded steel inserts in certain tray routes, the contractor shall have to secure the supports on wall/floor/ceiling surfaces by providing suitable anchoring system/ steel inserts having adequate load bearing capability.

4.6.11 Sufficient spacing not less than 250 mm shall be provided between different tiers of trays to permit adequate access, for installing and maintaining the cables.

4.6.12 The cable risers or vertical raceways shall be covered by 2.5 mm thick sheet steel, hot dip galvanized/painted cable tray covers with suitable stiffeners upto 2.5 metres from respective floor for mechanical protection. The sheet cover shall be of removable type.

4.6.13 Conduits shall be used for routing of cables (power/control) from cable trays to equipment/ junction boxes. The size of the conduit shall be selected on the basis of maximum 40% fill criteria. Pipe sleeves (Hume/GI) shall be used for routing of cables between floors, road crossing, entry/exit from outside of building etc. All conduits/pipe shall have their ends closed by caps till the cables are pulled. After the cables are pulled, the ends shall be sealed by suitable sealing compound having fire withstand capability.

4.6.14 Cable laid on trays and risers shall be neatly dressed and clamped at an interval of 1500 mm. and 900 mm. for horizontal and vertical cable runs respectively.

4.6.15 All power cables shall be clamped individually & control cables may be clamped in groups of three or four cables.

4.6.16 All single core power cables shall be laid in trefoil formation and suitably clamped with nylon/ FRP trefoil clamps or with other approved means. The nylon/FRP trefoil clamps shall have very high mechanical strength, fire retardant and self extinguishing characteristics. These clamps shall be with necessary fixing hardwares like bolts, nuts, washers etc. which are hot dip galvanized.

4.6.17 For direct buried arrangement before the cables are placed, the excavated portion shall be filled with a layer of sand. This sand layer shall be leveled and the cables laid over it. The cables shall then be covered with 150 mm sand on top of the largest diameter cable and sand shall be lightly pressed. A protective covering with 70 mm thick bricks shall then be provided on top. The remaining portion of the excavated trench shall then be back filled with soil, rammed and leveled.

4.6.18 Each cable and cable tray shall be tagged with numbers. Cables and conduits shall be tagged at their entrance, at every 30 m and exit from any equipment, junction box. The tags shall be of aluminium or other approved means with the number punched on it and securely attached to the cable. The location of cable joints, if any, shall be clearly indicated with cable marker with an additional inscriptions "Cable-Joint" and "Cable Number".

4.6.19 The contractor shall put ferrules on all control cable cores in all junction boxes and at all terminations. The ferrules shall carry terminal numbers as per drawings. All ferrules shall be coloured, plastic & interlocked type.

4.6.20 All cable entry points shall be properly sealed and made vermin and dust proof. Unused opening, if any, shall be effectively closed. Sealing work shall be carried out with approved fire sealing compound.

4.6.21 Cables shall be installed without joints as far as practicable. Jointing kits shall be suitable for the type of cable and for the particular type of installation. The contractor shall provide jointing kits complete with insulating materials, stress grading/relieving materials, plastic mould, resin, earthing materials and all other accessories. A suitable loop shall be provided near all joints. Suitable loop shall also be provided for all power cables of 66kV, 11 kV and all LT Power Cables of bigger size at the terminating ends.

4.6.22 Communication cables shall run on instrument trays/ducts. Wherever these are not available, cables shall be taken sufficiently away from power cables. Communication cables shall cross power cables at right angles.

4.6.23 Top trays with exposure to elevated walkways shall be provided with covers for mechanical protection.

**4.7.0 Earthing System**

4.7.1 All conduits, trays, cable armour and cable end box, electrical equipment such as motors, switchboards, panels, cabinets, hand rails, rails, fence & fence gates, columns, junction boxes, lockout switches, fittings, fixtures, etc. shall be effectively grounded. The grounding of equipment shall be done by GI flat connected to the risers of main ground mat.

4.7.2 For prefabricated cable trays, a separate ground conductor shall run along the entire length of each row of cable tray and suitably clamped on the cable tray.

4.7.3 All ground conductor connections shall be made by electric arc welding/brazing and all equipment earth connections shall be made by bolting with the earthing pads. Ground connections shall be made from nearest available station ground grid risers.

4.7.4 Equipment shall be generally be furnished with two separate ground pads with tapped holes, bolts, nuts and spring washers etc. Equipment ground connections, after being checked and tested shall be coated with anti-corrosive paint. At least two earth connections shall be provided for all electrical equipment as per IE rules. Longer run of cable trays etc. shall be periodically earthed.

4.7.5 Earthing conductors along their run on walls and columns shall be supported by cleating with approved materials/welding at intervals of 750 mm. For system earthing, earthmat consisting of interconnected mesh of mild steel rods buried in the ground under the main plant area and all off site areas, interconnected together by minimum two numbers of parallel conductors.

4.7.6 Each earthing lead from the neutral of the Transformers shall be directly connected to two electrodes in treated earth pits which in turn shall be connected to station earthing grid.

4.7.7 Earthing for Electronic equipment shall be carried out separately through insulated copper cable & shall be grounded with separate earth electrode. All the earth pits of electronic equipment shall be interconnected. The combined earth resistance shall be less than 0.5 ohm.

**4.8.0 Lightning protection system**

4.8.1 All areas of the power plant shall be provided with lightning protection as per IEC/IS. The lightning protection system for buildings shall consist of Horizontal/Vertical /Galvanised Steel/ Copper air terminations, down conductors, test link and earth electrodes. The installation shall include laying clamping/cleating anchoring/welding of the down conductors on walls/ columns etc. and connection to the earth electrode through a test link.

4.8.2 Every down conductor shall be provided with a test joint at about 1500 mm. above ground level and connected to an individual earth electrode. The earth electrode shall in turn be connected to the main plant earthing grid. All joints in the down conductors shall be of welded type only.

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4.8.3 The lightning protection system shall not come in direct contact with other equipment/systems such as cables, conduits, electrical equipment, underground metallic ducts etc. All metallic structures within 200 mm. vicinity shall be bonded to the lightning protection system.

4.8.4 All down conductors shall be cleated/welded/brazed to the wall/columns at an interval 1500 mm. All welded/brazed joints shall be coated with anti-corrosive paint for rust protection. The horizontal roof conductors at the top of building/ structures shall be cleated at an interval of 1500 mm. by providing necessary cement mortar sand blocks.

**4.9.0 Cable Trays and Cable Tray Supports**

4.9.1 Cable trays shall be pre-fabricated ladder type, made of 3 mm thick sheet steel with hot dip galvanized furnished in standard lengths of not less than 2.5 m.

4.9.2 Cable trays shall be complete with all necessary hot dip galvanized sheet steel accessories such as coupler plates, ground continuity connections, nuts, bolts, washers, clamps etc. Also necessary horizontal/ vertical bends, horizontal/vertical Tees, Reducers, Horizontal cross pieces etc. shall be supplied to make the system complete.

4.9.3 Cable tray support system shall be of sheet steel prefabricated and galvanised or of site fabricated and painted type.

4.9.4 Sheet steel covers of minimum 2 mm. thick shall be provided for wall/column mounted vertical raceways and wherever specifically required. The width of the cover shall be same as that of the tray.

4.9.5 Provision shall be made in the cable trenches so that water should not be entered inside any building through cable trenches.

**4.10.0 Cable Termination & Jointing Kits**

4.10.1 The cable termination and jointing kits shall be either "Heat Shrink" / "Cold Shrunk" / Push ON type. The kits shall include all insulation and sealing materials apart from conductor fittings and consumable items. Joints and terminations shall meet test requirements as per IEC/ VDE 0278. The straight through jointing kits shall be suitable for underground buried installation with uncontrolled backfill and possibility of flooding by water or overhead tray installation.

4.10.2 Cable ties & trefoil clamps shall be of special nylon high tensile material. Cable markers shall be of aluminium.

**4.11.0 Junction Box**

4.11.1 Junction boxes shall be conforming to degree of protection IP55. The boxes shall be of die cast aluminium (LM 6) complete with removable cover plate with gaskets, two earthing terminals, terminal blocks etc.

4.11.2 The boxes shall have provision for wall, column, pole or structure mounting and shall be provided with cable/conduit entry knock outs & terminal blocks.

4.11.3 The terminal blocks shall be mounted securely on brackets welded to the back sheet of the box. The terminals shall be 650 V grade, one piece construction complete with terminals, insulation barriers, galvanised nuts, bolts and washers and provided with identification strips of PVC. The terminals shall be made of copper alloy and shall be of box clamp type.

4.11.4 The terminals for junction boxes shall be suitable for terminating two (2) nos. 2.5 mm¨ stranded copper conductors on each side.

**4.12.0 Receptacles**

4.12.1 **Industrial Receptacles**

The industrial receptacles shall be heavy duty type rated for 20 A and 32A , 240V AC complete with plug and switch housed in galvanized sheet steel enclosure having degree of protection of IP 55. These shall be of three pin type with the third terminal connected to earth. Receptacles shall be provided in all the indoor and semi indoor areas such that the any point is accessible within 25m of cabling distance from the receptacle. For outdoor area also necessary receptacles shall be provided as per Owner/Owner's representative's requirement to be indicated during detailed engineering. Receptacles shall be provided in all the buildings of auxiliary equipment, GTG area, HRSG area, GIS building area, Transformer yard. The receptacle shall have safety shutters and other safety interlocks for safe operation.

4.12.2 **Welding Receptacles**

The welding receptacle to be supplied shall be of 63 A and 100A, industrial heavy duty type with 5pin (with earth connection) suitable for 415 V, 3 phase, 50 Hz supply. In every enclosed area, for every 50 m interval, 1 No. receptacle shall be provided. For outdoor area, necessary receptacles shall be provided as per requirement. Receptacles shall be provided in all the buildings of auxiliary equipment, GTG area, HRSG area, ACC area, Transformer yz`ard & switchyard.

The receptacle and switch shall be housed in a sheet steel enclosure complete with gasket, cable glands etc. All receptacle enclosures shall have 2 Nos. earthing terminals.

The enclosure shall be min. 2 mm. thick galvanized sheet steel and shall conform to the degree of protection IP-55 class.

All receptacles shall be provided with matching plug tops.

In hazardous areas, receptacles shall be of flame proof type.

The receptacle and switch shall be interlocked with the plug such that it shall not be possible to remove the plug with the switch in 'ON' position.

**4.13.0 Cable Glands & lugs**

4.13.1 Cable glands shall be tinned brass, shrouded, double compression type, complete with necessary armour clamp and tapered washers etc. Cable glands shall match with the different cable sizes.

4.13.2 Cable lugs shall be tinned copper lugs suitable for termination of different sizes of HT/LT/ control cables. Lugs for power cables shall be of compression type, whereas lugs for control cables shall be of insulated terminal crimping type.

**4.14.0 Fire Stop Cable Sealing System**

4.14.1 In order to restrict the propagation of cable fire and spread of toxic smoke, the cable entry below switchgear panels/ control panel, cable penetration through walls and cable shafts on the floors need to be sealed by fire seal system.

4.14.2 Fire stop cable sealing shall have two (2) hours fire rating. The sealing compound shall have special property to allow for thermal expansion of cables both under normal and short circuit conditions. The sealing system shall be proven type and tested as per relevant standard.

4.14.3 Necessary fire proof doors in cable spreader rooms shall also be provided.

4.14.4 If required by the fire stop sealing system to achieve the fire rating of 2 hours, cable coating shall be adopted on cables. The coating shall have minimum two hours fire protection rating. Cables at least 1 m before & after the penetration seals shall be suitably coated. Cables shall be sized to take care of any derating due to fire stop sealing.

**4.15.0 Safety Devices**

4.15.1 The contractor shall supply and install all danger plates. The danger plates shall be written in *Gujarati*, Hindi and English and shall be provided for the electrical equipment as per regulation.

4.15.2 *High voltage insulating mats as per IS:15652:2006 shall be pasted / permanently fixed before each switchboard/panels throughout the power plant and also required for maintenance of panels (as required), as per the directive of Engineer-in-charge for all the sub-stations in the power plant. They shall be of suitable voltage grade.* In the switchgear room and inside plant area, first aid boxes shall be provided as per the requirements of Indian Electricity Rules & Regulations.

4.15.3 Necessary exit signs and escape routes are to be clearly marked with illuminated sign boards.

**5.0.0 PAINTING**

The Contractor shall paint steel fabrications at site with two (2) coats of epoxy based primer followed by two (2) final coats of epoxy paint. All damaged painted surfaces shall be cleaned and coated with two (2) coats primer followed by a finishing coat of paint. All damaged galvanized surfaces shall be coated with cold galvanizing paint. All equipment after erection shall be touched-up where required with coats of finishing paint.

# VOLUME - III

# SECTION -4.0

# DETAILED TECHNICAL SPECIFICATION

# CONTROL & INSTRUMENTATION

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## SECTION -4.0

## DETAILED TECHNICAL SPECIFICATION

## CONTROL & INSTRUMENTATION

### 4.1.0 INTRODUCTION

This section sets outs the scope of supply, services, and design technical requirements of instrumentation and control equipment. Instrumentation and control systems specified here are only basic and minimum, detailed design shall be carried out by the contractor for safe, reliable, efficient, automatic operation of the combined cycle power plant. Any items not included hereunder but specified elsewhere in this specification shall also be included. The type and make of I & C equipment shall be proven in similar power plants and shall be approved by the Owner/Owner's representative. Measurement and control equipment offered shall be complete in all respects and any equipment / accessories not explicitly indicated in this specification, but considered essential for proper functioning of equipment and process shall be included in the Bidder's scope of supply and work. If the Contractor proposes or supplies any additional plant/equipment, all corresponding instrumentation and control equipment shall be included in his scope, along with all necessary special tools and product specific configuring and diagnostic devices.

### 4.2.0 SCOPE OF SUPPLY AND SERVICES

4.2.1 The following I&C systems shall be supplied, installed, commissioned and tested for successful and satisfactory operation of the proposed combined cycle power plant.

4.2.2 Gas turbine generator control & protection system, vibration monitoring analysis system, fire detection and protection system for the gas turbine generator complete with system cabinets, VDU/keyboard based proprietary operator station and engineering workstation (EWS) at local control room, dedicated operator station at remote control room, all hardware, software, other interfaces, flame scanners (UV type) and field sensors/instruments/erection hardware including GT inlet fuel flow meters and other accessories required to complete the system. It is preferred that Gas Turbine control system shall be seamlessly integrated with plant DCS utilizing same family of hardware. Gas turbine proprietary control system shall be linked to plant DCS through soft link.

4.2.3 Microprocessor based steam turbine generator control system, protection system, turbo supervisory instrumentation complete with system cabinets, dedicated operator in CCR, all hardware, software, other interfaces, field sensors/instruments/erection hardware and other accessories required to complete the system. It is preferred that Steam Turbine control system shall be seamlessly integrated with plant DCS.

4.2.4 Instrumentation complete with system cabinets, dedicated operator station in CCR, all hardware, software, other interfaces, field sensors/instruments/erection hardware and other accessories required to complete the system of HRSG. Control system of HRSG shall be from plant DCS.

4.2.5 Instrumentation complete with field sensors/instruments, erection hardware and other accessories to complete the system for steam requirement for existing process plant. Control system shall be integrated with plant DCS.

4.2.6 Supply of all furniture required for mounting of DCS/ PLC/ GTG Control System/Fire & Gas Detection System, lab instruments etc.

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4.2.7 **HMI FORCCCPPPLANT:**

| Sl. No. | HMI Requirements | Quantity (In Nos.) |
|---|---|---|
| 1. | Desktop mounted Operator Workstations (OWS) for operation, control and monitoring of the complete Block including proprietary Gas Turbine Generator controls, Steam turbine Generator controls, Heat Recovery Steam Generator (HRSG) and its auxiliaries, Balance of Plant etc. *(Located in proposed Control Room)* | Four |
| 2. | OWS/EWS for Gas Turbine Generator controls, Historian PC (Located at GTG local control room), | Two |
| 3. | 63"Large Video Screens (LVS) with individual CPU and input/output devices | One |
| 4. | Engineering Station with colour laser printer | One |
| 5 | Engineering Laptop | One |
| 6 | Remote operator station in existing control room | One |
| 7 | HART Management System (HMS) workstation | One |
| 8 | MIS Station/OPC Server with Hardware Firewall | One |
| 9 | BMS OWS/ENGG PC | One |
| 10 | Substation automation system (SAS) | One |
| 11 | Fire protection and detection system (FPDS) | One |
| 11 | ColorLaser Printer(A3/A4) | One |
| 12 | Laser Printers (B/W)(A4) | One |
| 13 | 132 column Dot Matrix Printers (for alarms, SOE, daily log, and operator action/event log) | One |

4.2.8 Instrumentation complete with field sensors/instruments, erection hardware and other accessories to complete the system for WTP.

4.2.9 Microprocessor based Compressed Air System complete with system cabinets, alarm annunciation windows, push buttons and indications, redundant communication link with plant DCS system,all hardware, software, cables, other interfaces, dew point meter and field sensors/instruments/erection hardware (one lot).

4.2.10 Microprocessor based control system for AC & Ventilation system complete with system cabinets, alarm annunciation windows, push buttons and indications, redundant communication link with plant DCS system, all hardware, software, cables, humidity switch other interface and field sensors/instruments/erection hardware (one lot).

4.2.11 Fuel gas conditioning system shall be controlled and monitored from DCS.All hardware, software, other interfaces, cables, flame scanner / emission monitoring system (for fired gas heater) and field sensors/instruments/erection hardware (one lot).

4.2.12 Micro-processor based analog addressable main fire alarm panel, local fire control panel, repeater panels for fire alarm and detection system compete with analog addressable fire alarm detectors, alarm annunciation windows, OWS and printer, interface to plant DCS system, all hardware,

software, cables, other interface and field sensors/instruments erection hardware (one lot). Provision for interface/ hook up of existing Fire alarm panel with proposed fire alarm panel shall be made. Approximately provision of interface of 60 signals of existing fire alarm panel shall be mad at proposed fire alarm panel. One common repeater panel shall be provided (existing & new unit) at main fire control station, 2 km away from proposed power plant.

4.2.13 Substation automation system(SAS)shall be provided for electrical systems. SAS shall be interfaced to DCS through redundant communication soft link.

4.2.14 One redundant GPS based Time synchronization system with slave clocks.

4.2.15 Steam & water analysis system (one lot) complete with sample conditioning and analyser panels, sensors and other accessories.

4.2.16 Stack Emission monitoring system (one lot) complete with all the analysers, controller, dedicated PC at CCR with all the software, calibration unit and other accessories.

4.2.17 Electronic water level Indicator for the HRSG drums mounted in the Drum floor and indicated in the CCR with all the accessories, as per the ASME - (one Lot).

4.2.18 Vibration monitoring & analysis system for all the HT drives and driven equipment other than GTG and STG and other accessories (onelot).

4.2.19 The BMS shall be of PLC based. The system shall be complete with reliable and provenflame scanners, and flame intensity meters. Communication with DCS system shall be through redundant soft link or hardwired for monitoring. One OWS cum engineering station shall be provided which will be placed at main control room.

BMS shall be TUV approved or SIL 3 certified as per IEC 61511.

Bidder shall offer functionally complete BMS for the Heat Recovery Steam Generation unit.

The BMS shall ensure:

- A reliable start-up
- A safe shut-down
- Detection of complete / partial loss of ignition in the Furnace/Burners
- Prevent accumulation of un-burnt fuel in the furnace.

UV/ electronic sensor & self-check type Fire-eye make Flame scanners (SIL certified) suitable for fuel like Natural Gas shall be provided for burner flame monitoring. The scanners shall be mounted on a sight tube with an adjustable base joint to allow optimum flame sighting at start-up. The scanners shall be mounted in a watertight enclosure and pre-wired to a terminal strip. Enclosure shall be of NEMA-4 type. Air purging and cooling through instrument air shall be provided to protect the scanner from excessive heat Flame safety system shall be enclosed in a NEMA-12 enclosure; this shall be provided with supervisory manual start facility.

Flame safety system shall have all components as required by NFPA with one UV flame or equivalent scanner and amplifier per element.

The flame safety system panel shall have as a minimum the following indications:

- Power on
- Limits complete
- Purge in progress
- Purge complete
- Pilot valves energised
- Main gas valves energised
- Flame detected
- Main fuel valve opened.

The flame safety system shall have as a minimum the following safety interlocks to ensure safe start-up of the burner:

- Turbine exhaust gas flow switch (2/3 Logic)
- Low fuel gas pressure switch ”
- High fuel gas pressure switch ”
- Low scanner air pressure switch ”
- High furnace temperature switch ”
- High steam pressure switch ”
- Low instrument air pressure switch
- Loss of flame etc.

4.2.20 Auxiliary panel with Start, Stop push buttons, Remote/Local selection shall be provided at control room for feed pumps and BMS of plant. It shall contain annunciation window for those drives.

4.2.21 All control room furniture (one lot)

4.2.22 Field instruments/sensing devices (one lot)

4.2.23 Flow elements/Control valves/ other pipe mounted instrumentation equipment (one lot)

4.2.24 Gas flow meter, flow computer, Gas leak detection system with all the hardware and other accessories.

4.2.25 Instrumentation, control cables and special cables(one lot)

4.2.26 Power supply system for Instrumentation and Control system and grounding (one lot)

4.2.27 Erection hardware for I&C systems (one lot).

4.2.28 Instrument lab equipment (one lot) with all the furniture.

4.2.29 All tools and tackles, special testing equipment and consumables required for erection and commissioning activities.

4.2.30 Spares required for I&C equipment which consists of recommended spares, commissioning spares and mandatory spares.Bidder shall furnish the above list during the submission of bid.Consumables like paper, cartridge, etc. required for 6 months of operations shall be supplied by BIDDER.

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4.2.31 The scope of work & services shall include design, engineering, documentation, procurement, manufacture, assembly, inspection, supply, packing, transportation to site, storage, erection, calibration, testing and commissioning of the complete Instrumentation & control (I&C) system required for the combined cycle power plant.

4.2.32 Receipt of material at site, site storage and handling, complete erection of instruments, complete cabling, site supervision pre-commissioning, testing, start-up, run tests, load test, performance and acceptance testing of the complete system.

4.2.33 Bidder shall be fully responsible for design, materials selection, sizing and selection of the proper instruments for their system.

4.2.34 All equipment supplied shall be of proven quality both with respect to design and materials. No prototype instrument or instrument of an experimental nature shall be offered or supplied. Bidder shall be responsible for the replacement of all defective parts/equipment during the guarantee period.

4.2.35 The Owner/Owner's representative reserves the right of selecting the manufacturer / model of control & instrumentation items in the interest of standardization wherever necessary and the Bidder shall agree to supply equipment of particular make if so desired by the client without any cost implication.

4.2.36 Bidder shall clearly define the operational philosophy suggested by him, which should be in line with requirements specified in the main package/equipment specification.

4.2.37 Support of spare parts for I& C equipment for period of 10 years.

4.2.38 Any I&C equipment required during any stages for the efficient / safe / reliable operation of the plant either during detail engineering / commissioning shall be supplied, installed and commissioned by the successful Bidder without any additional cost.

4.2.39 Submission of drawings and documents as indicated in this section.

4.2.40 Arranging inspection at the manufacturer's premises.

4.2.41 Training for I&C major and specialized I&C equipment supplied at the manufacturer works and at site. The engineers shall be given special training in shop, laboratory and drawing office of the BIDDER, where the Instrumentation and Control Equipment shall be designed, and manufactured and in any other power plant where similar type of equipment designed, manufactured and supplied by him is under installation, test, operation or maintenance, to enable the engineers to become fully familiar with the equipment offered

4.2.42 Participation of Bidder representatives with Owner/Owner's representative and other equipment suppliers at various stages of the project.

4.3.0 **DESIGN REQUIREMENT**

4.3.1 The design, manufacture, assembly, testing as well as performance of the equipment shall conform to the latest edition of relevant IEC/ISA and other international codes/specifications. The I & C equipment and systems shall be designed, manufactured & installed to meet the specification requirements, and perform accurately and safely under the operating and environmental conditions existing in the power plant. The Instrumentation and control equipment shall be designed suitably that are subjected to saline atmosphere.

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4.3.2 All control and instrumentation functions shall be shown on the piping and instrumentation diagrams. The symbols to be used shall be in accordance with ISA / ISO standard and shall be subject to approval by the Owner/Owner's representative. All measurements and alarms shall be listed. Complete schematic control diagrams shall be provided for all instrumentation. Functional application and also specific control (modulating/interlock) application (by short text) for each measurement along with signal destination shall be indicated in Process and Instrumentation Diagram (P&ID). All reference engineering documents shall also be indicated in the P&ID.

4.3.3 Automatic single push button start facility from the plant DCS to be provided for the main plant equipment such as GTG, STG, HRSG and other DCS controlled systems. For balance of plant systems such as water treatment plant, Instrument and service air compressor, raw water system and other packaged control systems are to be designed that fully automatic operation should be possible with minimum local intervention and remote start/stop, monitoring from the plant DCS.

4.3.4 Triple redundant sensors/transmitters shall be provided for the following as a minimum,

- HP, MP & LP drum level
- HP, HRH & LP steam flow
- HRSG HP / MP Steam Temperature
- HRSG HRH Steam Temperature
- HRSG Flue gas inlet temperature
- Condenser vacuum (ST controls)
- Condenser Hot-well Level
- Sensors for unit/equipment protections, trips and initiation of unit run-back.

Dual redundant sensors/transmitters shall be provided as a minimum for all other closed loop and open loop controls as follows,

- HP, MP & LP steam pressure
- HP, MP & LP drum pressure
- HRSG flue gas pressure / temperature
- HP, MP & LP bypass pressure
- HP, MP & LP bypass temperature
- LP steam header temperature
- HP economizer feed-water flow
- MP economizer feed-water flow
- LP economizer feed-water flow
- CEP discharge flow
- Fuel gas performance heater shell liquid level
- Fuel Gas Scrubber Level
- Fuel gas performance Heater Outlet Temperature
- Condensate storage tank and De-mineralized storage tank level
- Sensors for trips, interlocks and permissive.

Where signals from redundant instruments are used for protection and auto changeover of equipment, analog transmitters shall be used in place of process switches. Process switches shall be used only for generating alarms. Wherever redundancy in measurement is considered, it shall have redundancies from process tapping points to I/O channels.

4.3.5 The design of the entire control system and related equipment shall adhere to the principle of 'fail safe operation' wherever the safety of personnel and plant equipment is involved. 'Fail safe operation' signifies that the loss of signal, loss of power or failure of any component should not cause a hazardous condition. However, it shall also be ensured that occurrence of false trips is

minimized. No single failure either of component or power source of DCS shall cause loss of generation.

4.3.6 Sequence of event recording system shall be integral part of DCS with minimum 250 points.

4.3.7 DCS shall be provided with 100% redundancy for processors, Communication as well as network components, power supply. Redundant inputs/ outputs shall be connected to different input/output cards of DCS i.e. triple redundant inputs shall be connected to three separate input cards. The logics for redundant drives shall not be in the same processor.

4.3.8 A consistent control and instrumentation philosophy shall be applied throughout the plant and be implemented in terms of a range of equipment exhibiting a minimum diversity of type and manufacture. Range of the instrument shall be so selected that max. operating value lies in 65-75% of the full scale range.

4.3.9 Control & Instrumentation shall be provided such that no single failure can cause a unit trip, loss of load/overall power output or even a forced outage of the power station. Modular redundant control systems shall be provided for all plant safety critical control and protection systems.

4.3.10 For hazardous area, the I& C systems to be designed as per the relevant area classification and applicable standards.

4.3.11 Area Classification

All Instrumentation shall be suitable for area classification as per approved area classification drawings. Hazardous area instrumentation in Zone-1 and Zone-2, irrespective of area classified as Zone-1 or Zone-2, all Instrumentation shall be suitable for Zone-1 or Class-I, Division-I and Gas grouping as per approved area classification drawing.

For classified area in general, intrinsically safe philosophy shall be followed for all input/ output in hazardous area except for MCC input/ output. Solenoid valves shall explosion proof type. For all instruments, Bidder must select external barriers, wherever applicable, on entity concept. All barriers shall be isolating type.

Bidder shall select the barrier based on the following requirements:

i) The barrier shall be of latest/ enhanced available versions of makes selected

ii) The model no. selected should be well proven as per the criteria specified

iii) The barriers selected should have back-up support and representation available locally

In case barrier is required for any other Input / Output the same shall be of MTL / P&F makes only. Approval of actual model number shall be obtained from Owner/Owner's representative before proceeding.

Instruments which are not available as per their standard design from any reputed manufacturer as intrinsic safe, can be supplied in flameproof design. All such instruments shall be certified for the area classification.

Junction boxes for flameproof instruments shall be certified flame proof.

All hazardous area instrumentation items shall be provided with Certificate from statutory authority as per requirement.

4.3.12 In the interest of a neat and clear, space-saving layout of the installation, easy maintenance, simple starting-up, operational checks and fault-recognition, a system made up of standard sub-assemblies with plug-in modules design shall be provided. In the case of power supply failure no reprogramming shall be necessary and no controller parameter shall be lost.

4.3.13 To ensure smooth and optimal maintenance including efficient spare parts management of various I&C instruments/equipments like vibration monitoring analysis systems, all 4-20mA electronic transmitters/ transducers, control hardware, control valves, actuators and other instruments/ local devices etc. being furnished by the Bidder for GTG, HRSG, STG, BOP including its auxiliaries and systems like fuel system, circulating water system, chemical dosing system, Hydrogen Generation Plant (if applicable), DM plant, cooling towers, cooling water system, chlorination system, effluent treatment plant, compressed air system, fire protection system, HVAC, potable water system, emergency DG facility etc. and other plant auxiliaries for similar applications, the Bidder shall ensure that they are of the same make, series and family of hardware as far as possible. Bidder shall furnish a composite list of bought-out items along with proposed sub-vendors for each of the same.

4.3.14 Where large number of transmitters (Pressure, DP type flow and Level), switches (Pressure etc.) are envisaged, they shall be grouped in local instrument racks and enclosures. In general local instrument racks shall be provided in indoors and local instrument enclosures/canopies for outdoors/ boiler areas.

4.3.15 The operator stations in the local and remote control rooms shall be housed in the enclosed control desk with interior lighting, louvers with brass mesh, space heater and telephones.

4.3.16 As a minimum the following pressure measurement points are to be provided by the Bidder:

Pressure gauges at the suction, discharge of the pumps, compressors and fans, common header of pumps and fans, inlets and outlet of heat exchangers, de-super heaters, pressurized vessels and other main equipment outlet and inlet

Pressure switches at suction, permissive and trip of pumps and fans/blowers, common discharge header of pumps, discharge pressure low for auto-start of standby pumps and pre-trip alarm conditions

Differential pressure indicators across filters (Gas, water, oil service, air), strainers (Gas, water, oil service, air), cooling water line of the condensers, coolers etc.

Differential pressure transmitters across filters (Gas, water, oil service, air), strainers (Gas, water, oil service, air) for high and high high alarm, cooling water line of the condensers, coolers etc. .

Pressure transmitters at the suction and discharge of main process / pumps / compressors, for all controlled parameters, inlet and outlet of cooling water line of the condenser, flue gas line of HRSG at inlet / outlet of various pressure parts, pressure conditions of major vessels like HRSG's drums, de-aerator etc.

Differential pressure transmitters for all level measurements, differential pressure measurements, flow measurements of condensate, steam, feed-water, air etc.

4.3.17 As a minimum the following temperature measurement points to be provided by the Bidder,

Temperature gauges at main process pump discharge, where there is a change of temperature in the process, inlet / outlet of heat exchangers, de-super heaters etc.

Temperature switches to be provided wherever temperature abnormality to be alarmed if RTD and T/C is not provided, wherever equipment / system to be tripped on high temperature if RTD and T/C is not provided.

Temperature transmitters for all control applications.

Resistance temperature detector for monitoring points where temperature changes occur, bearing/ winding temperature.

Thermocouple for monitoring points where temperature changes occur.

Metal temperature measurement for HP super-heater, re-heater and HRSG drum.

Thermo-wells for performance test point, RTD, thermocouple, temperature switch, temperature indicators.

4.3.18 Flow nozzles shall be used for main steam flow, feed-water flow and other critical measurements where weld-in construction is required. Orifice plates shall be used for other liquid flow measurements where flanged construction is acceptable.

Ultrasonic flow meters / coriolis mass flow meter to be used for custody transfer of natural gas.

Flow glass to be provided for coolant from equipment, coolant from the coolers.

Variable area flow indicators to be provided at the common outlet header of the identical equipment, CW blow-down etc.

Turbine flow meters/magnetic flow meters shall be envisaged for effluent flow.

Flow switches to be provided at the common outlet header of the identical equipment.

4.3.19 Guided wave Radar type level transmitters shall be used for condenser hotwell level and low pressure applications.

Differential pressure transmitters shall be used for general service level measurement of all drums, feed-water heaters, de-aerators and other pressurised and vented tanks.

Transparent gauge glasses shall be used for low-pressure applications. Level gauges shall be provided for all surface mounted overhead tanks, hotwell, de-aerator, and any other storage tanks. Bi-colour type level gauge shall be provided on both sides of the HRSG drums. Electronic drum level indicator to be provided for HRSG. Where level gauges cannot be installed, alternative mechanical means of level measurement and indication such as float and chord type shall be provided.

Level switches shall be provided for all tanks/sumps for low and high alarm, for all tanks /sumps for very low of pump, for all tanks/sumps for normal starting and stopping of sump pumps.

Level transmitters shall be provided for hotwell, de-aerator feed tanks, HRSG drum, blowdown tank, turbine main oil tank, condensate storage tank, DM storage tank, clarified water storage tank etc.

Non contacttypelevel transmitters shall be used for CW sump level.

4.3.20 The following instruments to be provided as a minimum in the Water treatment plant.

| **INSTRUMENT LIST FOR WTP** | | |
|---|---|---|
| **B)** | **DM PLANT** | |
| 1 | Mixed Bed | Conductivity transmitter at the outlet (common for each MB) |
| | | Pressure gauge at the I/L& O/L |
| | | pH transmitter (ultra Pure Water) at the outlet (common for MB) |
| | | Dual Channel Silica analyzer at the common outlet of MB |
| | | FT at the I/L & O/L |
| 2 | DM Water Tank | Float and Board type level indicator |
| | | Level switch low low and Level switch high |
| | | Differential pressure/Ultrasonic type level Transmitter |
| 3 | DM water transfer pump/HRSG Initial fill pump | Pressure Gauge on the discharge of each Pump. |
| | | Pressure switch on the common discharge header |
| | | pH transmitter at the discharge of pumps. |
| 4 | Acid dosing system | Level gauge |
| | | Level low switch |
| 5 | Caustic dosing system | Level gauge |
| | | Level low switch |
| 6 | HRSG Blow down Pit | Level switch low low and Level switch high |
| 7 | HRSG Blow down transfer pumps | Pressure Gauge on the discharge of each Pump. |
| | | Pressure switch on the common discharge header |
| 8 | SSF backwash water storage tank | Level switch low low and Level switch high |
| 9 | SSF backwash water transfer pump | Pressure Gauge on the discharge of each Pump. |

4.3.21 The type of field instruments shall be selected by the Bidder based on the process and the reliability of the instrument at similar power plants.

4.3.22 IBR certificates to be provided for all the instruments, flow elements, control valves and other equipments as applicable

4.3.23 Tagging Philosophy: tagging of instruments shall be as per client's tagging philosophy which is explained elsewhere in tender specification.

4.3.24 Nameplates shall be installed for all I&C equipment bearing the service description, instrument number and calibrated range.

4.3.25 In the event of conflict between the requirements of any two clauses or documents forming a part of this section, the more stringent requirements shall apply unless otherwise confirmed by the Owner/Owner's representative in writing. The decision of the Owner/Owner's representative shall be final and binding in all such cases.

4.4.0 **MAINTENANCE REQUIREMENT**

4.4.1 To ensure easy maintenance Make of all I&C equipments like control valve, actuator, all electronic transmitters, control hardware, local devices, other instruments etc. shall be uniform to the extent possible.

4.4.2 Selection of a particular Make and model of instruments shall be such to permit maximum interchange ability, easy maintenance and repair and to maintain minimum inventory.

4.4.3 Maintenance platforms and access ladders for all the instrumentation equipment installed at inaccessible heights. Sufficient maintenance space shall also be provided against each instrumentation equipment area with safety barricades in the platforms and handrails in the ladders.

4.4.4 Easy access shall be provided for all components in the equipment and system offered to reduce the maintenance period.

4.4.5 Adequate number of test equipment like test sockets, test cables, digital voltmeters, recorders, signal generators etc., shall be provided by the Bidder to facilitate ease in maintenance.

4.4.6 Necessary maintenance equipment tools and special erection tools which are not specifically mentioned in the specification but are normally required for ease in maintenance and to have minimum down time, shall be included in the Bidder's scope.

4.4.7 Standardization concept shall be used in selecting the components for the systems.

4.4.8 Provision shall be made for isolating sub-systems/modules, which are identified to be faulty, thus enabling on-line replacement without taking equipment off-line.

4.4.9 All the documentation shall be in English Language.

4.5.0 **AVAILABILITY REQUIREMENT**

4.5.1 Adequate redundancy shall be built in at various levels to increase the system availability and reliability.

4.5.2 To ensure high reliability of the trip circuit and to avoid spurious tripping of the plant, multiple input logic system, (e.g. 2 out of 3 logic) shall be provided for important and vital trip functions.

4.5.3 The equipment / instrument shall employ state of art technology to guard against obsolescence, Bidder to ensure the supply of spare part for period of 10 years.

4.5.4 Control valves/dampers shall be driven to the fail safe position or hold position in case of control system failure, as required. This arrangement is necessary to avoid system upsets and subsequent loss of operation.

4.5.5 The total system availability for plant DCS shall be above 99.9 The Bidder shall submit detailed calculations, which with the help of a schematic of various sub-systems connected in series or parallel as the case may be and the MTBF and MTTR values for the various equipments shall show that availability of 99.9% is possible.

4.5.6 The I&C system shall be designed with extensive self-diagnostics and troubleshooting features. Adequate facility shall be provided for quick repair/maintenance and on-line replacement of faulty modules. This shall not result in spurious trip. Where a major equipment/unit trips likely to be inhibited when the card is pulled out, Bidder shall identify it during detailed engineering stage.

4.6.0 **LAYOUT REQUIREMENT**

4.6.1 Main Plant CCR

The Main plant central control room (CCR) shall contain all equipment pertaining to Human Machine Interface (HMI) to facilitate remote control and monitoring functions. The central control room / Electronics equipment Room shall be provided with false flooring and false ceiling. The Main plant CCR shall be designed for required illumination level, ergonomically design aspects; minimum acoustics levels and overall as ethic feel of a CCR. All rooms in main plant CCR shall be maintained in air-conditioned environment at 22°C ± 1°C and relative humidity of 50 ± 5%.The Main plant CCR shall consists of the following rooms.

4.6.1.1 CCR

The CCR shall house the LVS, operator , printers, emergency push button station, Electrical control panels etc. unit/station auxiliaries bus transfer panel, transformer and switchgear control panel, GTG and STG control cabinets, CCTV, fire and smoke detection panel and panels necessary for the complete operation and monitoring of the plant.

4.6.1.2 Electronics equipment Room

The EER to be located adjacent to the CCR shall house all DCS cabinets, Plant Communication Equipment Cabinet, Master clock system, Steam turbine generator panels, interposing relay cabinet, various electrical system panels Cable connections to the cabinets shall be suitably sealed to prevent the ingress of dust or vermin or the propagation of possible fires etc.

4.6.1.3 Shift In-charge room shall contain the operator station and the printer.

4.6.1.4 Engineering/ Computer Room

The computer room shall contain all the servers (if applicable), engineering stations, printers, racks for documentation etc.

4.6.1.5 Instrument lab room (Air conditioned).

4.6.1.6 Conference room.

4.6.1.7 Office room

4.6.1.8 Pantry room.

4.6.2 Local control room.

Local control rooms and control panels shall be provided for the normal operation of auxiliary plants, at locations where local operations shall be performed. Air conditioning shall be provided for Local control room.

4.6.3 SWAS Room shall be partitioned into wet and dry rooms. Air conditioning shall be provided for the dry room which shall house all the analyzers and transmitters.

4.7.0 **CODES AND STANDARDS**

The design & specification of I&C system shall be in accordance with the applicable laws, State local codes, ordinances and industry standards applicable to design and construction as indicated below.

- American Gas Association (AGA)
- American National Standards Institute (ANSI).
- American Society of Mechanical Engineers (ASME).
- The Institute of Electrical and Electronics Engineers (IEEE).
- Deutsche Industries Norman (DIN)
- Instrumentation Systems and Automation Society (ISA).
- National Electrical Manufacturers Association (NEMA).
- National Fire Protection Association (NFPA)
- Scientific Apparatus Makers Association (SAMA).
- Indian Standards (IS)
- International Standards Organization (ISO)
- British standards (BS)
- International electro technical committee (IEC)
- American petroleum Institute (API)
- Tariff Advisory Committee (TAC)

Other recognized equivalent international standards shall be utilized as required to serve design, fabrication, and construction guidelines when not in conflict with the above listed standards. Such acts of the Bidder shall be brought to the Owner/Owner's representative's notice before proceeding with the same.

4.7.1 **Temperature Measurement**

- Instrument and apparatus for temperature measurement - ASME PTC 19.3
- Temperature Measurement Thermocouples – IEC 60584 – 3 / ISA MC 96.1 - 1982.
- Thermometer-element-Platinum resistance – IEC 751 / DIN 43760.

4.7.2 **Pressure Measurement**

- Instrument and apparatus for pressure measurement - ASME PTC 19.2.
- Instrument Accuracies - IS 3624 / ASME

4.7.3 **Flow Measurement**

- Instruments and apparatus for flow measurement (Flow nozzle assembly)- ASME PTC 19.5 (1972) Interim supplement, Part-II, BS 1042.
- Instruments and apparatus for flow measurement (Orifice plate)- ISO 5167 Part – 1 / BS 1042.

4.7.4 **Electronic Measuring Instruments And Control Hardware**

- Automatic null balancing electrical measuring instruments - ANSI C 39.4.
- Safety requirements for electrical and electronic measuring and controlling instrumentation - ANSI C 39.5 / 1974.
- Compatibility of analog signals for electronic industrial process instruments ISA-S 50.1: ANSI MC 12.1.
- Dynamic response testing of process control instrumentation - ISA -S26.
- Surge withstands capability (SWC) tests - ANSI C37.90.1-1989 / IEC-255-4.
- Electro-Magnetic Compatibility Tests – IEC 801
- Tests for electronic equipments – IEC 68

4.7.5 **Enclosures**

- Classification of hazardous area – IEC 79
- Degree of protection for enclosures – IEC 60529.
- Electrical Instruments in Hazardous Area – ISA RP 12.11
- Purged and pressurized enclosure for electrical equipment in hazardous location - NFPA Article 496 Volume-4, 1978.
- Environmental conditions for process measurement and control systems – ISA S71.04

4.7.6 **Sampling System**

- ASME PTC 19.11.5 2008 Steam and Water Sampling, Conditioning, and Analysis in the Power Cycle.

4.7.7 **Interlocks, Protections,Symbols**

- Turbine water damage prevention - ASME-TDP-1-1980.
- Boiler safety interlocks – Applicable NFPA 85 sections.
- Instrumentation Symbols and Identification– ISA – S5.1.
- Binary logic diagrams for process operations – ISA – S5.2.
- Graphic symbols for distributed control/shared display instrumentation – ISA – S5.3.

4.7.8 **Annunciators**

- Specifications and guides for the use of general-purpose annunciators - ISA RP 18.1.

4.7.9 **Control Valves**

- Control Valve Sizing - ISA-75.01.
- Control Valve capacity test - ISA-75.02.
- Face to face dimensions of Control Valves - ANSI B16.10.
- Control valve seat leakage classification – ANSI / FCI 70.2
- Valves flanged threaded and welding end - ANSI B 16.34

4.7.10 **Cables**

- Thermocouple extension wires / cables - ANSI MC96.1.
- Colour coding of Instrument cables - BS-5308, Part-2.
- Specification for PVC insulated cables – IS 5831 / 8130/ 1554/ 10810 / equivalent IEC standards.

- Guide for design and installation of cable system in power generating station (insulation, jacket materials) IEEE Standard 422 / NEMA VE-1, and NEC.
- FRLS tests - IEC 332 / IEC 754 / IEEE 383 / SS-4241475 / ASTM D2863/ 43
- Requirements of vertical tray flame test - IEEE 383.
- NFPA 70.

4.7.11 **NFPA 72 – National fire alarm code**

4.8.0 **PLANT CONTROL PHILOSOPHY**

4.8.1 The overall operation and supervision of the Gas turbine generators, HRSGs, steam turbine generators, auxiliaries, balance of plant and associated electrical system shall be coordinated from the Central Control Room DCS.

4.8.2 The extent of remote control and level of automation shall be such that minimum operator shall be capable of supervising and controlling the day to day running of the units from the CCR with little assistance from local operators.

4.8.3 The following primary systems, in general, are to be controlled and monitored through the plant DCS:

- HRSG (Steam water & Air/flue gas system)
- HP Steam System
- MP Steam system
- LP Steam System
- Reheat Steam System
- HRSG Blow-down System
- Auxiliary Steam System
- HP, MP, LP Bypass systems
- Steam System Vents and Drains
- Condensate cycle system
- Feed water System
- Condenser cooling Water / cooling tower system
- Closed Cycle Cooling Water system (ACW)
- DM water distribution system
- De-mineralized cooling water system
- Chemical dosing System
- Fuel Gas System
- Plant Protection System
- Plant start-up and shutdown system
- Coordinated control system

4.8.4 Control and monitoring system for Gas Turbine Generators (GTG) and its auxiliary equipment including its lube oil temperature controls shall be provided through a proprietary micro-processor based control system mounted in a local enclosure. This proprietary control system shall consist of one OWS/EWS, one Colour laser printer,all located in the local control room. The proprietary control system OWS shall be capable of tag data archiving, retrieval and display with 1 sec resolution. Historian station shall be provided separately or integrated with OWS storage capability of tag data minimum 30 days. The control and protection system for GTG shall have PTR (proven track record) and certified by TUV. GTG control systems shall be interfaced to the plant DCS systems for redundant communication Soft link to DCS. Dedicated operator stations for local operation/monitoring (separate from DCS operator stations) of GTG and auxiliaries shall be provided in CCR. GTG control and monitoring system shall be implemented in a redundant fail safe & fault tolerant configuration. Power supply modules, communication & network interface cards,

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controllers, for controls and interlocks shall be redundant. Protection, controls system for GTG to be implemented in two out of three voting logic. Apart from serial communication link signals interfaced with plant DCS, signals such as critical alarms, trip feedbacks, SOE, fire protection signals, interlocks & controls, commands shall be hardwired. During start up, GT shall be controlled from local operator station and after start-up the control shall be transferred to remote CCR for operation. The GTG control system shall be capable initiating load throw-off and unit operation at house load. The system shall have one push button start for the GTG accordingly as per process requirement, different group controls/sub-group controls shall get operational commands and in turn individual drive shall get start/stop or open/close command. Safe shut down emergency stop push button shall be provided.

4.8.5 Control and monitoring system for the steam turbine generator (STG) governing control shall be through a microprocessor based control system. STG control system shall be interfaced to the plant DCS system through redundant Communication soft link to DCS. STG auxiliaries monitoring and operation shall be carried out through plant DCS operator stations in CCR. STG control & protection system shall be carried out in fail-safe & fault tolerant based system.STG protection system shall be implemented in DCS. Apart from serial communication link signals interfaced with plant DCS, signals such as critical alarms, trip feedbacks, SOE, interlocks & controls, commands shall be hardwired. Power supply modules, communication & network interface cards, controllers for controls and interlocks shall be redundant. Safe shut down emergency stop push button shall be provided.

4.8.6 Control systems integral to turbine- generator shall include turbine protection system, electro-hydraulic governing (EHG) system; turbine supervisory system.

4.8.7 Control and monitoring system for HRSG and its auxiliary equipment shall be through DCS.

4.8.8 Control and monitoring system for various balances of plant systems/equipment shall be as follows:-

- Fuel Gas Heating System (If provided)

  Operation/monitoring through local control panel or remote CCR located DCS operator station. Critical signals such as on / off / trip feedbacks / critical alarms/SOE interfaced with plant DCS via hardwire. The local control panel and other electrical/electronic equipment shall be designed as per the electrical area classification of IEC.

- Water Treatment Plant

  Control and monitoring shall be through DCS. Operation/monitoring through VDU/keyboard based operator station control room. MB shall be semi-automatic. MB Regeneration shall be manually.

- Instrument & Service Air System

  Control and monitoring shall be through microprocessor base control system interfaced to plant DCS through redundant communication link. Operation/monitoring through both CCR located DCS operator workstation and local control panel located near to equipment. Critical signals such as compressor start, stop & status / Dryer status feedbacks / critical alarms/SOE interfaced with plant DCS via hardwire. Remote start and stop of Compressors shall be provided from DCS.

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- Fire detection/protection System

  Micro-processor based analog addressable main fire alarm panel, local fire control panel, repeater panels for fire alarm and detection system compete with analog addressable fire alarm detectors, alarm annunciation windows, OWS and printer, interface to plant DCS system, all hardware, software, cables, other interface and field sensors/instruments erection hardware (one lot). Provision for interface/ hook up of existing Fire alarm panel with proposed fire alarm panel shall be made. Approximately provision of interface of 30 signals of existing fire alarm panel shall be mad at proposed fire alarm panel. One common repeater panel shall be provided (existing & new unit) at main fire control station, 2 km away from proposed power plant. Required hardware and software along with cable shall be provided by supplier.

- Air Conditioning (A/C) and Ventilation

  Stand-alone type microprocessor based control system shall be provided for AC and ventilation system. Status monitoring of A/C and ventilation in plant DCS through dual redundant serial communication link with critical signals (start/ stop/ critical feedbacks) hardwired.

- DG Set

  DG set shall be controlled from Local AMF (Auto main failure) panel. Provisions or monitoring of DG set parameter from DCS through redundant serial link or hardwired shall be provided.

- Steam and Water Analysis System (SWAS)

  Analysers output signals for steam and water analysis parameters shall be directly monitored in plant DCS in addition to the fault alarm signals via hardwire.

- Stack emission monitoring system (SEMS)

All Stack emission monitoring system parameters shall be directly monitored in plant DCS through hardwiring in addition to the fault alarm signals via hardwire.

- Controls of Plant Electricals

  The electrical system of Power Plant will be controlled and monitored from the Plant DCS system. The controls for the following will be through mimic screens in the VDU (LCD).

  - 11 kV System (Motors only)
  - 415 V System (motors only)

  Critical signals, Analog signals, Status alarms and controls of the switchgears will be extended to DCS system. All theI/Os of plant auxiliary systems will be terminated in a marshalling / remote I/O panel located locally in the respective Switchgear room.

  Sequence event recording / status of breakers & fault reporting of 11 kV System (Motors only), 415 V System (motors only) distribution system, Diesel generator, 110 V D.C system, 110 V AC UPS etc. will be indicated in the Plant DCS system.

  Monitoring of essential power supply parameters and warning in case of abnormal conditions.

  Auto and manual synchronization for generator breakers.Manual synchronization for other synchronizing breakers.

The load control will be done by Power Plant Operator depending on the Load Dispatch Center requirement.

- **Control Scheme for Drives**

  Contactor operated drives

  a) Contactor operated drives will be operable from Remote i.e. from Central Control Room (CCR). Drives will be provided with start and Emergency Stop Push Button (EPB).

  b) Remote manual operation of all drives will be done from OWS.

  c) Remote control commands i.e. start/stop, will be generated from DCS and will be issued to switchgear through interposing relays located in respective switchgear. The start and stop push button station in the field will be wired directly to switchgear. The EPB (stay put type) will be provided with press to lock and turn to release type, keyless mechanism.

  d) Necessary electrical protections for the drives will be realized at switchgear, whereas process interlocks and protections are realized in DCS.

  e) Following signal exchange will take place between Switchgear & DCS:

     i) Drive Start & Stop commands
     ii) Drive ON & OFF
     iii) feedback
     iv) Switchgear disturbed (Thermal O/L operated / Control supply failure / EPB Operated / switchgear isolated)
     v) Local / Remote selector switch in Remote mode will be DCS( L/R selection command)
     v) Current and KW measurement will be provided in DCS for important drives as per drives the list furnished by Suppliers. Current transducers will be provided in Switchgear for those dives.

4.8.9 Breaker operated drives

a) Breaker operated drives will be normally operable from remote. Remote manual operation of these drives will be done from CCR through OWS.

b) The switchgear has two positions of operation i.e. Service and Test. Service position is the normal mode of operation. The test position is envisaged to test the switchgear operation. Following are the operational combinations for breaker operated drives.

   i) Test Position: Switchgear Testing (Start/Stop) from SWGR under racked – out condition.
   ii) Service Position: Drive Operation (Start/Stop) will be from CCR.

c) Remote control commands i.e. start/stop will be generated from DCS and will be issued to Switchgear through interposing relays located in respective Switchgear.

d) The Emergency Stop Pushbutton (EPB) will be wired directly to switchgear. The EPB (stay put type) will be provided with press to lock and turn to release type, keyless mechanism. Under its locked position, the drive operation will be inhibited.

e) Necessary electrical protections for the drive will be realized at Switchgear, whereas process interlocks and protections are realized in DCS.

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f) Following signal exchange will take place between switchgear and DCS:

i) Drive Start & Stop commands.
ii) Drive ON & OFF status feedback (in service and test position of SWGR by main contacts)
iii) Switchgear disturbed (Control power supply fail, Trip circuit Unhealthy, EPB Operated, Breaker Auto Trip).
iv) Switchgear Healthy (Breaker in Service, Spring Charged).
v) Lock out Relay (86 relay) operated.
vi) Local / Remote selector switch in Remote mode (command from DCS)

g) Current transducers, 4-20mA types, will be mounted in the SWGR for monitoring the current in DCS. Auxiliary power supply to these transducers will be provided from the control power supply of the respective switchgear.

4.9.0 **DRIVE CONTROL PHILOSOPHY**

4.9.1 **Bi-Directional Drives (Inching Or Open/Close)**

All bi-directional drives are provided with non-integral starters.All these drives shall be operable from Remote i.e. from Central Control Room (CCR) / local control panel. Local operation of the drives shall be possible through integral open / close push buttons.

Necessary electrical protections shall be realized at non-integral starter, whereas process interlocks and protections shall be realized in DCS.

Following signal exchange shall take place between DCS &non-integral starter of actuator.

1. Valve Open & close commands.
2. Valve opening (Running in forward direction)
3. Valve closing(Running in reverse direction)
4. Non-Integral starter disturbance (Loss of power/control supply, Thermal O/L, Local/off/Remote S/S in Local or off mode etc.)
5. Valve Status feedback by means of end position limit switch (open/close), torque switch contacts (open/close).
6. Position feedback (4-20mA, two-wire electronic type) for inching drives.

4.9.2 **Unidirectional LT Drives**

Unidirectional LT drives shall be operable only from Remote i.e. from CCR / local control room or panel. In addition, Local push button shall be provided for emergency stopping of drive.

Remote start / stop commands, generated in DCS / local control room or panel shall be wired to MCC through interposing relays housed in respective MCC.

Emergency stop of the drive shall be envisaged for selected applications from the local push button provided near the drive. The stop push button (Stay put type) shall be provided with a press to lock and turn to release type, keyless mechanism with a protection cover. Under locked position thedrive operation is inhibited from remote. The local emergency stop pushbutton shall be wired directly to MCC.

Necessary electrical protections for the drive shall be realized at MCC, whereas process interlocks and protections are realized in DCS / local control room or panel.

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**Following signal exchange shall be envisaged between MCC & DCS/ local control panel:**

Drive start & stop commands

Drive On&Off feedbacks

MCC disturbed (Thermal Overload relay operated, MCC control power supply fail, local PB operated)

Current measurement shall be provided in DCS / Local Control Panel for monitoring for all drives greater than 30KW & for critical drive less than 30KW. The Current Transducers shall be 4 -20mA, isolated output type, provided in MCC. Auxiliary power supply to these transducers shall be from the control supply of the respective switchgears.

4.9.3 **Solenoid Operated Drives**

Solenoid operated drives shall be operated from remote CCR / Local Control Panel. Local operation of these drives is not envisaged. All solenoid valves are powered at 24V DC, 110 V ACunless otherwise specified.

Remote open / close commands shall be generated in DCS / Local Control Panel and shall be issued to the solenoid through interposing relays in control room, provided to match the impedance and current rating of control command relays with solenoid burden and located in relay panel, which is in Control room.

Necessary process interlocks shall be realized in DCS/ Local Control Panel

The following signal exchange shall be envisaged between solenoid operated drive and DCS / LCP.

Valve open / close command

Valve Status feedback from the drive by means of limit switches (wherever available) for process/logic.

4.9.4 **Unidirectional HT Drives**

The switchgear has two modes of operation i.e. “Service and Test”.

`Service’ mode is the normal mode of operation. In service mode, the drive is operable from the plant DCS

The `TEST’ position is envisaged to test the switch gear from local during maintenance / commissioning

Remote start / stop commands, generated in DCS shall be wired to switchgear through interposing relays housed in respective switchgear.

Local push button shall be provided for only emergency stopping of drive. The stop push button (Stay put type) shall be provided with a press to lock and turn to release type, keyless mechanism. Under locked position the drive operation is inhibited from remote. The local emergency stop pushbutton shall be wired directly to switchgear.

Necessary electrical protection for drive shall be realized at switchgear, whereas process interlocks and protections are realized in DCS.
Following signal exchange shall be envisaged between Switchgear and DCS:

Drive start & stop commands

Drive status feedbacks by means of ON & OFF contacts (in service/test position of switchgear)

Master trip relay operated (Electrical trip).

SWGR disturbed (control power supply failure, trip coil unhealthy, local push button operated)

SWGR available (Breaker in service position, breaker spring charged, SWGR in remote)

SWGR Breaker in test position

Motor current - Current transducers 4 -20 mA type shall be mounted in the SWGR for monitoring the current in DCS. Auxiliary power supply to these transducers shall be from the control supply of the respective switchgears. For HT drives and driven equipment bearing temperature and motor winding temperature measurement also vibration signals for Motor and Pump/Fan HT drives (X-Y direction both at DE and NDE) shall be provided.

4.9.5 **Variable Speed LT Motors With Bypass**

The Control & Operation shall be identical to L.T. Motors with the following addition. VFD drive speed reference analog output from DCS shall allow DCS to give the speed set point for the drive when the drive is selected in remote mode (Local/Remote mode selection shall be from DCS) & VFD mode is selected from the VFD panel (a digital input shall be considered in DCS such that the contact make to signalize as the drive is selected in VFD mode). An analog input from the drive to DCS shall indicate the drive speed at DCS. If the Local mode selected from the DCS, then the Drive can run from two different locations. It can run either from the VFD panel or it can run from the LCS depending upon the selector switch position mounted over the VFD panel.

4.9.6 **Analog Drive**

Analog drive is hooked up & interfaced to DCS / Local Control Panel. A drive control function residing in Processing Units is used to position the pneumatically operated control valves. Interlock and protection Open / Close Commands originating from field or generated internally in control logics are interfaced with the drive control function residing in processors.

Control Valve actuator design shall take care of fail-safe condition i.e. bringing valve to full open / full close or stay put mode, on signal air failure or air supply failure respectively.

Auto / Manual operator control and display for various control loops shall be provided.

MMI Control displays have the following functionality:

Indication of Set point.

Indication for deviation between set point and measured value.

Measured value indication.

Final control element position feedback indication.

4.10.0 **DESIGN BASIS FOR DCS**

4.10.1 **System Requirements**

The following specification shall serve as a guideline to indicate the special requirements for the DCS.The plant control system configuration shall be as per Drawing No.20-5111168-I-351.

The DCS must be capable of fulfilling all requirements of the plant in an optimal way. The offered system shall have been in satisfactory operation in at least three similar applications for at least two years continuous operation and confirm guarantee against obsolesce for 10 years. The DCS offered shall be of the latest design. The operating system shall be based on latest window platform.

Microprocessor based fault tolerant system with SIL - 3 certification shall be provided for DCS.

For designing the system all the specification requirements shall be considered, where applicable. All components and systems offered by the Bidder shall be of established reliability. The maximum reliability shall be achieved by the Bidder considering the meantime between failures (MTBF) and meantime to repair (MTTR) such that system shall be available for 99.9% or better.

The operation of the plant DCS shall be based on simplicity and rapid access for monitoring and taking control actions.

Plant DCS to provide plant co-ordination for start-up, synchronization, normal load range, shut down and emergency operation of the plant in a coordinated sequence.

DCS shall provide automatic supervisory control and pre-planned protective actions (run back, over-ride control, control mode transfer etc.) during upset conditions if the operator or normal modulating controls cannot be expected to provide a timely or adequate response.

The operation mode of the system must be conceived in such a manner that access to the process variables, motors and actuators shall be possible very quickly with only a few key strokes. In critical situations the switch from one display which supports operator control actions to another such display must be possible directly without the need to select additional intermediate displays. Systems are preferred which, in addition to the capability of taking control actions from dedicated displays; also provide the facility of taking such actions via graphic displays.

The operator station, LVS and other peripherals shall perform control and monitoring functions including data archiving & alarm monitoring, dynamic graphic display for plant operation, Group display and trend group display, Real time and history trending of each loop, Alarm display and storing alarms for history, Multi window graphic display, Logging functions, Printing of system alarms, process alarms, graphics with dynamic reading and logging, operation of printing function shall be continuous, scheduled and as well as on demand. Surge arrestors shall be provided suitably to avoid damage of system from high spikes.

The following redundancy shall be considered,

- Plant DCS

Power supply modules, communication & network interface cards, controllers, serial interface to other control systems shall be redundant.

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A functional group control hierarchy shall be devised for all major plant equipment and their auxiliaries to allow operator to select a lower level of certain system or equipment during trial runs, testing etc.

DCS system shall comply with following general failure criteria:-

- No single fault can cause the complete failure of the control system.
- No single fault can cause the Turbine/Boiler/Generator protection system control to malfunction or become inoperative.
- The grouping of control functions into system blocks shall be arranged such that failure of any one block shall only partly degrade the control of the overall system. Such degradation shall always be manageable by operator intervention.
- The control system shall be structured to reflect the redundancy provisions of the plant so that no single fault within the control system can cause the failure of the duty equipment or make the standby equipment unavailable.
- As a result of a control system fault, a plant item or control function shall always respond to its controls at the actuator level. That item or control function shall be required to be isolated from automatic control system.

To meet the above failure criteria, the DCS system shall incorporate diagnostic/self-checking facilities so that internal faults can be detected within the system itself prior to any resulting disturbance to the process. In addition, the protection and safety systems shall incorporate channel redundancy or diversity of measurement as well as self-checking and adequate test facilities. For some important systems, "On line" test shall be employed with no effect to the proper functioning of the protection system.

In order to achieve high plant safety and availability, the control systems shall be functionally distributed, highly modular and in a hierarchical configuration. This guarantees that any faults arising in the control system shall always be confined to a limited section of the plant. The hierarchical configuration shall enhance the transparency of the plant for the operating personnel, in particular when faults arise.

Essentially, the configuration as defined shall have the result that in the event of a fault in the control system, manual operations shall be required only at one or very few locations at the same time.

Controllers shall be 100% hot standby.

Concept for I/O assignment shall be as follows:

- No two identical / similar equipment shall be grouped in the same I/O module and in the same rack.
- Redundant inputs/ outputs shall be connected to different input/output cards of DDCMIS i.e. triple redundant inputs shall be connected to three separate input cards.

In case of control power interruption for a short time (seconds) the Systems must maintain the plant in operation and after power restoration no false commands shall be issued.

To avoid damage to the plant equipment in the event of a major failure in the Systems, a safe shut-down of the plant must be guaranteed.

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OPC servers provided shall be dual hot redundant and be of latest version type. The OPC shall support data access, Alarm & event, Historical data access.

The system shall be provided with extensive diagnostic features so that a system failure can be diagnosed down to the module level giving location and nature of fault. Ease of maintenance and troubleshooting shall be a primary consideration in equipment selection. The interposing relays provided shall be with minimum 2NO+ 2NC contacts.

4.10.2 **System Components**

**Controller Sub-System**

The automatic control functions of the system shall be executed by microprocessor based controllers. The multi loop controller shall have 1: 1 hot redundancy in each processor, power supply, and communication controller shall be redundant. To ensure that the above security aspects are met, the primary controller shall be backed-up by secondary controller that takes over automatically when the primary controller fails. The control output shall be fed back to both the controllers to allow bump-less transfer to be accomplished.

The maximum loading limits of various control system components shall be as follows:

Control Processor - 60% (max.)
RAM - 50% (max.)
OIS CPU - 50% (max.)

The time taken for stand-by controller to take over in the event of failure of primary controller shall not exceed one scan cycle of the controller. The transfer shall be bump-less and procedure less.

The controllers shall be capable of performing regulatory control, sequencing and interlocking.

The controller shall be capable of performing the following output processing functions.

a) Output open check
b) Output high/low alarm
c) Output high/low limiter
d) Output velocity limiter

The basic control functions shall include proportional, integral and derivative algorithms.

Advance control functions shall be inclusive of feed forward, Cascade control, high-low limit control, dead-time, lead lag, high-low signal selection, real-time computational capability etc. apart from other algorithms used in the plant DCS like feedback controls, Mean value and auto selection logic, bypass valve control, star-up/shut down curves.

The controller sub-system shall be capable of performing the following input signal processing functions like square root extraction, linearization for thermocouples, pulse train input function, line segment function, digital filtering, totalizer functions etc. as a minimum.

Controller shall be able to operate in either manual, auto, cascade mode. Mode change over in either direction shall be procedure less and bumpless.

Functional grouping of controllers shall be done as per the plant control system configuration drawing (20-5111168-I-351). No mixing of functional groups is allowed. If STG controls are part of the plant DCS then separate controllers for STG to be envisaged.

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The grouping of control loops in controllers shall be done based on the input / output (I/O) handling capacity of the individual controllers such that the system availability in the event of loss of one controller is more than 50% (i.e., whenever there is more than one similar equipment necessarily the two shall be implemented in different controllers).

The controller shall be capable of carrying out following alarm check functions:

- Input open/output open check
- High high, high, low and low low alarms
- Velocity and deviation alarms
- Alarm hysteresis
- Alarm bypass
- Alarm output off.

The system shall be capable of sending the following messages to the operator interface sub-system:

- Self-diagnostic alarms
- Process alarms
- Loop status changes

The controller shall have facility for slow and fast ramping of set point and output. Also all controllers shall have anti-reset wind up as a standard.

**Data Acquisition Sub-System**

Data acquisition subsystem shall have dual redundant processors, power supplies and communication including cables. All other accessories as required to make the system complete shall be provided.

Data acquisition sub-system shall cater to both analog and discrete inputs from open loops. The inputs shall include 4-20mA DC, thermocouples, resistance temperature detectors (RTD), voltage signals, resistance signals and discrete contacts, as a minimum. All I/O modules shall be hot swappable online.

The data acquisition system shall be capable of performing the following alarm check functions as a minimum:

- Input open check
- Deviation alarm check
- High/low/high-high/low-low limit alarm check
- Alarm bypass

The sub-system shall be capable of processing linear and non-linear analog inputs, linearization for thermocouples and RTD inputs, square root extraction, totalizing of inputs and burn out protection for thermocouple inputs.

It shall be possible to display all variables of the data acquisition sub-system on the operator consoles by addressing from the keyboard.

The MIS station shall be a node connected to the plant LAN and the office LAN and shall be capable of exchanging plant data with MS Excel running on office LAN PCs. Hardware firewall shall be provided with MIS Station/OPC server.

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4.10.3 **Man Machine Interface**

Each operator's interface sub-system shall have high resolution colourLEDflat panel display (VDU) of screen size 24". Resolution shall be minimum 1280 x 1024 pixels. Each operator interface sub-system shall consist of electronics, Qwerty keyboard with special function keys, optical mouse with scrolling button, TFT LED with antireflection features, minimum Core 2 duo processor or latest processor 2.4 GHZ, required network cards, speakers, all required cables. A set of electronics may support multiple LED's. Two (4) GB RAM minimum shall be supplied such that the system shall not slow down while processing multiple tasks. The most current release of fully tested hardware shall be supplied. The features above are applicable for all the stations in the power plant.Supplier to supply latest configuration for operator station, engineering station.

63” Large video screen (LVS, 24X7) shall ensure operation even if the operator stations fail. LVS shall consist of LED displays, separate controllers with latestWin OS, QWERTY Keyboard, optical mouse,latest processor,3.4 GHZ, 4 GB DD RAM, and other accessories. LVS shall be of ceiling hang type or suitably supply.

The operator, as a minimum, shall have access to all the displays, acknowledge alarm as and when they are annunciate on the operators' console, special function keys for single stroke operation to have direct access to any parameter assigned, Auto/manual/cascade mode changeover of each controller with bump less transfer from one mode to another, facilities for slow and fast ramping of set point and output of each close loop parameter. It shall be possible to use the DCS OIS as EWS and vice versa with password protection.

Access to changing control parameters, alarm limits and security level shall be through limited passwords or key lock system.

The sub-system shall be provided with highly reliable and field proven Hard Disks for storing of complete system software and operational data with minimum 30% spare capacity. Suitable battery back-up shall be provided for protection of volatile memory (for 72 hours).

The system shall be also equipped with high capacity storage drives of latest make / model.

In case the proprietary design/architecture of the manufacturer calls for separate Application/History processor for intensive computation, operation and bulk memory storage, the same shall be provided separately as application/history processor station with redundancy.

All the operator keyboards shall be interchangeable. All operator stations shall be identical and fully interchangeable. It shall be possible to carry out control/monitoring of total plant from any of the station and any station can be assigned for control/monitoring of any particular part of the plant. Any change made for any parameter for an input from any display shall be automatically updated on all displays configured for that input. Bidder to ensure that, any single failure in MMI hardware/software including controller, coupler, interfacing devices, cables etc. shall not lead to non-availability of more than one operator station. The Operator station shall also include diagnostic functions that automatically detect process faults.

The Operator station must provide enough information under abnormal or hazardous conditions caused by failures in plant equipment or in the instrumentation and control system to allow the operator to identify the equipment causing the trouble, take measures to correct it, and move the process back to its normal operating state.

The OIS shall be capable of acquiring, storing, archiving and displaying tag data with 1 sec resolution minimum with online storage capability of tag data for 180 days. It shall have features to enable printing of various logs including daily logs, event logs, operator action logs, alarm logs, trip

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logs etc. The alarm history shall include the last 10000 alarms with filtering facility. It shall also have capabilities to include or exclude tags from the scan cycle, back-up and restore facility for all OIS data, display page pop-up on digital tag state change, single button snap shot facility for display screens, operator configurable trends, alarm function keys on OIS keyboard including alarm acknowledge, reset, paging, summaries and all keys for plant operation and monitoring arranged in an ergonomic design.

To determine whether it is the instrumentation and control equipment that is causing the problem, the Operator station should provide the following diagnostic features and make the results of diagnostic tests available to the operator:

- On-going tests and reasonable checks on the sensors and analyzers that measure the process variables of interest.
- On-going self-tests on the components and modules within the distributed control system itself: controllers, communication elements, computing devices, and the human interface equipment itself.

Simulation of process variables shall be possible.

The engineering station configuration shall be same as of that of the operator interface system except for the keyboard which shall be QWERTY type. The engineering station shall have provision for performing the following engineering functions.

- Database configuration including configuration of all displays and loops for various sub-systems.
- Automatic downloading of the configurations in each sub-system.
- Configuration of various control functions or control blocks to implement various control strategies and downloading the same into the respective control stations.
- Configuration/reconfiguration of alarm settings, their values, addition/deletion of alarm from groups, controller tuning like changing P, I, D values, dead time values etc.
- Defining the key lock functions or engineer keyboard functions.
- On-line compilation of all types of dynamic graphic displays.
- Setting of real time clock.
- Plant/group alarms inhibit function.
- Start/stop of each sub-system, including printers.
- Enabling/disabling of different instruments/ peripheral connected to the system.
- Scan-on /off-scan of different tags connected to the system.
- Preparation and compilation of logs/reports/ historical trend points.
- Calling of detailed self-diagnostic displays for maintenance aid.

- Loading, editing, compiling and executing of all programs written using high level languages supported by the system.

- Performance calculation and load calculation using standard high level languages and using the real time data available on the DCS highway. It shall be possible to view the plant performance in any of the operator and MIS stations also.

Online configuration changes shall automatically update all modules, tags and subsystems affected by the change. Online configuration changes shall follow a prompt- validation sequence requiring a final acknowledgement step before the change is transmitted.

It shall be possible to save all database and configuration data on both removable and non-removable media for back up purposes without taking the system off line. It shall be possible to down load the data bases and configuration data to all modules from a single location.

Each analog input/output and analog control block shall be assigned an engineering unit. Engineering unit shall be a minimum of 6 free format alphanumeric characters. Engineering unit shall be automatically displayed along with the variable. System shall accommodate user configurable engineering units.

Printers shall be network printers and shall be freely assignable. Printers shall be provided for printing of various events, shutdown reports etc. and making hard copies of various displays/ graphics, log reports, sequence of event recording etc.

Laser/Dot matrix printers will be provided.

Any printer can be specified as an alarm or report printer, and also respond to operators print request.

4.10.4 **Mass Storage Sub-System**

The historical data storage and retrieval system shall store and process system data for future analysis. The data shall be transferable to removable storage media for long term storage and retrieval. The binary data to be stored shall include status of SOE (1milli-second resolution), alarm and other binary inputs. All the important analog data shall be stored at the second interval. Selected logs viz. start up log, trip analysis log shall also be stored.

Mass storage system shall be offered with necessary removable hard disks in *RAID-1 or RAID-5*configuration, controllers and back up devices. The mass storage system offered shall be capable of storing process events, alarm events, graphics, logs, reports in addition to the functional requirements of the system. The mass storage sub-system shall be capable of acquiring, store, archive and display tag data with 1 sec resolution minimum with online storage capability of tag data for 180 days. Historical recording shall also be possible for storing hourly, shift, weekly, monthly averages for at-least 200 process variables. It shall also be possible to record the alarm events.

All events (such as changes in set-points, auto/ manual mode changes, alarm inhibits, changing over from one key lock position to another etc.) alarms and messages shall all be stored as historical messages and presented to the operator as and when required. Important parameters trends etc. related to plant efficiency and performance equipment history etc. shall be duly secured in the storage medium viz., optical disk drive unit for long time archival. Bidder to elaborate in his proposal, the memory capacity offered and the back-up in number of days stored considering the worst case loading. At least minimum one month storage to be considered in the hard disk without back up.

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4.10.5 **Plant Data Bus / Communication System**

The communication sub-system shall be a digital communication bus that provides a high-speed data transfer rapidly and reliably between the various sub-systems. The transmission rate shall be minimum 100 Mbps or better as per IEEE 802.3 / 802.4/ 802.5.Communication sub-system shall be dual redundant, consisting of two separate communication buses and two separate communication interfaces for each node. Both data highway subsystems shall be active at all times. Healthiness of each bus shall be automatically tested periodically at regular intervals without affecting system operation.

In case of main bus failure or any communication device failure, the transfer to the dual redundant back up device shall be automatic without interrupting the system operation and without any operator's intervention. Information about the failed bus/device shall be displayed on the operator / engineer station.

Failure of a particular node shall not be treated as failure of communication bus. Transceiver failure at a particular node shall not be displayed as data highway failure. Bus and node devices shall be suitably isolated against the surges and noise. The redundant data buses shall be routed along different routes and in conduits.

It shall be possible to switch over the communication from main bus to the dual redundant bus manually without disturbing the system operation.

It shall be possible to connect or disconnect any device from the system without disturbing the operation.

The mechanism used by the communication system for error checks and control shall be transparent. Error checking on all data transfer shall be done by cyclic redundancy check and / or any other advanced codes.

The data highway offered shall have 30% spare nodes without highway extender for future expansion. It shall be ensured that the bus loading does not exceed 60%.

4.10.6 **Sequence of Events Recording (SER)**

The Sequence of Event Recorder shall be integral of the DCS. It shall be possible to perform the engineering function of the Sequence of Event Recorder from the engineering station offered for the DCS.The Sequence of Event Recorder signals shall be time stamped with one millisecond resolution at the I/O card level and shall be capable of handling up to 250 points without compromising on the specified resolution.

4.10.7 **DCS Power Supply Modules**

The system power supplies shall be suitable for 110 V AC 50 Hz, 1Ø UPS power.

The power supplies shall have a fuse rated suitably, according to the nominal current requirement. The power supplies shall have built-in diagnostic circuitry, which checks for out-of-range voltages and over temperature conditions. Each power supply unit shall have pair of LEDs to indicate normal operation and alarm condition.

The power supplies shall be provided with necessary cooling fans. The power supplies shall be provided with galvanic isolation. The power supply units shall be provided with miniature circuit breaker (MCB) of sufficient rating.

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All power supply to cabinets shall be redundant & have auto change over facility or diode auctioneering. Power supply failure monitoring shall be provided in DCS for controller and I/O cards.

Power supply for operator station VDUs and system peripherals shall be from UPS. Each PCU shall have redundant power supply modules and shall in turn be fed from two independent power supply feeders.

4.10.8 **DCS Input / Output Modules**

Input / Output (I/O) modules shall be modular plug-in-type suitable for mounting in racks. The multichannel I/O cards for all AI/AO/DI/DO cards shall have a maximum of 16 channels. The analog input card shall capable of powering the transmitters with 24V DC and shall be capable of accepting the following signals. All process input / output cards shall have suitable isolation Galvanic / Optical for each channel at input / output respectively. Interrogation voltage for digital cards shall not be grouped and provided for each individual channels. A/D conversion of the measuring signals shall be such that the required data accuracy be guaranteed (minimum resolution 10 bits). Signal outputs shall be provided with protection against short-circuits. The principle of A/D converters shall be that of integration. 50 Hz noise shall be suppressed in a suitable way.

| | | |
|---|---|---|
| Analog Inputs | : | 4-20 mA DC signals, 2 wire & 4 wire<br>RTD and T/C signals |
| Analog Outputs | : | 4-20 mA DC<br>1-5 V DC |

Digital input modules (DIM) shall be provided with internal voltage source to convert contact state of potential free contacts, either change-over or ON-OFF into logic level signals. Possibility of surface film or contaminant on the contact shall be considered while selecting this source. Input interrogation voltage shall be 24V DC. Each module shall be provided with circuitry to detect card/channel failure and same shall be indicated. Couple of channel failure shall not result in total card failure. Each module shall be designed with self-checking features for detecting faulty operation. In case of individual card failure, on line replacement of the faulty module shall be possible.

Digital output modules shall be provided for controlling ON/OFF status of final control devices like motor starters, the outputs shall be 24 V DC or 110V AC through interposing relays. All solenoid valve shall be rated for 24 VDC or 110V AC, 5A. Interposing relays shall be accordingly provided for 110 VAC, 24VDC rated solenoid valve for energizing these valves from the DOMs. Digital output modules (DOM) shall convert the internal level of the system into external binary signal levels required by the process. Digital output modules (DOM) shall be able to source / sink sufficient current while energizing field outputs. The outputs shall be able to drive breaker coils, contactors etc., directly. DI/DO modules shall be provided with glass fuse protection.

For HT drive 110 V DC 5 A contact rating Interposing relay shall be used with 2 NO/2 NC potential free contacts. Separate External relay for ON and OFF shall be used.

All modules shall be provided with circuitry to detect card/channel failure and same shall be indicated. Couple of channel failure shall not result in total card failure. Each module shall be designed with self-checking features for detecting faulty operation. The input / output modules shall have SMART transmitter interfacing capability, detection of breakage in wire, out of range detection, contact bounce filtering, thermo-couple open circuit check features, RTD open circuit and closed circuit capabilities. Incase of individual card failure, on line replacement of the faulty module shall be possible.

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All inputs / outputs shall have isolators and current limiting circuitry so that faults, short circuits, open circuits and overloads in one signal do not affect any other signal. Input / Output modules shall incorporate signal conditioning / filtering circuits to reduce the effects of electrical surges, noises and contact bounces. Minimum of 20% wired spare shall be provided on each card, wired up-to the terminal blocks

Each I/O module shall be electrically isolated from external control circuit by suitable means. The minimum isolation level between I/O module and external circuit shall be 1000 Volts DC. I/O module isolation shall be optical type. On board channel-to-channel and channel-to-ground isolation to be provided.

Input / Output modules shall be designed to withstand vibration / EMI / RFI / Surges effects as per relevant standards.

Status indication of each input shall be available on the operator & engineering workstations.

It shall be possible to remove and insert the modules while the system is 'ON' (Hot swap of I/O modules)

Diagnostic LEDs shall be provided on the front plate of each module to indicate faults.

Identification labels (color-coded) to indicate one type of I/O card; signal level etc. shall be provided on the front plate for each I/O module.

4.10.9 **Panels, Desks, Racks And Cubicles**

In general in the following sections, panels shall mean marshalling panels, system cabinets, relay panels & power supply panels unless otherwise stated.

Unless otherwise specified, panels and cubicles shall be of floor mounted and free standing construction including those used for alarm and protection relays and the like. The electronic cubicles shall house rack mounted consisting of I/O, processor and power supply modules.

**Panel Earthing**

Two separate earth circuits shall be provided for earthing, one as electronic earth (or instrument grounding) through separate group of pits for earthing of instruments & electronics and second safety earthing for earthing of system cabinets. These two earth circuits shall be electrically isolated from each other.

Each cabinet shall be provided with a copper bus-bar 25 mm wide, 6 mm thick and of suitable length with tapped holes to suite M6 bolts. The copper bus shall be mounted suitably inside the cabinet and shall be electrically isolated from cabinet steel structures through insulated spacers.

All circuit grounds of electronic instruments, shields & drain wires of signal cables shall be connected to this ground bus.

All doors and removable covers shall be gasketed all around with neoprene gaskets. Ventilating louvers shall have screens and filters. The screens shall be made of either brass or SS wire mesh.

Design, material selection and workmanship shall be such as to result in neat appearance inside and outside with no welds rivets or bolt heads apparent from outside, with all exterior surfaces true and smooth.

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Cable entries to the cabinets shall be from the bottom, unless otherwise specified. Spare cable entry holes shall be provided in all control panels.

Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent equipment. Equipment mounted inside the cabinets shall be so located that terminals of adjacent devices are readily accessible without the use of special tools. Terminal markings shall be clearly visible.

Wherever required cabinets shall be matched with other cabinets in the control room with respect to dimensions, colour and appearance.

Fans with dust pad shall be provided in system cabinet as well as marshalling cabinet to maintain proper ventilation. Cabinet shall be from Rittal make. Fan arrangement shall be on the front or back door of cabinet.

Lifting eyebolts shall be provided for all cabinets. Anti-vibration pad & kick plate shall be provided for all cabinets.

Receptacle for 230V AC supply & telephone set shall be provided in the system cabinets.

Internal & External paint colour of all cabinets shall be Light grey to RAL 7035.

All cabinets shall be made of 2 mm thick CRCA steel sheet. Hinges of panel doors shall be concealed type. Flush Pull with Lock type handle and key arrangement shall be provided for all cabinets.

All cabinets shall have front and rear doors. Each cabinet shall be of maximum 2100 mm height (excluding 100 mm channel base). Doors shall be fabricated from CRCA steel sheet of minimum1.6 mm thick.

Protection class of all cabinets shall be minimum IP-42as per IEC 60529.

Marshalling shall be done in the back side of cabinet and cards shall be placed on the front side. Side panel mounting is not envisaged. 300 and +/-15% termination shall be carried out in each panel. 15 % deviation allowed depending on situation and component arrangements to optimize the cabinet size.

Side panel wiring of I/Os shall not be allowed in the system cabinets and marshalling cabinets.

**Painting**

The Bidder shall submit a detailed paint procedure for all the panels and other equipment in his scope for the Owner/Owner's representative's approval. The procedure shall include surface preparation, paint process and physical characteristics, application and type of paint to be used. All surfaces shall be properly cleaned and prepared to receive prime and finish coatings of epoxy paint. The finish shall be designed to minimize reflections from extraneous lighting sources.

**Internal wiring**

The wires shall be neatly looped and supported in non-flammable plastic wiring raceways. The wiring is to be of general-purpose classification for non-hazardous areas as per the applicable standards. Slotted wire-ways should be used and sized, such that no more than 50% of the cross sectional area of the wire -way is filled. All AC wiring in a cabinet should be routed in steel wire - way to reduce noise in instrument signal wiring. If this is not feasible, it should be physically separated from the DC signal wiring as much as possible. Parallel runs of AC and DC wiring closer

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than 300 mm should be avoided. Power supply to each instrument / equipment shall be through double pole miniature circuit breaker (MCB) of adequate rating. All these MCBs shall be housed in a separate switch box mounted inside the cabinet.All wiring shall be carried out with 600 V grade, single core, stranded copper conductor wires with PVC insulation.The minimum number of strands per conductor shall be seven.

Terminal blocks of size suitable for 2.5-mm² cable shall be provided for all external wiring. Adequate space/ partitions shall be provided to prevent touching electronic hardware when working at terminal blocks.

Fused TBs shall be provided for all digital input and output signals.

Wire terminations shall be made with solderless crimping type of tinned copper lugs, which firmly grip the conductor. Insulated sleeves shall be provided at all the wire terminations.

Tag no. engraved identification markers made of PVC, plastic or suitable material shall be fitted at both ends of each wire. The marker shall not fall off when the wire is disconnected from terminal blocks. Single lettered ferrules are not acceptable. 'Cross ferruling' method shall be used for identification i.e. ferrule shall identify the terminal nos to which both ends of the wire is connected.

Terminal blocks shall be shrouded 600V grade clip-on type, complete with identification strips. A minimum clearance of 100 mm shall be provided between blocks of terminals. Not more than two wires shall be connected to a single terminal.

At-least 20% spare terminals shall be provided for each cabinet and this shall be distributed uniformly in all terminal blocks. 20% spare space and slots in the system cabinets shall be provided for future use.

Each row or column of terminal blocks shall be identified with a unique identification and the terminals in a block shall be sequentially numbered.

Necessary cable glands shall be provided for glanding all incoming and outgoing cables. All cable glands shall be of nickel-plated brass and double compression type. At least 20% glands of each size shall be supplied as spare.

All the signals connected to a module shall be grouped and wired to a single terminal block in the marshalling/IO and system cabinets. The terminal blocks shall be suitably tagged for easy identification.

The following colour code shall be used for cabinet wiring.

| | | | | |
|---|---|---|---|---|
| AC wiring | | Phase | - | Red |
| Neutral | - | Black | | |
| D.C. wiring | | Positive | - | Blue |
| | | Negative | - | Grey |

Interlock wiring powered by external sources - Yellow

Earthing - Green or Green with yellow stripes

**Interior lighting and receptacles**

Each cabinet shall be provided with a fluorescent lighting fixture rated for 230V, 1 phase, 50 Hz supply for the interior illumination of the cabinet during maintenance. The fitting shall be complete with switch-fuse unit and the respective cabinet door switch shall control the switching of the

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fitting.Fluorescent lamp shall be provided for illumination in all cabinets, which shall be operated by door limit switch.

Each cabinet shall be provided with a 110 V AC, 1 phase, 50 Hz, 5 Amps, 3 pin receptacle switch mounted inside, at a convenient location.

**Name Plates**

All components mounted inside the cabinet shall be provided with individual nameplates with the tag no. and service engraved. The nameplates shall be mounted directly below the respective component. Also the cabinet shall be provided at the top with a nameplate engraved with cabinet designation. Nameplates shall be made of anodized aluminum engraved with white letters on black background.

**Built in-Spare Requirement for DCS and PLC:**

Following Built in spares shall be supplied.

20 % of the input / output connected to each I/O card shall be spare. These spares shall be built in spares in the system and connected up to terminal block.

20% spare wired slots to accommodate 20% input / output modules for future with wiring space to be provided. This will be over and above the input / output count and 20% built in input / output spare.

20% terminal blocks in system / marshalling cabinets to connect to spare slots.

10% or minimum 1 no. of each type of module including prefab cable whichever is greater shall be provided in each cubicle.

Consumables like paper, cartridge, etc. required for 6 months of operations shall be supplied.

Also Bidder shall furnish recommended spare list as per his experience.

4.10.10 **GPS Master / Slave Clock**

Independent GPS Master Clock System shall be supplied with necessary redundant hardware & software to receive the synchronizing signals from remote satellite and provide outputs to synchronize all systems like DCS, GTG, STG, electrical relays & all plant PLC etc. The required time formats and number of time signals required for synchronizing the various consumers shall be decided based on requirement (eg. NTP, SNTP, IRIG-B)

Global Positioning System to which the master clock gets synchronized shall be an absolute system to provide continuously 3 dimensional position fixing, velocity measurement and Time reference generation.

The master clock shall be configured as Real Time Clock with display of time in 24 hrs format and date.

The offered master clock system shall consist of the following minimum items:

GPS Antenna
GPS Receiver
Signal Processing Unit
Local and Remote display units(As Required)

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Power supply and Battery charger
Maintenance free Battery.
All required cables, mounting accessories, cabinet for the processing electronics etc.

The fully wired panel shall accommodate GPS receiver, Signal Processing Unit, Battery Charger and Power supply Unit and Battery shall be supplied as required.

4.10.11 **Software Packages**

Standard software modules shall be available for performing the required control and monitoring tasks. Implementation of the control functions shall be easily possible using readily understandable configuration procedures.

The system shall comprise of a standard library of control and computational functions that are pre-programmed and stored in ROM. During the system configuration, the user shall be able to select the appropriate functional blocks from the library, link them together, set the various inputs and tune parameters associated with each block.

Following features shall be available as minimum.

a) Logic Gate programming

b) Functional block

c) Sequential flow chart

d) Structural text

e) Ladder Logic

Graphical user interface (GUI) shall be available as standard for programming control loops.

The offered system shall include the display of a number of mechanical flow diagrams or electrical single line diagrams by means of dynamically updated displays. The offered system shall also include plant performance monitoring/calculation functions. Performance monitoring/calculation shall be carried out for systems like Gas Turbine Generator, Steam Turbine Generator, HRSG& overall plant performance. A centralized performance calculation on-line engineering/ programming and on-line diagnostic station shall be provided as part of the DCS system of various modules. Performance calculation shall be in accordance with international standards ASME PTC-6, ASME PTC-8.2/11/12.1/12.3/46 for turbine, boiler and the overall plant respectively.

The software shall be user friendly and flexible so as to enable the user to modify the content to their requirements. The software shall give the following displays as a minimum.

- Plant overview displays

  These displays shall summarize the key information needed to provide the operator with an overall picture of current plant conditions. The display shall also identify key problem areas.

  Summary of the names of various areas in the plant shall serve as a menu to the next level of displays.

- Area level displays

  The displays at this level shall provide information concerning a portion of the plant equipment like HRSG, turbine generator etc. After obtaining a summary of the plant status from the plant

level displays the operator shall be able to move down the next lower level to look at the situation in a selected plant area.

- Absolute value displays

  These displays shall show the absolute value of the process variable in bargraph form. The displays shall also show the set point, high and low alarm limits, setpoints, control outputs, man, auto, cas mode indications. When any of these limits is exceeded the bargraph shall change colour. Open loop displays shall mimic the indicator stations and push button stations; indicator displays shall include bar graphs for selected process variable with alarm set points. Push button station displays shall allow the operator to perform logic operations such as opening and closing of valves or starting and stopping of motors and shall include feedback indications like open and close position indications for the valves and running/stopped indications for the motors.

- Parameter Displays

  These displays shall display the tag number and the current value of the process variable in engineering units. If the process variable is in alarm condition the corresponding tag number shall change colour and start flashing. In all these level displays the top line of the display shall display the date, time and alarm status. These displays in addition to graphic displays shall be used to perform control operations**.**

- Loop level displays

  The displays at this level deal with individual control loops, control sequences and data points. These displays shall be used by the operator for control and analysis purposes

- Tuning displays

  These displays shall help the operating personnel and instrument engineers to tune the control loops. These displays shall include trend plotting capability, necessary functions to allow the operator to control the loop, a list of the tuning parameters (e.g. proportional band, reset rate and derivative rate) associated with the loop.

- Trend display, historic trend display for various timings.

  It must be possible to group the trended variables by related process functions as well as by similarities of time scale of interest. The trend graph must clearly label the tag no, service, engineering units, time increments, and absolute time of day of the trended variables. The operator must be able to obtain a precise reading (in engineering units) of both the current value as well as past values of the trended variable. The same graph displaying the trend should also show auxiliary information that would help the operator evaluate the status of the trended variable. This information includes the nominal value of the variable, the set point of the associated control loop, and the allowed range of the variable and the allowed rate of change. Up to 10 trends in trend windows may be displayed on an operating screen, ZOOM and PAN function must be available to facilitate operator analysis of process condition over varied time span.

  The system should be able to trend PV, SV, MV of all closed loops and PV and any system calculated values of all open loops connected to the system with a scan rate of 1 second.

  The historical trend should be able to trend PV, SV, MV, loop status, calculated variables etc. of all the signals connected to the system with a sampling time of 1 sec for a period of atleast 180 days.

- Graphic displays.

  Static fields - to provide a background for the dynamic position of the display. They include labels, symbols and other elements that do not change.

  Data fields (in engineering units) - Process information that is updated automatically.

  Dynamic display elements - These change size, color or shape as a function of changing process conditions (e.g. line drawings, process equipment symbols, bar graphs, or pie charts). They can include both user-defined elements as well as standard library symbols.

  For improved operator efficiency, windowing (picture in picture) capabilities for graphic display shall be preferred. The capabilities shall be powerful enough to allow the operator to control / monitor additional information such as trends, loop face plate, operator guide messages etc., by calling up these information as windows within the same graphic page without the need for switching between graphic pages and other information displays. It shall be possible to have more than one trend or more than one loop faceplate display at configurable locations on the graphic page to provide better informative displays for improved efficiency of operation. Bidder shall furnish a write-up about these capabilities in the offered system with supporting documents.

  The number of graphic pages per process unit shall be as per requirement of client.

- Self-diagnostics displays

  Card level failure, bus failure or any other failure at any part of the integrated system should be displayed on the VDU as system alarm. An overview of the entire process information network (PIN) showing the various nodes on the network should form the self-diagnostic overview displays. Any malfunction at any sub-system shall be indicated by change of color. By a single keystroke, the operator should be able to go to the sub-system level diagnostic display, which shall show all the cards interconnected by different internal buses. Again, malfunction of a particular card/bus shall be shown by a change of color. In addition, diagnostics feature shall be available at the local level also, by means of LED indicators, at the different cards of the sub-systems. It shall be possible to print detailed diagnostic displays on the printer.

- Alarm display.

  It shall have an ability to handle process alarms as well as system alarms on the operators` stations for operators` attention. First-out alarming function, which enables the operator to know which alarm in a sequence, occurred first. Priority alarming functions, which rank the current alarms by their importance to process operation. Alarms shall be prioritized based on the colour codes and categorized accordingly.

  Alarms with brief comments shall appear immediately on top section of the operator stations` screen with different kinds of sound depending on priority alarm without any inconvenience to the operator while viewing other important displays of the plant. The process alarm and system alarm shall be displayed separately on the operator station.

  All alarms shall be displayed as they occur with change in colour of display in the following sequence, activating an audio signal:

  Continuous flashing: unacknowledged alarm
  Steady display : acknowledged alarm

  Alarm monitoring and reporting shall be based on priority levels.

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In addition to alarms appearing on different displays, the system shall also be able to display alarm summary and alarm history, listing the date and time occurrence, tag no, point description, type of alarm (absolute value or deviation), serial number of alarm in the sequence of occurrence etc.

Alarms shall disappear from display only when they are acknowledged and cleared. Any abnormal condition in any sub-system or any other function devices shall be displayed as system alarm message on the Operator's/Engineer's console, irrespective of display selected.

The following alarm classification applies to alarms with DCS:-

Stability alarm

Stability alarm indicating a disturbance or deviation in normal process operation. These alarms are generally software configured within DCS.

Bad Input alarm

When an input signal to the DCS falls outside the range of prescribed limits, the system shall generate an alarm to indicate a faulty instrument signal. It shall be possible to suppress these alarms selectively on a per loop basis.

System alarm

These alarms shall be generated by the system diagnostic features to indicate faults within the DCS. Also alarms to be included in this category are system status, power supply failure, fan failure and abnormal system environments. These alarms shall be printed separately from operational alarms.

Alarm Discrimination

The DCS shall permit operators to completely discriminate between all alarm categories. This discrimination can be both via colour or priority.

Alarm Summary Display

It shall be possible to display summary of alarms in chronological order and shall disappear from display only when they are acknowledged and condition of alarm status returns to normal. The alarm display shall list the following for each alarm as a minimum:

The date and time of occurrence
Point identification (i.e. tag no.)
Point description

Type of alarm

The system shall be able to display on alarm summary a minimum of the latest 100 alarms. When all the alarms cannot be displayed on one screen area, operator shall be able to monitor the hidden alarms by scrolling the display. From the alarm summary display, operator can call any pre-defined display stored in DAS.

- Plant start-up, shutdown messages.
- X-Y plot
- Logs, pre & post trip logs, trend logs, hourly/shift/daily logs.

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- Control group display.
- Operator guide messages display
- Equipment operating history

Facility to accumulate running hours for all the cyclesof start and stop from initial commissioning and last overhaul of the equipment.

Important parameters related to plant efficiency and performance, equipment history etc. shall be duly secured in the storage medium viz. Optical disk drive unit for long time archival. The number of signals shall be decided during detailed engineering.

Auto calibration of GT control valves, IGV shall be possible from the GT control system operator station with password protection

- Others - to be listed by the Bidder.

Software packages such as Asset management system, Equipment capability curves to be provided. Necessary licenses shall be provided for all software being supplied with the control system. The licenses shall be at-site basis and shall be valid for the entire plant/equipment life cycle. The license shall not be hardware/machine specific i.e. if any hardware/machine is upgraded, the same license shall still be valid.

4.10.12 **Performance Requirements**

| | |
|---|---|
| • Loop execution time for CLCS | Maximum 250 ms (For all Loops) |
| • Loop execution time for CLCS | Maximum 100 ms (For all critical Loops) |
| • Loop execution time for OLCS | Maximum 100 ms (For all Loops) |
| • SOE Signals | 1 millisecond |
| • Loop execution time for protection and governing Controls | Maximum 20 ms |
| • Updating rate of Analog display | Max. 1 seconds (for measurement) |
| • Updating rate of Analog display | Max. 1 second for OLCS/CLCS |
| • Updating rate of Digital value display | Max. 1 seconds (for measurement) |
| • Updating rate of Digital value | Max. 1 second for OLCS/CLCS |
| • Updating rate of pulse signal | Max. 1 second |
| • Change over to back up controller | less than 20ms (bump-less) |
| • Time for display on screen | Max 1-2 seconds on demand |
| • Keyboard command execution time | Max. 2 sec |
| • Controller Loading | Max. 60 % under worst loading conditions |
| • Data Bus Loading | Max. 60 % under worst loading conditions |
| • Protocol of communication bus | Ethernet TCP/IP |

4.11.0 **DESIGN BASIS FOR PLC**

4.11.1 The microprocessor based Redundant Programmable Logic Controllers (PLC) (OWS / EWS shall be provided as specified in this section) shall consist of dual power supply modules, hot stand by processor modules and communication modules with redundant communication link for communicating with remote Central control room DCS. The PLC shall be 100% modular and expandable. On-line replacement of all modules shall be possible.

4.11.2 Microprocessor based fault tolerant system with SIL - 3 certification shall be provided for PLC.

4.11.3 Each operator's interface sub-system shall have high resolution colour LCD flat panel display (VDU) of screen size 24" with touch screen capability. Resolution shall be minimum 1280 x 1024 pixels. Each operator interface sub-system shall consist of electronics, Qwerty keyboard with special function keys, optical mouse or trackball, TFT LCD with antireflection features, minimum Core 2 duo processor 2.4 GHZ, required network cards, speakers, Win OS and all required cables. A set of electronics may support multiple LCD's. Two (4) GB RAM minimum shall be supplied such that the system shall not slow down while processing multiple tasks. The most current release of fully tested hardware shall be supplied. The features above are applicable for all the stations in the power plant. Supplier shall supply latest configuration for operator station, engineering station.

4.11.4 Where signals from redundant instruments are used for protection and auto changeover of equipment, analog transmitters shall be used in place of process switches. Process switches shall be used only for generating alarms. Such redundant instruments shall also have independent process tapping points.

4.11.5 The system shall provide for sequencing of automatic start-up / shutdown bringing standby equipment into operation on failure of main equipment and manual intervention facility for all the equipment.

4.11.6 All the necessary hardware, licensed software, interfacing/driver cards, hubs/switches, cables and connectors for this purpose shall be supplied and installed and commissioned by the Bidder to make it fully functional upto the full satisfaction of the Owner/Owner's representative. 20% wired I/O spare upto the terminal blocks shall be considered by the Bidder and processor / communication loading should not be more than 60%.

4.11.7 Input / Output (I/O) modules shall be modular plug-in-type suitable for mounting in racks. The multichannel I/O cards for all AI/AO/DI/DO cards shall have a maximum of 16 channels. All modules shall be provided with circuitry to detect card/channel failure and same shall be indicated. Couple of channel failure shall not result in total card failure. Each module shall be designed with self-checking features for detecting faulty operation. In case of individual card failure, on line replacement of the faulty module shall be possible.

4.11.8 All inputs / outputs shall have isolators and current limiting circuitry so that faults, short circuits, open circuits and overloads in one signal do not affect any other signal. Input / Output modules shall incorporate signal conditioning / filtering circuits to reduce the effects of electrical surges, noises and contact bounces. Minimum of 20% wired spare shall be provided on each card, wired up-to the terminal blocks.

4.11.9 Each I/O module shall be electrically isolated from external control circuit by suitable means. The minimum isolation level between I/O module and external circuit shall be 1000 Volts DC. I/O module isolation shall be optical type. On board channel-to-channel and channel-to-ground isolation to be provided. Input / Output modules shall be designed to withstand vibration / EMI / RFI / Surges effects as per relevant standards. Status indication of each input shall be available on the operator & engineering workstations. It shall be possible to remove and insert the modules while the system is 'ON' (Hot swap of I/O modules) Diagnostic LEDs shall be provided on the front plate of each module to indicate faults. Identification labels (color-coded) to indicate one type of I/O card; signal level etc. shall be provided on the front plate for each I/O module.

4.11.10 The supplied PLC system shall have open system architecture to integrate/communicate with any third party system. It is the Bidder's sole responsibility of interfacing the PLC and SAS system with central control room DCS and make this soft link communication fully functional up to the full satisfaction of the Owner/Owner's representative.

4.11.11 Communication link between the PLC and the DCS shall be redundant and routed along different routes.Conduits or trays shall be provided for the same. PLC cubicles located in the air conditioned

local control room shall be of IP 42 rating while those located outdoors shall be of IP 66 construction. Fans with dust pad shall be provided in system cabinet as well as marshalling cabinet to maintain proper ventilation. Cabinet shall be from Rittal make. Fan arrangement shall be on the front or back door of cabinet. Each cabinet shall be provided with a copper bus-bar for panel earthing and of suitable length with tapped holes to suite M6 bolts. The copper bus shall be mounted suitably inside the cabinet and shall be electrically isolated from cabinet steel structures through insulated spacers. All doors and removable covers shall be gasketed all around with neoprene gaskets. Ventilating louvers shall have screens and filters. The screens shall be made of either brass or SS wire mesh. Cable entries to the cabinets shall be from the bottom, unless otherwise specified. Spare cable entry holes shall be provided in all control panels. Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent equipment. Equipment mounted inside the cabinets shall be so located that terminals of adjacent devices are readily accessible without the use of special tools. Terminal markings shall be clearly visible. Lifting eyebolts shall be provided for all cabinets. Anti-vibration pad & kick plate shall be provided for all cabinets. Internal& External paint colour of all cabinets shall be Light grey to RAL 7035. Marshalling shall be done in the back side of cabinet and cards shall be placed on the front side. Side panel wiring of I/Os shall not be allowed in the system cabinets and marshalling cabinets. Fluorescent lamp shall be provided for illumination in all cabinets, which shall be operated by door limit switch.

4.11.12 The system power supplies shall be suitable for 110 V AC 50 Hz, 1Ø UPS power.

4.11.13 **Internal wiring of Panels**

The wires shall be neatly looped and supported in non-flammable plastic wiring raceways. The wiring is to be of general-purpose classification for non-hazardous areas as per the applicable standards. Slotted wire-ways should be used and sized, such that no more than 50% of the cross sectional area of the wire -way is filled. All AC wiring in a cabinet should be routed in steel wire -way to reduce noise in instrument signal wiring. If this is not feasible, it should be physically separated from the DC signal wiring as much as possible. Parallel runs of AC and DC wiring closer than 300 mm should be avoided. Power supply to each instrument / equipment shall be through double pole miniature circuit breaker (MCB) of adequate rating. All these MCBs shall be housed in a separate switch box mounted inside the cabinet. All wiring shall be carried out with 600 V grade, single core, stranded copper conductor wires with PVC insulation. The minimum number of strands per conductor shall be seven.

Terminal blocks of size suitable for 2.5-mm² cable shall be provided for all external wiring. Adequate space/ partitions shall be provided to prevent touching electronic hardware when working at terminal blocks.

Wire terminations shall be made with solderless crimping type of tinned copper lugs, which firmly grip the conductor. Insulated sleeves shall be provided at all the wire terminations.

Tag no. engraved identification markers made of PVC, plastic or suitable material shall be fitted at both ends of each wire. The marker shall not fall off when the wire is disconnected from terminal blocks. Single lettered ferrules are not acceptable. 'Cross ferruling' method shall be used for identification i.e. ferrule shall identify the terminal nos to which both ends of the wire is connected.

Terminal blocks shall be shrouded 600V grade clip-on type, complete with identification strips. A minimum clearance of 100 mm shall be provided between blocks of terminals. Not more than two wires shall be connected to a single terminal.

At-least 20% spare terminals shall be provided for each cabinet and this shall be distributed uniformly in all terminal blocks. 20% spare space and slots in the system cabinets shall be provided for future use.

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Each row or column of terminal blocks shall be identified with a unique identification and the terminals in a block shall be sequentially numbered.
Necessary cable glands shall be provided for glanding all incoming and outgoing cables. All cable glands shall be of nickel-plated brass and double compression type. At least 20% glands of each size shall be supplied as spare.

All the signals connected to a module shall be grouped and wired to a single terminal block in the marshalling/IO and system cabinets. The terminal blocks shall be suitably tagged for easy identification.

Name Plates:All components mounted inside the cabinet shall be provided with individual nameplates with the tag no. and service engraved. The nameplates shall be mounted directly below the respective component. Also the cabinet shall be provided at the top with a nameplate engraved with cabinet designation. Nameplates shall be made of anodized aluminum engraved with white letters on black background.

Standard software modules shall be available for performing the required control and monitoring tasks. Implementation of the control functions shall be easily possible using readily understandable configuration procedures. Various display, alarm and trend display, reports shall be provided.

The system shall comprise of a standard library of control and computational functions that are pre-programmed and stored in ROM. During the system configuration, the user shall be able to select the appropriate functional blocks from the library, link them together, set the various inputs and tune parameters associated with each block.

Following features shall be available as minimum.

a) Logic Gate programming
b) Functional block
c) Sequential flow chart
d) Structural text
e) Ladder Logic

Graphical user interface (GUI) shall be available as standard for programming control loops.

PLC system shall be synchronized with Plant DCS GPS system.

The PLC system features shall include but not be limited to the following:

- Scan time for digital and pulse inputs not greater than 100msec.
- Scan time for all analog inputs not greater than 500msec.
- Execution time not greater than 100msec.
- Max. System loading of 60% under worst loading conditions.
- Independent measurement circuit for each measurement.
- Grouping of signals in each card is subject to approval at the time of detailed engineering.
- Failure of one logic shall not result in failure of the other logics.
- Overall accuracy of measurement signals shall be 0.5%.

4.12.0 **CLOSED LOOP CONTROLS**

All control loops shall be stable for all operating conditions and in all load ranges, and shall have optimum performance in compliance with the latest standards.

They shall be matched in such a way that optimal control is accomplished in compliance with the requirements.

As far as possible, the design shall be such that in the main control loop, one failure shall not lead to an outage of more than one control loop.

Interlocking/protection shall be independent of the control loop or alarm annunciations, i.e. separate measuring points or independent analog transmitters shall be provided. Apart from these wherever signal multiplications are required, it shall be suitably taken care by the Bidder.

In the case of failures, e.g. interruption of power supplies, in the event of switch tripping, etc., the control circuit shall automatically be transferred to a safe condition. In the event of failure of auxiliary power, the actuators shall remain in their position or if this is not possible they shall take over a position which is safe for the process. Similarly, power supply failures shall not result in any undesired or dangerous control actions.

The control system shall have advanced control algorithms like adaptive control, self-tuning control etc.

4.12.1 **Gas Turbine Control Systems**

The starting provision for gas turbine shall be provided locally and in control room. All Instruments and controls shall be supplied by the vendor and tested along with the turbine/Governor/Generator. The basic concept of turbine control is that a speed governor together with temperature limits and start-up conditions commands the full control to provide proper fuel flow to the turbine.

The complete turbine control system must be fully integrated to the functions for governing, protection, sequencing, power supplies, remote control interfaces and operator control and indication. The gas turbine generator shall be capable of automatic operation i.e. starting, synchronization, loading and shut down by initiating soft push-buttons on the operator console in the GTG local control room (LCR) and CCR. The control and sequencing system shall be provided for gas turbine generator package with the following basic functions as minimum:

a) Start up preparation
b) Ignition
c) Light off
d) Start up and acceleration to full speed on no load (island operation)
e) Synchronizing
f) Loading
g) Unloading
h) Shut down
i) Running down / automatic shaft turning
j) Purging at firing speed for gas fuel
k) Protection against abnormal process/ equipment conditions under all operating conditions namely start up/ normal operation/ shutdown/ emergency shutdown etc.
l) Full load rejection without GTG shutdown

Control system to provide a normal start and fast start sequence, selectable from both local and remote control room

Fuel flow shall be continuously modified to ensure that the GTG exhaust gas temperatures are within permissible limits of operation. Elaborate alarms, status and guidance messages for the operator during start-up, running and shutdown programs shall be implemented in the control system associated with the GTG and indicated in the local / remote CCR.

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The GTG can be automatically synchronized to the grid with matched voltage & frequency conditions. Further loading of the GTG is under the influence of load controller to match the system demand. GTG can be started from local and also shall have the facility to start from CCR.

Vibration detectors/proximeters axial position detectors shall be as per Vendor standard.

Vibration monitoring & Analysis system, bearing metal temperature sensors for the GTG shall be provided.

Monitor based operation and monitoring facility shall be provided. Associated peripherals like key board, mouse, printer, etc. shall be provided. Features of alarm logging, event logging with resolution of 1 millisecond, historical trip logging shall be provided. User defined log allowing selection of any desired data for automatic logging at a user selected time interval shall be provided. Each alarm and event shall be logged with a high resolution time tag. Sufficient memory capacity shall be provide in the system for data storage.

Microprocessor based fault tolerant system with TUV category / SIL - 3 certification or equivalent shall be provided for gas turbine control, protections, sequencing redundant system.

Redundant processors shall monitor redundant sensors and vote on all critical control functions. Redundant processors for governor shall have 100% redundant system.

Separate processors shall be used to perform control protection and input/output functions. Each processor will have its own redundant power supply from a reliable source.

Voting disagreements on inputs, calculated signals or outputs shall be alarmed as diagnostic faults and displayed separately from the gas turbine generator operating alarms. Errant trips shall be avoided.

Extensive built in diagnostics shall be provided in the control system Faults shall be identified down to the board level for the control panel, and to the circuit level for the sensor or actuator component. Facility for on-line replacement of boards shall be provided.

On-line testing of synchronizing system and diagnostics on closure time of circuit breaker shall be provided.

In addition to fault tolerant system, there should be a processor/hardware through whichcriticaltripping like electrode over speed and loss of flame failure shall be initiated.

The gas turbine generator control system shall be designed to perform the followingfunctions:

a) Automatic closed loop control including:

(i) Start-up control
(ii) Acceleration control
(iii) Speed/load control
(iv) Temperature control
(v) Automatic synchronization
(vi) Variable inlet guide vane control
(vii) Isochronous as well as peaking control

(b) Automatic sequencing of unit auxiliaries up to synchronizing, synchronizing and loadingas required during gas turbine generator start-up and shutdown on initiation of a singlecommand. Automatic loading may follow directly the starting sequence without anyadditional action of operator.

(c) Protective functions like fuel cut-off and shutdown of auxiliary when inadmissibleoperating conditions are encountered and control system failure. Monitoring and annunciation of malfunctions and stating of standby auxiliaries an applicable within the gas turbine generator, auxiliaries and the control system.

(e) Loading and unloading of gas turbine by remote and manual means at synchronizedspeed.

The gas turbine generator system shall have facility for single push button automaticstarting, synchronization, loading and shutdown of a gas turbine generator.

The starting system shall be automatic which only a single action to start the requiredauxiliary equipment and initiate the complete starting sequence up to synchronizing.

Facility Auto/manual operating mode selection switch for starting of the gas turbinegenerator is to be provided.

The sequential multiple start-up system shall be designed for “fail-safe” operation, in that,failure at any step of sequence shall automatically revert the equipment/system to nextlower safe stage of operation and the cause of failure shall be annunciated.

Proximately shall be provided to separately log actual operating hours/equivalentoperating hours of gas turbine.

4.12.2 **Governing System**

The gas turbine shall be provided with an electronic governor with hydraulic actuator forgovernor values for controlling the shaft speed. The speed governing and fuel controlsystems, with gas turbine operating between zero and its maximum gas turbinecapability shall be capable of stable control of:

(a) The speed of unit when unit is operated in isolation.

(b) The fuel energy input to gas turbine when unit is operating is parallel with other units.In certain cases the control is obtained by a combination of (a) and (b) above. Thegoverning system shall prevent the gas turbine from reaching the turbine trip speed onan instantaneous loss of load.

The governor speed changer shall be capable of adjusting the no-load speed, while inoperation to any value between 95% and 105% of the rated speed. The dead band atrated speed and at any power output up to and including the maximum power outputshall not exceed 0.1% of the rated speed.

When the generator is working in parallel with grid and the frequency variations arewithin specified ranges the set load shall be maintained with load limiter. Suitable deadbands and upper/lower load limits shall be provided to facilitate proper system tuning.

Governing system shall also incorporate feature of controlling load to limit thefiring/exhaust temperature of the turbine over the full operating range of ambientconditions.

Air flow control at compressor inlet for part load efficiency improvement shall be providedin the control system.

The speed control should incorporate a limiting device such that the rate of loadingcannot exceed the safe limits for the machine.
Fuel control system shall include a separate fast acting shutoff valve, which stops all fuelflow to the gas turbine under any shutdown condition and shall not open until allpermissive firing conditions

are satisfied. The risk of fuel leakage in gas turbine aftershutdown shall be minimized with provision of vent vales or redundant positive shutoffvalves.

The governing system shall be capable of generating signal to trip the circuit breakers inthe event of emergencies. The protection system shall work on a: fail-safe" mode so thatfailure of any system component shall have a minimum effect on the plant availability.

Gas turbine control system shall also perform the following function:

(a) NOx control
(b) Inlet air filtration system
(c) Fuel gas conditioning

Bidder shall provide electronic counters for GTG unit for intergrading the number ofstarts, quick loads, and base load hours, etc. for computing the equivalent operatinghours (EOH). The EOH calculation shall be implemented in GTG control hardware.

The fuel flow measurement shall also be displayed/printed on LED monitor / Printers alsointegration of the above flow measurements shall be provided.

*Provision of Sample point shall be made in the fuel gas line to collect the fuel gas for analysis.*

All instruments including junction boxes provided in the GTG enclosure, shall beprovided with explosion proof enclosure/intrinsic safety and certified for the applicablearea classification. Zenerbarriers/transformer isolated barrier (TIB) shall be provided forintrinsically safe circuits, Each input/output in a loop shall have a separate zener barrier.

No barrier shall be shared between two loops/inputs/outputs. All zener barriers/TB shallbe of isolated type.
All intrinsically safe/explosion proof instruments shall be certified by reputed statutorybody for use in specified hazardous area.

The signals from GT turbo supervisory system shall be hooked up to plant DCS throughsoft link.

4.12.3 **Local Control Panel**

A local panel shall be supplied for the GTG set with suitable full size opening doors toprovide complete access to all equipment in side. Local panel shall be provided withsuitable whether protection against dust, fumes atmosphere.

The local panel shall contain as a minimum the following indication:

- Gas turbine/generator speed indicators.
- Start/stop push button for all auxiliaries.
- Exhaust gas temperature indicator (average)
- Fuel pressure OK lights
- Ready light
- Run light
- Malfunction indicator lights (turbine summary status).
- Emergency shutdown push button
- Local horn for audible alarm and horn silence push button
- As per manufacturing standard

The local panel shall contain as a minimum the following Alarms and trip:

| Sr. No. | Malfunction Alarm/Trip | Pre-alarm | Trip with simultaneous alarm |
|---|---|---|---|
| 1 | Fail to crank | - | X |
| 2 | Fail to Ignite | - | X |
| 3 | Flame out (combustor) | - | X |
| 4 | Fuel system malfunction | - | X |
| 5 | Abnormal fuel (Liquid/Gas)pressure | - | X |
| 6 | Turbine Fuel (Liquid/Gas)Supply temp. low | - | X |
| 7 | Fuel (Liquid/Gas) filterdifferential pr. High | - | X |
| 8 | GT overspeed/pickup fail | - | X |
| 9 | Turbine Exhaust temp. high | - | X |
| 10 | Air Inlet diff. Pr. High (Tripleredundancy with 2 out of 3 voting) | X | X |
| 11 | Lube oil pressure low (startstandby pump) | X | X |
| 12 | Lube oil reservoir level low | X | - |
| 13 | Lube oil reservoir level high | X | - |
| 14 | Lube Oil Filter Diff. Pres. High | X | - |
| 15 | Generator, Gearbox & GTbearing metal temp. high | X | X |
| 16 | Generator, Gearbox & GTreturn oil temp. high (whereapplicable) | X | X |
| 17 | Lube oil cooler downstreamtemp. high | X | - |
| 18 | Main Lube oil pump failure | X | - |
| 19 | Emergency lube oil pump failure | X | - |
| 20 | Standby lube oil pump failure | - | X |
| 21 | Turbine enclosure pressureabnormal | X | - |
| 22 | Generator enclosure pressure Low | X | - |
| 23 | Turbine/Generator enclosuretemp. high | X | - |
| 24 | High axial displacement | X | - |
| 25 | High vibration | X | X |
| 26 | Low control oil pressure | X | X |
| 27 | Control power failure | X | X |
| 28 | Individual start failure | - | X |
| 29 | Emergency stop | - | X |
| 30 | Fire detection | - | X |
| 31 | Gas detection | X | - |
| 32 | CO2 released | X | X |
| 33 | Ventilation filter diff. Pressurehigh | X | - |
| 34 | Unit above base load | X | - |

The control system shall include provisions for complete interfacing with DCS System for monitoring control etc. as per details specified elsewhere.

4.12.4 **Local Gauge Board**

A local gauge board of SS316 with suitable weather protection against dust, fumes atmosphere shall be provided, containing as a minimum gauges/indicators forthe following:

- Outlet pressure of each lube oil pump
- Differential pressure across all lube oil filters
- Electric generator, gearbox, Turbine lube oil supply pressure.
- Turbine/Electric generator enclosure pressure and temperature.
- Water coolant pressure gauges for oil cooler.

- Inlet and Outlet temperature gauges for oil cooler.

**The following minimum controls shall be provided in the GTG:**

4.12.5 **Speed Control**

The task of the gas turbine speed control, or governor, is to control the speed of the turbine shaft and to operate the turbine in response to the set point.

The speed regulation must guarantee stable operation over the complete regulation range.

The increase in speed in the event of sudden unloading from maximum power to idling, referred to the nominal speed, shall not be more than 8% even transiently so as to exclude the possibility of actuating the over speed trip mechanism in the event of load shedding. The droop of the speed governor must be set within the limits 0 to 5.0% or better. Over-speed occurring under any conditions must not have any harmful effect on the turbine generator unit or its auxiliaries.

Droop characteristic of the speed control shall be interchangeable to isochronous mode with exact frequency control independent of the load. The response sensitivity, the setting range of the droop of the speed governor and also the design of the speed governor of the gas turbine set must correspond fully to the requirement.

4.12.6 **Load Control**

Load control shall be activated automatically after closing of the generator circuit breaker, and the changeover shall be bumpless. The load control system shall act either as frequency control, constant load control or as temperature control. The load (speed) set point shall be adjustable from no load to full load, peak load and the droop shall be adjustable within acceptable limits. Constant load control shall be fully automatic in which pre-selected constant load value is maintained by variation of the speed setting only. An automatic temperature control system shall be capable of maintaining the pre-selected output exhaust temperature by varying the load. When reaching limiting temperature values of the gas turbine by increasing the load, the output signal of the speed control shall be limited and an optional signal must be remotely given showing "base load". Provision shall be provided to increase the limiting temperature by selector switch to allow for peak load operation. When reaching this limit a signal must be remotely given showing "peak load". The Contractor shall state the minimum generation capacity required for stable operation when operating under load control and operating parallel with other turbine-generators.

4.12.7 **Inlet Guide Vane Control**

This control shall control the angular position of the air compressor inlet guide vanes to provide stable compressor operation at low speeds. The system shall also include the capability of modulating the inlet guide vane position as required to maintain rated firing temperatures during normal on-line operation of the turbine generator.

4.12.8 **Temperature Control**

The temperature control system shall assure that the turbine is always operated within the design stress limitations of the turbine parts. There shall be selectable temperature control levels corresponding to base and peak load. This control system shall limit fuel at start-up or during operation if maximum safe operating temperature shall be reached.
If it is impossible or impractical to measure the turbine inlet temperature directly, the temperature control system is to be designed to control the turbine inlet temperature indirectly by controlling the exhaust temperature.

The temperature control system receives the exhaust temperature signal from thermocouples installed in the exhaust gas path, their signals are to be averaged, amplified and converted, preferably to a voltage signal which is directly proportional to the average exhaust gas temperature.

The temperature shall be input to an integrated system which shall store and analyse the temperature spread characteristic.

4.12.9 **Start-Up And Shutdown Control System**

After the start procedure has been initiated, start-up of the gas turbine generator set including auxiliaries is to proceed automatically (i.e. running up to full speed in readiness to be synchronized), and a further signal should initiate parallel switching, and take-up of the pre-set electrical load, completely automatically; similarly, on a stop signal, the shutdown sequence is to follow automatically and initiate the shaft turning device during the cooling down period.

In addition, it must be possible to operate the gas turbine set manually from the local and remote, via individual group controls up to the point of, and including, parallel switching to the grid.

The start cycle is to be programmed so that the gas turbine and the connected exhaust duct system and heat recovery steam generator shall be purged with five times the air volume before an attempt is made to ignite.
The start-up control system is to be provided for normal start, fast start and combined cycle start in co-ordination with HRSG, STG and other auxiliaries. .

The start-up/shutdown sequential control, running and stopping shall be performed within the microprocessors. Inputs from external devices are to be brought in through optical isolators and outputs (start/stop, signals to pumps, fans, solenoids etc.) are to be through electromagnetic relays. Sequence status is to be provided on the VDU located in the CCR.

The following conditions are to be indicated as a minimum:

- unit on start-up control
- unit on acceleration control
- unit on speed control
- unit on temperature control
- unit on fuel control
- flame in combustion chambers
- start signal initiated
- master protection circuit check
- turbine ready to start condition
- start-up or shutdown sequence in progress
- auxiliary lubrication pump running
- fired speed reached
- acceleration speed reached
- operation speed reached
- turbine starting sequence complete
- Unit on load control (Droop mode / isochronous mode)

The shutdown system shall be automatic for the following functions as a minimum:

- flame detector
- over speed
- emergency stop push-buttons
- failure to start-up

- turbine exhaust temperature high
- Other signals as per manufacturer's standard.

4.12.10 **Gas Turbine Generator Auxiliary Control System**

The control of all the GTG auxiliaries such as lube oil systems, compressor controls must be of fully automatic operation. It shall be noted that in the event of unavailability of individual devices or equipment, the appropriate auxiliary devices or stand-by equipment, if available, shall start automatically.

4.12.11 **Plant DCS Closed-Loop Control for Steam Generator**

The Control & Instrumentation facilities to be supplied shall ensure continuous operation of the Boiler and other auxiliaries without manual intervention.

All control loops must guarantee stable functioning within the operating range.

The following closed loop controls shall be provided in the plant DCS as a minimum.

- BFP minimum re-circulation control
- CEP minimum re-circulation control
- Hot well level control
- De-aerator level control
- De-aerator over flow control
- De-aerator pressure control
- HP drum level control
- MP drum level control
- LP drum level control
- Super heater temperature control
- Condensate pre-heater temperature control
- Condensate receiver tank level control
- HP By pass control
- MP Bypass control
- LP Bypass control
- Chemical dosing auto – stroke control
- Coordinated control system

4.12.12 **Drum Water Level Control**

For boiler drum level control, control valves shall be provided in the feed water line.

Up to 30% boiler load, the low-load or start-up valve is operative. At 30% boiler load this valve should close and thereafter, up to 100% boiler load, the feed water flow is to be controlled by the main feed water control valve. A standby 100% control valve shall be provided and the changeover shall be automatic.

The transition from the low-load valve to the main feed water valve and vice versa must ensure smooth operation and be achieved automatically.

A three element control scheme based on drum level and steam/feed water flow is preferred and the valve shall be designed for the highest possible pressure before the valve. Minimum steam / feed-water are to be maintained to avoid tripping of the boiler.

For the drum level control, 3-element strategy shall be employed. The drum level duly compensated for pressure variations shall be compared with net steam flow out and net feed water flow into the drum in a 3 element configuration to maintain the drum level at desired value under dynamic conditions. The feed water flow shall be temperature compensated for pressure and temperature variations. Control system shall employ transmitters in redundant configuration for this important loop.

Redundant configuration shall be employed to generate through Analog Value Detectors, contacts for 'Drum Level Very High' and 'Drum Level Very Low' status.

The drum level measurement shall be suitably compensated so that no drift in the zero and span calibration occurs when the boiler starts from cold to the normal operating conditions.

The drum level condensing vessel shall be equipped with an external filling point connected to the feed water line.

4.12.13 **Superheated Steam Temperature Control**

In the load range from 60% to 100% of MCR the superheat temperature shall be controlled at constant value. This shall be achieved by feed water injection into the superheated steam between the first and second stage of superheating and the second and final stage of superheating.

Each of the de-superheaters control loops shall be provided with a complete, independent control system to be designed either as a cascade control or a two-loop control. The steam flow signal shall be fed forward as the disturbance variable. The spray de-superheater shall be provided with automatic shut-off valves. The feed forward circuit shall be used for the sufficient control response.

4.12.14 **De-Aerator Pressure Control**

The steam supply to De-aerator shall be provided with the Low Pressure steam from Boiler. The Pressure Control Valve in this line shall modulate the De-aerator pressure.

4.12.15 **De-Aerator Level Control**

The De-aerator level is maintained at a fixed point by a modulating level control valve in the DM Water line to De-aerator.

4.12.16 **Coordinated Control System**

A coordinated control system shall be provided so as to operate the combined cycle module in the most efficient manner and at the same time maintaining the outputs of the GTGs, STG and other auxiliaries within their safe operating limits. For this purpose, a module load control system shall be provided to control the output of the combined cycle module as a block so as to meet the load demand either as set by the operator or as received from the Load Despatch Centre. Based on load or peak load operation have to be pre-selected by operator from operator workstations. The necessary tracking, permissive and sequence logic shall be provided to ensure bump-less transfer in all modes of control.

Unloading of run back of the HRSG and turbine-generator unit shall be controlled by the Co-ordinated Control System. The unloading rate shall be consistent with minimising turbine thermal stresses and maintaining stable HRSG control.

The Bidder shall identify all conditions pertaining to the plant in his supply under which he considers unloading is necessary. The Bidder shall state the unloading sequence applicable to each upset condition (e.g. low vacuum, loss of a feed pump, etc.)

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HRSG pressure unloading shall be provided, to protect the turbine against water carry-over. A sub-system with in the Central Control System shall compute the appropriate load limit in accordance with the applicable constant or variable pressure control characteristic and the HRSG pressure deviation. The Bidder shall provide all the necessary definitions for the unloading sequence under both constant and variable pressure operation.

4.12.17 **Steam Turbine Controls**

The major controls associated with the STG shall be:

- Turbine Governor Control
- Seal steam pressure control
- Condenser hotwell / condensate tank level control with condensate extraction pump minimum recirculation control
- Exhaust hood spray control

The steam from the HRSG shall be admitted to the STG at controlled rate under dynamic conditions through steam admission valves under governor control.

Turbine supervisory instruments shall be provided with locally mounted supervisory instruments for safe start-up, operation & shutdown of STG, and shall consist of the following as a minimum:-

- Differential expansion
- Key phasor
- Axial shift
- Shaft eccentricity
- Thrust wear
- Bearing and shaft vibration
- Bearing Temperature
- Speed measurement
- Overspeed switches
- Metal temperature
- Exhaust hood temperature
- Cylinder/flange metal temperatures, top and bottom casing temperatures including differentials
- Oil drain temperature
- Control valve position

Lube oil system consists of below instruments (minimum):

- Lube oil tank level gauge
- Lube oil tank level transmitter
- Lube oil tank level low switch for alarm
- Lube oil tank level high switch for alarm
- Main oil pump (MOP) suction pressure gauge
- Main oil pump (MOP) discharge pressure gauge (LCP)
- MOP discharge pressure low switch for alarm and interlock (AOP auto start)
- AC Auxiliary Oil Pump (AOP) discharge pressure gauge
- DC Emergency Oil Pump (EOP) discharge pressure gauge
- DC Emergency Oil Pump motor starter cubicle
- Lube oil cooler inlet pressure gauge
- Lube oil cooler inlet temperature gauge
- Lube oil cooler outlet temperature gauge

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- Differential pressure indicator with high alarm contact across lube oil filters.
- Lube oil header pressure gauge (LCP)
- Lube oil header pressure low switch for alarm and interlock (EOP auto start)
- Lube oil header pressure very low switches (3 nos.) for alarm and interlock (turbine trip with 2/3 voting logic).
- Lube oil supply to each turbine, generator and exciter bearings pressure gauges.
- Temperature gauges & temperature elements on the return oil lines from each turbine, generator, exciter bearings and gear box.
- Indication of downstream oil cooler temperature (local & remote indicating)
- Lube oil to turning gear pressure adequate switch for interlock (turning gear start permissive)
- Contact outputs for DCS for low alarm and very low trip settings.
- Adjustable throttling devices orifice plates for the oil supply lines and sight glasses for return oil lines, as required.
- Level gauge & level switch low for overhead oil tank.
- MOP discharge pressure transmitter for remote indication.
- DP transmitter across lube oil filters.
- Pressure transmitter for lube oil header pressure.
- Modulating control valve in bypass line of lube oil cooler for lube of temperature control.
- Necessary instrument for performance calculation.
- COOLING WATER: Oil Cooler inlet and outlet temperature gauges, Oil Cooler inlet pressure gauge.

Multiple primary devices and redundant networks shall be implemented for a completely automated, safe and efficient operation of the plant with its associated auxiliaries under dynamic conditions of plant operation. The system shall also provide for plant performance monitoring for fuel consumption vs power output.

The separate turbine governing system shall be provided as follows:

Steam Turbine shall be provided with hydraulic as well as digital electro-hydraulic governing (EHG) systems. EHG enables the operation of the turbo set in interconnected grid system. With precise maintenance of rated frequency by means of exact frequency load characteristics, with good response, reliable operation, reliable control during load rejection, low speed deviation under all operation conditions, safe operation etc.

An independent electronic over speed protection devices (with 2 out of 3) shall be provided for STG

EHG shall consists of

a) Equipment for obtaining various inputs and

b) The control system incorporating the power supply, sub-controllers for valve position, speed, load and steam pressure.

As a minimum EHG shall provide the following functions,

- Turbine start-up modes selection such as warm, cold, hot
- CV warming control
- Start-up control
- Line speed matching control
- Governor control
- Governor/Load limiter control automatic changeover
- Load limiter control
- Valve transfer control

- Load control
- Initial steam pressure limit control
- Turbine protection and protection tests
- On-line and off line Valve test
- Over speed test
- Vacuum unloader control

4.12.18 **Speed Control**

The function of the speed control shall be start up and shut down of the turbine, bringing to house load operation on load shedding, limitation of turbine speed before reaching the over-speed protection limit, and for load control when necessary. This speed controller essentially shall compare the speed reference generated by the speed reference limiter circuit, and the actual speed of the turbine, and accordingly provides output by changing steam input pressure/flow.

4.12.19 **Load Control**

The load control loop shall consist of load reference setter, frequency load droop and the load controller. The load controller shall be designed for the operation in conjunction with power system, with PID characteristics. The steam turbine shall be equipped with a load changer and limiter device for the purpose of changing and limiting load by controlling the degree of opening of the governor controlled valves to any value with the full range of valve travel, while the steam turbine is in operation.

The output of the power/load controller shall act along with other controllers in a selection mode on the electro-hydraulic convertor and thus shall act on the turbine control valves.

4.12.20 **Pressure Control**

Pressure control shall be operated on initial pressure control mode or limit pressure control mode by selection from desk corresponding to maximum valve opening. As the steam conditions approach the working range of controller, tracking to a present takeover margin shall be effected, so that the pressure controller can rapidly assume control of the valves. When pressure controller controls the valves, the load controller is tracked as per pressure controller.

When the turbine is in operation, one of the three controllers (speed, load and pressure) shall be exercising the control and others shall be matched continuously for quick transfer. The speed and load controllers shall be tied up to a maximum selector circuit. The output of this circuit shall be compared with the sum of speed and 100% load signal via a minimum selection circuit to avoid erroneous load control signal. The speed/load control signal shall be compared with pressure control via a minimum selection circuit.

4.12.21 **Valve Position Control Loop**

The output of the speed/load/ pressure controller loop shall be fed to the main steam control valve position control loop to set the valve lift through electro-hydraulic converter. The feedback signal representing the valve lift shall be derived from the position of the electro-hydraulic converter plunger as an analog value from the differential transformer type transducer. There shall be transducers continuously scanning the position of the plunger. An alarm shall be initiated if the signals from the two transducers differ by more than 5 or 3%. The valve lift control shall ensure high overall sensitivity and good transient response.

4.13.0 **OPEN-LOOP CONTROLS**

Sequential start-up and interlock protection system shall be provided for all major critical auxiliaries of the plant. The system structure shall provide for control from the highest level of unit operation down to the individual drive level.

4.13.1 **Gas Turbine Protection System (GTPS)**

The GTPS shall protect the Gas turbine in every phase of operation from overload and damage. It shall be continuously ready for operation and shall not be capable of being switched off, even accidentally.

The following signals as a minimum must be incorporated in the GTPS:

- Turbine speed greater than max. at least 2 (two) independent systems of which one shall be a mechanical system with the possibility of testing during continuous operation)
- Bearing metal temperature (thrust and journal) greater than max.
- Bearing housing vibrations and/or rotor vibrations greater than max.
- Wall temperature difference of turbine casings greater than max.
- Lube Oil pressure low
- Control oil pressure lower than min.
- Relative expansion greater than max.
- Natural Gas pressure high/low (while firing)
- Exhaust Gas Temperature high
- generator trip operated
- unit trip operated
- local turbine trip operated
- Fire/Smoke detected
- GT exhaust pressure high
- GT air filter differential pressure high
- Fuel valve failure
- Emergency manual trip
- Governor system failure
- Flame failure
- Any other as recommended by the manufacturer

The protective circuits must be so constructed that faults in one protective interlock cause no erroneous release, but at the same time do not prevent the initiation of a trip in an actual case of danger. The protection signals used shall have 2 out of 3 auctioneering.

4.13.2 **Gas Turbine Auxiliaries**

The following open-loop controls shall be controlled:

- Gas Turbine Oil supply
- Turning Device
- Auxiliary oil Pumps

The task of the ‘main turbine oil supply’ sub-group shall start and stop the entire oil supply of the main turbine, to monitor normal operation and to minimize the effects of malfunctions.

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The control programs for main turbine oil supply shall comprise controls for the following:

- Switching on and off of all lubricating oil, control oil, jacking oil pumps, etc. on the basis of the oil pressure and other turbine criteria.
- Switching on and off of the relevant stand-by unit or of the emergency lube oil pumps, as the case may be.

The main oil pump shall be A.C motor driven. The auxiliary oil pump shall start automatically in the case of a drop in oil pressure.

The task of the 'turning device' sub-group shall automatically start the turning device in order to avoid thermal stresses in the turbine unit.

Hydraulic or electrically driven turning devices shall be employed. The turning device shall disengage automatically as soon as the turbine speed exceeds the turning speed. It is necessary, when the turbine is running down, to bring the turning device into operation again before the turbine comes to rest.

The turning device shall be switched off when turbine temperatures permit. A jacking oil pump shall be provided to avoid during starting of the turning device mixed frictional effects at the bearings. Interconnection between the lubricating oil supply and turning operation shall be ensured by automatic interlocks.

4.13.3 **Steam Turbine Protection System**

The turbo generator set shall be protected from overload and damage through the complete operating range through the Turbine control panel (TCP) envisaged. The following are the minimum protection criteria to be provided. There should be an alarm at high set point and trip with alarm at high high set point.

- Turbine over-speed (one through mechanical speed sensing and another through electronic speed sensing) (non-contact type)
- Governor failure
- Very high axial displacement
- Very high shaft vibration
- Very low lubricating oil pressure / level
- Very low trip oil pressure
- Bearings / metal temperatures very high
- Inlet steam pressure very high
- Exhaust steam pressure very high
- Exhaust steam pressure very low
- Casing top/bottom differential temperature very high
- Drum level high high
- Condenser very high water level
- Condenser vacuum protect
- Generator protection operated
- Emergency hand lever trip (manual, mechanical system)
- Remote push-button trip (manual)
- GTG / HRSG tripped
- Any other as recommended by the manufacturer

In case turbine trips due to any of the above conditions, the Emergency Stop Valve (ESV), the non-return valves shall be automatically closed and the bypass system shall bypass steam to condenser.

4.13.4 **Balance Open-Loop Controls**

The design of the Open-loop Control shall be implemented in the DCS.

The interposing relays shall be housed in the Motor Control Centers (MCC) of the switchgear or at DCS endand are to be considered as part of the Open-loop control system.

All main system drives shall be provided with individual remote stop / start capability. Additional local start / stop push-buttons shall be provided in cases where local operation of the plant is necessary. In all such cases the local controls shall act only if selected by a group or individual selector in the central control room/MCC. Group selector shall be provided where a large number of local start / stop push buttons are required.

Local push buttons shall be connected to their associated command logic in order to ensure that the same starting conditions are achieved before an item of plant can be started from either the local or the remote position.

In cases where it is necessary for safety reasons to provide a local emergency off push buttons, the push button shall interact directly with the MCC/switchgear. The push button shall be provided with suitable mechanical interlocking device in order to avoid restarting. It shall be protected against malfunction by a cover or similar protection.

After a voltage failure in the electronic equipment and upon restoration of this voltage the system shall not cause unintended orders to the breakers concerned.

In the event of On/Off commands arising simultaneously or commands repeating alternately, provision shall be made to lock out these commands.

Subgroup controls are to be provided for start-up, operation and shutdown of associated functional units and drive groups, i.e. it shall be possible to start or stop main aggregates with all associated equipment by pressing one push-button. These controls may be designed either in the form of combinational controls or in the form of sequential controls. In the case of combinational controls the issue of commands depends solely on the interlinking of certain process criteria ; in the case of sequential controls the command sequence takes place in steps and is monitored for time, taking into account incoming process criteria in a predetermined sequence and in at fixed scanning time.

The steps of the individual programs and missing criteria shall be displayed on the VDU. Subgroup controls must be capable of being switched On and Off and must have defined manual commands for ‘operation’ and ‘stop’. Any faults in the control system which could cause blockage of the control sequence must be confined to one control sequence. For this reason an autonomous design is required for each subgroup control.

All functions performed by automatic systems must be capable of being implemented as individually remote-controlled operations via command modules.

Any faults in the control system or in the plant must lead to an automatic changeover from a faulty unit to an appropriate stand-by unit.

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4.13.5 **Interlock, Protection**

To protect individual units or parts of the plant, interlocks are to be formed in accordance with process criteria, which can be either active or passive depending on their functions.

Active interlocks shall automatically disconnect units or parts of the plant before they reach a critical operating condition. In addition, such dangerous conditions must be immediately indicated to the operating personnel by means of the alarm annunciation and shall lead to a print-out by the event recorder.

Passive interlocks are intended to prevent operational errors or wrong commands from being carried out in the event of selective faults in the automatic control.

For that reason active and passive interlocks must not be capable of being switched off operationally from the CCR.

Protection signals must be hardwired and interference free. The use of scanning devices or multiplexers shall not be allowed.

4.13.6 **Interlocks For Alarm Annunciation**

Some alarm annunciations are of interest to the operating personnel only if the corresponding parts of the assembly or units are in the start-up, operating or shut-down condition. These linked annunciations are usually made up of signals showing conditions and process monitoring criteria. The alarms shall be inactive when the relevant unit or equipment is supposed to be out of operation.

4.13.7 **Feed Pumps**

Start-up and shut-down of the individual feed pumps shall be implemented by separate automatic system for each pump, which acts via a control program on all the pump auxiliary units and systems and thus starts up or shuts down the entire unit automatically without further manual intervention.

This automatic system shall comprise not only the start-up and shutdown of the cooling water and lubricating oil systems but also the control of the discharge gate valve in the main and bypass piping.
A superimposed control program initiated by push-button shall effect properly timed activation and de-activation of the automatic systems as well as automatic transfer to the stand-by unit in the event of outage of one of the operating feed pumps.

The pump protection system, which effects instant shutting down of the pump unit must comprise atleast the following criteria :

- level in feed water tank less than min.
- journal bearing temperature of pump greater than max.
- suction valve “not open”
- thrust bearing temperature of pump greater than max.
- lubricating oil pressure less than min.
- pressure difference of feed water strainer greater than max.
- vibrations greater than max.
- After approx. 5 sec. delay :
- flow less than min. and minimum flow valve less than 100% open
- all discharge gate valves “closed”.

- Pump discharge Pressure Low Low

The following minimum interlocks shall be provided for pump start:

- level in feed water tank greater than min.
- suction valve 100% opened
- lubricating oil pressure greater than min.
- auxiliary cooling water valve opened greater than min.
- temperature difference pump casing less than max. (no pump distortion)

In the event of reverse running of pump the discharge gate valves must close

**Minimum flow control**

The minimum flow valves of the feed water pumps shall be opened so that the pump is able to work in a closed circuit via the feed water tank in the event of the flow going below the minimum value as detected by the flow metering facility on the individual pump.

4.13.8 **Cooling Water Pumps**

Start-up and shut-down of the individual cooling water pumps shall be implemented by sequence automatic system for each pump and the discharge valve which acts via a control program and thus starts up or shuts down the entire sequence automatically without further manual intervention.

A superimposed control program initiated by push-button shall effect properly timed activation and de-activation of the automatic systems as well as automatic transfer to the stand-by unit in the event of outage of one of the operating pumps.

The pump protection system, which effects instant shutting down of the pump unit must comprise at-least the following criteria:

- Sump level less than min.
- bearing temperature of pump greater than max.
- Discharge valve “not open”
- thrust bearing temperature of pump greater than max.
- lubricating oil pressure less than min.
- discharge pressure of pump less than min.
- vibrations greater than max.

The following minimum interlocks shall be provided for pump start:

- Sump level adequate.
- Disc valve 10% opened
- lubricating oil pressure greater than min.
- Bearing and winding temperature less than min.
- No reverse rotation

4.13.9 **HRSG Protection**

The protection functional system for HRSG shall operate in coordination with the operational and protective requirements of GTG, STG and it’s auxiliaries, NFPA sections. Following minimum protections shall be provided:

- HP/MP/LP drum level very low

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- HP/MP/LP drum level very high
- HP/LP BFPs trip
- HRSG Flue gas inlet temperature very high.
- Any other as recommended by the manufacturer

4.13.10 **Unit Auxiliaries**

There are also a large number of small automatic systems in the auxiliary steam, condensate water lines, in particular automatic pump controls, which shall be controlled and remotely operated from the central control room.

Example of these auxiliary automatic systems is as below:

Auxiliary cooling water pumps

4.14.0 **TECHNICAL REQUIREMENT FOR INSTRUMENTATION**

4.14.1 **Field Instruments**

a) Analoginputs signals from field instrumentation to the control systems are 4-20 mA DC signals. Instrumentation can be self-powered, or loop powered from the control systems. Self-powered analog signals shall be true “isolated from ground” signals.

b) Field switches shall be micro switch type with auto reset. Switches shall have NO and NC contacts. Switch contacts shall be snap acting, 2 Nos of SPDT, hermetically sealed, potential-free with a minimum contact rating of 230 V AC 5A/ 24V DC 1A.

c) Transmitters shall be used to provide the required 4 to 20mA signals for all controllers and receivers. Transmitters shall be of the electronic, two-wire type, four-wire type capable of driving an output impedance of 600 ohms minimum at 24 V dc, and shall be generally powered from the control system I/O cards. All the transmitters supplied shall be SMART type with HART capability

d) SMART+HART transmitters’ calibration shall be carried out through a PC based system to be located in the computer room.

e) Pressure, DP type flow, differential pressure, level, temperature, and other miscellaneous transmitter accuracy shall be within 0.075% of calibrated span and shall have repeatability of +0.1% of span or better. Errors caused by change in ambient temperature shall not exceed 0.01% of span per°C change. Temperature variations of +55°C shall not affect the 0.1% accuracy rating for 0.1% repeatability.

f) The plant instrument air supply pressure shall be:

1. Maximum supply pressure 7 kg/cm$^2$
2. Minimum supply pressure 4.5 kg/cm$^2$

g) All instruments and analysers shall employ EMI,RF protection in the system design.

h) Instrument tags should be permanently attached to the device. If this is not possible, the instrument tag should be fastened to the instrument with stainless steel wire.

i) All field mounted instruments shall have degree of protection IP-65 as per IS: 2147 / IS: 13947. Instruments falling under hazardous area classification will be provided with explosion proof housing as per IS: 2148. FM / CMRS certificates shall be provided for all ex-proof housing. All

instrument enclosures shall be epoxy coated. It shall be suitable for following ambient conditions.

Temperature : 50$^{o}$C
Relative humidity : 95%

j) IBR certification shall be provided for instruments / valve / Erection hardware wherever applicable. All field instruments shall be grouped and installed in enclosures to protect from direct sunlight and rain water etc. Wherever this is not feasible separate enclosures/canopies shall be provided.

k) Vibration switch (alarm, trip) and oil level switch to be provided for the cooling towers.

l) Transmitters, switches shall be grouped depending on the location. Individual instruments shall be mounted on stanchion or pipe mounted.

m) For saline applications and other applications which are corrosive in nature, the wetted part material to be selected which shall meet the process applications, preferably diaphragm seal to be used. Haste alloy C wetted part material and SS316L impulse piping / root valve material to be considered for the above applications.

n) All field instruments junction boxes & local panels located in hazardous area shall be explosion proof as per the relevant applicable standards.

o) **Metering Basis**

Following units shall be followed for metering different process parameters

| | | |
|---|---|---|
| Pressure above 0.1 kg / sq.cm | : | kg / sq.cm |
| Pressure below 0.1 kg / sq.cm and draft. | : | mm WC |
| Vacuum | : | mm Hg or mm WC |
| Differential pressure | : | mm WC |
| Temperature | : | $^{o}$C |
| Flow (gases) | : | N Cu.m /h |
| Flow (steam) | : | kg / h or t / h |
| Flow (liquid) | : | Cu. m / h |
| Flow (lub. Oil) | : | liters / hr |
| Level | : | % |
| Density | : | gm / liter |
| Conductivity | : | micro-mho /cm |
| Gas analysis | : | % by volume or as prevailed in the respective case |

4.14.2 **Pressure Instrumentation**

a. Pressure transmitters are electronic, analog 2-wire transmitters with isolated 4-20mA DC output signals.

b. Pressure transmitters shall be supplied with two valve manifolds.

c. All pressure transmitters shall be capable of withstanding their body rating conditions without permanent damage or loss of calibration.

d. Differential pressure transmitters of the capacitance type, regardless of the applied service, shall be capable of withstanding a differential pressure equal to full process pressure on either side of the measurement element without damage or loss of calibration. The diaphragm of gauge pressure transmitter will be designed to withstand a static pressure of 1.5 times the maximum span without damage or permanent deformation.

e. Differential pressure transmitters shall be supplied with three valve manifolds for air service and 5 way valve manifold for steam &water service. All pressure and differential pressure instruments will be provided with root isolation valve, instrument isolation valve and drain / vent valves etc. as per installation requirements. High pressure and temperature line instruments shall have double isolation valves. For high pressure applications impulse line shall be complete piping only. Piping material required for installation hook up shall be as per Piping Material Specifications.

The instrument tube fittings shall be of Swagelok or Parker make only.

a. All pressure & differential pressure transmitters will be easily accessible. Span & zero and range suppression & elevation adjustments will be provided. The accuracy (for PT/ DPT) should be better than ±0.075% of calibrated span including linearity, hysterisis& repeatability for rangeability of 1:10. The overall Response Time for transmitter shall be better than 130mSec.

b. Pressure gauges shall be generally 150mm dial, solid front safety case type with blowout back, ½" NPT bottom connection, drawn stainless steel case, 316SS bourdon and socket, stainless steel movement, micrometer pointer. Pulsation dampers shall be provided for pulsating pressure services. Liquid filled gauges shall be used for all pump discharges, vibrating or pulsating services. Pigtails shall be used on steam service.

c. Pressure switches shall generally be snap acting type, DPDT action, with individual "on" and "off" points to be on a calibrated scale or dial.

d. Dual type control switches such as pressure switches having two sets of contacts with independently adjustable set points shall not be used where set point adjustment and deadband are a problem (e.g. low pressure and vacuum applications). If a potential problem exists, two single purpose switches shall be used. Switch differential shall be adjustable.

e. The indicating type switches are not acceptable. If application requires indication and switching function, then a separate blind switch and a gauge to be used.

f. The gauges shall have ± 0.5% accuracy and over range protection of 150%.

g. Condensate pots for pressure transmitters and siphons for gauges shall be used for steam and high temperature applications. Chemical seals to be used for highly corrosive and viscosity applications

h. The switches shall have the following :.

Contact rating : 230V AC, 5A / 24V DC 1A.
Repeatability : ±0.5% FSR

4.14.3 **Temperature Instrumentation**

a. For temperature up to 300°C 3-wire RTD duplex type, PT 100 type shall be used. For temperature beyond 300°C thermocouples shall be used. Thermocouples shall be manufactured in accordance with the ANSI-MC-96.1. All thermocouples shall be ChromelAlumel (Type K) for 300°C< T < 850°C. R or S type for T> 850°C.Thermocouples shall have duplex elements and ungrounded measuring junction.

b. An extension nipple / union / nipple of sufficient length to extend beyond lagging and connection head shall be furnished for each thermocouple assembly. Terminal blocks shall be marked with polarity and connectors shall be resistant to heat, vibration and galling. The cap shall provide a weather tight enclosure and a chain shall be provided to prevent loss of cap. The cap shall be made of cast aluminium.

c. RTDs of Duplex type furnished by the Supplier shall be of the three-wire type made with 100 ohm platinum resistance elements. They shall be certified to meet the requirements of the International Temperature Scale, calibrated to the IEC-751 standard (Alpha = 0.00385 Ohms/Ohm/°C), and be guaranteed to an accuracy to within +1.1°C of this standard. The RTDs shall be contained in an insulated material and a sheath or sleeve of stainless steel SS-316 and shall be so mounted that they can withstand the greatest shocks and vibrations that can be imposed upon them in the system piping without deterioration. Specific information shall be furnished concerning type and accuracy of bridge circuits to be used with the RTDs. Response time of RTD with thermo-well shall be 30 sec or better.

d. Unless specified otherwise, each temperature element and thermometer shall be provided with a 1” socket weld type, 316 stainless steel tapered thermowell suitable for the requirements of the given application. Temperature element process connection shall be ½ NPTM.

e. Temperature transmitters are to be provided for all temperature measurements that are used in any CLCS. For thermocouple, cold junction compensation shall be implemented within the transmitter.

f. The thermocouple will be magnesium oxide insulated, metallic sheathed and of 6 mm O.D, K(chromel-Alumel), Platinum-Rhodium/Platinum. RTD shall be Duplex, Pt 100 ohm, 3 wire type as per DIN standard 43760 or equivalent. Thermo wells shall be ASME PTC 19.3 latest revision with process connection M 33x2 for threaded connection and 1 ½” flanged connection for Air and Gas system & tanks; accuracy shall be + 0.5 percent or better. Response time of thermocouple with thermo-well shall be 30sec or better.

g. Thermowell immersion length shall generally be between 1/3 and 1/2 the distance to the center of the pipe. Where thermo wells are installed in lines smaller than 4 inches, the piping shall be expanded to 4 inch size to accommodate the thermo well. Thermowell shall be drilled from solid bar stock.

h. All thermo well in a high velocity line or duct shall have an ASME PTC 19.3 calculation for determination of the wells resonant frequency. Thermo wells that do not meet the acceptance criteria shall be resized or relocated as necessary.

i. Thermocouple extension wire is to be solid, shielded, twisted pairs.

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j. If intermediate terminal blocks are required in a thermocouple measuring circuit, they need not be the same material as the thermocouple.

k. Dial thermometers shall be bimetallic, minimum 150mm dial, every angle form, hermetically sealed with external recalibration adjustment, ¼" OD SS stem, ½" NPT connection and SS case.

l. Temperature switches shall be actuated by filled bulb-type elements equipped with standard-length armored capillary tubing.

m. Temperature gauges shall have ±1% accuracy and overage protection of 125%.

n. Switches shall have the following:

| | | |
|---|---|---|
| Max. contact rating | : | 230V AC, 5A |
| Repeatability | : | ±0.5% FSR |
| Contact type | : | snap acting |

4.14.4 **Flow Instrumentation**

a. Flow nozzles shall be used for main steam flow, feed-water flow and other critical measurements where weld-in construction is required. Orifice plates shall be used for other liquid flow measurements where flanged construction is acceptable. Accuracy of the measuring orifice plates, nozzles, venturi's and annubar shall be minimum +-1%. Ultrasonic type flow meter shall be used for cooling water flow application with an accuracy of minimum +-0.4% of measured flow or better and haste alloy C wetted part material to be used if insertion type is provided.

b. Flow elements shall be accompanied by IBR certification.

c. Flow nozzles and orifice plates shall conform to requirements of ASME.

d. Flow nozzles shall be of the weld-in holding ring type ASME long radius, with dual wall taps and shall be of stainless steel. Metered pipe run and nozzle shall match the pipe material and size that metered section is to be installed in.

e. Orifice plates shall be 316SS, sharp square edge thin plate, and paddle type suitable for installation between raised face orifice flanges. Orifice flanges, gaskets and jacketing screws shall be furnished by the Supplier. Paddle shall be stamped with the orifice ID bore diameter on the upstream side. Orifice flanges shall be of the raised face, weld-neck type with dual 2 sets of taps as required for redundancy.

f. Beta ratios shall be between 0.2 and 0.7. Flow elements (flow nozzle & orifice) sizing shall as per BS-1042/ISO-5167.

g. Differential type flow transmitters shall be supplied with three valve manifolds directly mounted to the transmitter for gas applications and five valve manifolds directly mounted to the transmitter for steam and liquid applications.

h. Differential type flow transmitters shall be electronic, with square root extractor,analog 2-wire transmitters with isolated 4-20 mA dc output signals.

i. Ultrasonic flow meters / coriolis mass flow meter to be used for custody transfer of natural gas as per the AGA standards with accuracy of minimum 0.2 % of measured flow.

j. The flow sight glass shall be of rotary type with tempered glass, carbon steel body and bronze wetted parts.

k. Variable area flow indicators to be provided at the common outlet header of the identical equipment, CW blow-down etc. Carbon steel body with SS 316 float and scale shall be provided. Accuracy shall be minimum +-1%.

l. Flow switches to be provided at the common outlet header of the identical equipment. Carbon steel body with SS 316 element and contacts shall be provided.

m. For effluent flow measurements, turbine flow meters shall be considered.

4.14.5 **Level Instrumentation**

a. Differential pressure type level transmitters are SMART+HART type electronic, analog 2-wire transmitters with isolated 4-20 mA dc output signals. Guided Wave Radar, Displacer and ultrasonic level transmitters shall be 24V DC powered, SMART+HART with isolated 4-20 mA dc output signals powered from the transmitters. Displacer type level transmitters are of torque tube type.

b. Constant head chambers shall be furnished for all differential pressure-type level transmitters used with pressurised vessels. Reservoir piping connections shall be ½ inch outlet and a ½ inch inlet socket-welded type suitable for the pressure and temperature encountered.

c. Transparent gauge glasses shall be used for low-pressure applications. Transparent or reflex gauges shall be used for high-pressure applications. All gauge glasses shall be equipped with gauge valves, including a safety ball check.

d. For the measurement of Boiler water level, Feed water tank level and other levels measurement transmitters of differential pressure input shall be preferably used.

e. Guided wave radar transmitter shall be used for condenser hotwell level measurement and such low pressure application. External cage shall be provided wherever applicable. Probe dimensions e.g. length shall be provided as per requirement. Material of wetted parts (including flange) shall be of SS316L with Teflon spacer (minimum) or better i.e. shall be suited to service.

f. Electronic Drum Level measurement (EDLI) shall be provided for Drum level with indication at Firing floor and Control Room. Necessary special cables required for the same from field to control room. All alarm (low & high) and trip signals (low low and high high). Contact shall be provided and it shall be wired up to DCS for monitoring and interlock.

g. Level switches shall generally be cage float / Displacer type, rated for ANSI B31.1 requirements.

h. Non-contact type level measurement shall be provide for CW sumps and for CW make-up applications.

i.

| | | |
|---|---|---|
| DP Level transmitters | : | Accuracy-±0.075% or better |
| Hydrostatic level transmitter | | Accuracy-±0.1% or better: |
| Guided wave radar | : | Accuracy-±0.1% or better |
| All other level transmitter | : | Accuracy ±0.25% or better |
| Level switch | : | Contact type – snap acting<br>Contact rating – 230 V AC, 5A, / 24V DC, 1A |
| Repeatability | : | - ±0.5% FSR |

4.14.6 **Control Valves**

a. Control Valves are defined as Pneumatic or hydraulically operated modulating valves.

b. Control valves for regulating service shall be pneumatically operated and provided with characterized plugs. In general, equal percentage characteristics shall be provided for throttling service; linear characteristics for pressure reducing applications and quick opening characteristics for On/Off service. All control valves shall have a manual operation wheel.

c. Control valves shall be designed to prevent cavitation, flashing on the downstream side of valve or piping. For cavitation /flashing services, valves with anti-cavitation trims shall be provided. Hardened trim material shall be provided for control valves subjected to DP > 7 Kg/cm2 and for flashing applications 17 – 4 PH materials is recommended.

d. The control valves shall be of straight through globe body double port balanced type or of Angle body except for large cooling water lines.

e. Instrument air shutoff valve shall be provided on each control valve assembly.

f. The following end connections shall be used when weld type connections are specified in the piping line specification :
   1. Socket weld end connections: 2 inch and under control valve bodies.
   2. Butt weld end connection: 2-1/2 inch and over control valve bodies.

g. Valve bodies shall be Globe and shall be not more than two nominal sizes, smaller than the line in which they are installed.

h. Valve body material shall be as specified in the piping line specifications.

i. All integrally mounted instrumentation (controllers, positioners, regulators, etc.) to be designed for a maximum instrument air supply pressure of 7kg/cm2g. Minimum instrument air supply pressure is 4.5kg/cm2g. Separate air filter regulators with inlet and outlet gauges shall be provided for each control valve.

j. SMART positioners with HART compatibility shall be provided for all the control valves. Also depending on service where positioners might be subject to line vibrations or high temperatures, positioners located away from the valves shall be considered.

k. Colour of the control valve shall be identified based on the fail safe position of the valve.

l. All the control valve shall be provided with block and bypass valves. The bypass valves shall be automatic inching valve for critical applications only.

m. It is the intent that the valves shall fail either open or closed or fail lock in the event of failure of air signal or electric signal from any valve component (controller or positioner), as well as failure of the main control air supply or voltage to the solenoid.

n. Position transmitters of non-contact, 2-wire 4-20mA DC type shall be provided for modulating control valves. Also in general limit switches shall be provided for control valves wherever applicable.

o. Pilot solenoid valves for on-off service control valves are to be designed for 24 Vdc with a minimum orifice size of ¼ inch. Limit switches (open and close) to be provided for all on-off valves.

p. Instrument tubing is to be stainless steel, in accordance with the tubing line specifications. Minimum tubing size is ¼ inch, SS-316.

q. Control valve limit switches to be designed to operate at 24 VDC/110V AC.

r. The control valves shall generally have the max. flow handling capacity of 120% and the limit of valve travel shall generally be between 10% and 80%. The trim characteristics shall be so selected that the control valve is operated in the controlled flow range of 20 – 75 %.

s. The following shall be specified for control valves.

Max. noise – 85 dBA from 1m. distance from the equipment.

The max.permissible outlet velocity shall be as per ISA-S75.01 based on service (liquid, steam or flashing services). The control valve sizing shall be as per ANSI / ISA: S75.01. Leakage class shall be class V as per ANSI FCI 70.2 or better.

For fuel gas applications the valve leakage class shall be minimum class VI.

4.14.7 **pH Measurement**

a. Solid state / microprocessor based system with system accuracy of +/- 0.01 pH, auto span and zero calibration, manual zero and span calibration, integral indicator, automatic ultrasonic cleaner, iso-potential adjustment having flow type cells.

b. Output shall be isolated 4-20 mA DC linear signal. Accessories shall include preamplifier, screened junction box for electrode.

c. The pH shall have built-in reference chambers.

d. For pH measurement, reference calomel / silver, silver-chloride electrode shall be of rugged and sealed construction moulded in glass coupled polypropylene. Electrical connection shall be made directly on to the outer end of the element ensuring better electrical performance of the electrode.

Wherever, variations in sample temperature may occur, automatic temperature compensation device shall be provided.

4.14.8 **Conductivity Measurement**

a. Solid state / micro-processor based system with an accuracy of +/-0.5 %FSD, auto zero and span calibration, integral indicator having flow line (screwed) type cell. Housing for cell and analyzer shall be weather and water proof. Output shall be isolated 4-20 mA DC linear signal.

b. The conductivity sensors shall have built-in reference chambers.

c. The conductivity cell shall in general be of flow through type or insertion type depending upon the area of application.

d. Conductivity transmitter shall have local indication and provision for automatic temperature compensation up to 100 deg. C.

e. Condenser cooling water conductivity to be remotely monitored.

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4.14.9 **Silica Measurement**

a. Solid State/micro-processor based system with an accuracy of +/-1% of span or 2ppb whichever is minimum, response time better than 5 min for 90% change, required numbers of sample streams having features like auto zero & span calibration with manual provision also, ambient temperature compensation and integral indicator.

b. Self diagnostic features shall include alarm for no reagent, calibration fault and silica concentration low/high. Analyzer housing shall be weather and water proof. Output shall be isolated 4-20 mA DC linear signal.

Liquid handling unit comprising of valves, manifolds, tanks (if required), power supply unit, pressure reducer etc.

4.14.10 **DO2 (Dissolved Oxygen) Measurement**

a. The dissolved oxygen analyzer shall be of solid State/micro-processor based system based on chemo-optical type with an accuracy of +/-1% of span or 1ppb whichever is minimum, response time better than 30s for 90% change, ambient temperature compensation and integral indicator.

b. Self diagnostic features shall include alarm for transmitter fault, no reagent, calibration fault, high cell current as a minimum. Analyzer housing shall be weather and water proof. Output shall be isolated 4-20 mA DC linear signal.

The field mounted cabinets for DO2 analyzer system shall have the following:

- Auto zeroing and calibration facility
- Manual overriding
- Liquid handling unit comprising of valves, manifolds, thermometers, power supply unit, pressure reducer etc.

4.14.11 **Sodium Measurement**

a. The sodium analyzer shall work on potentio-metric method through solid State/micro-processor based system with an accuracy of +/-2% of span or better, response time better than 100 sec, ambient temperature compensation and integral indicator.

b. Self diagnostic features shall include alarm for transmitter fault, no reagent, calibration fault as a minimum. Analyzer housing shall be weather and water proof. Output shall be isolated 4-20 mA DC linear signal.

The field mounted cabinets for sodium analyzer system shall have the following:

- Auto zeroing and calibration facility
- Manual overriding
- Liquid handling unit comprising of valves, manifolds, thermometers, power supply unit, pressure reducer etc.

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4.14.12 **Chlorine Analyzer**

The chlorine analyser shall be continuous flow through type with accuracy of minimum +/-1% of span with automatic temperature compensation.

4.14.13 **Solenoid Valves**

On line two (2) way solenoid valves shall be provided, where process line of less than 2 inch with low pressure & temperature application is involved.

Three (3) way solenoid valves shall be provided commonly, where the pressure is admitted or exhausted from a diaphragm valve or single acting cylinder.

Four (4) way solenoid valve shall be provided for operating double acting cylinders. If applicable.

Dual coil Solenoid valves shall be supplied for equipment trips and single coil for balance.

Body material of bronze, plug material of SS316 shall be provided with a leakage class of class IV.

All single coil solenoids shall be of continuous duty operating on 24V DC,110 VAC and insulation class shall be H.

4.14.14 **Position Transmitters / Positioners**

Position Transmitters shall be provided for all motorized inching valves and control valves. Position transmitters shall be 24 VDC, 2 wire, system. SMART Positioners shall be provided for all pneumatically operated control valves, power cylinders etc., for converting controller output of 4-20 mA to 3-15 PSI (0.2 -1 kg/cm2) for interfacing with pneumatic actuators. Also depending on service where positioners might be subject to line vibrations or high temperatures, positioners located away from the valves shall be considered.

4.14.15 **Gas (Combustible) Leak Detection System**

A gas detection system (CGDS) shall be provided to identify presence of a fuel gas leak in the plant area. Gas detectors shall be located in the following plant locations:

- Fuel gas receiving station
- Gas turbine enclosure
- Any other point in the fuel gas path with possibility of gas leakage

Quantity of gas detectors in each location shall be determined based on the detection range of the gas detectors. Detection range shall be 0-100% LEL. Alarms shall be annunciated in plant DCS in case of gas leaks.

4.14.16 **Air Filter Regulators**

Air filter regulator along with gauges shall be provided in each of the

- Air supply line to valve positioners /power cylinders
- Air supply line to electric to pneumatic converters
- Air supply line to pneumatic interlocked valves

4.14.17 **Steam Water Analysis System (SWAS)**

SWAS shall consist of continuous on-line analysis of steam and water media to establish their purity and suitability for durability of pressure parts. The measurement shall be carried out at different cycle points of the plant to establish conductivity, pH, dissolved oxygen, sodium and silica content. The SWAS shall include all requisite microprocessor based analysers. All data shall be made available in plant DCS. Continuous monitoring of various parameters using indicator with an isolated analog outputs of 4-20mA, DC for each parameter shall be provided for monitoring in plant DCS.

SWAS shall be as per ASME PTC 19.11.5 (2008).

A Steam and Water Analysis System (SWAS) Room shall be provided with separate Dry panel room and Wet panel room. The dry panel alone shall be air-conditioned. SWAS shall be complete with sample conditioning and necessary analyzers and indication in dry panel. Chiller unit (if required) to cool the samples after primary coolers shall also be provided. Primary coolers shall be kept near the sample tap-off point.

The main analysers for steam and water shall be arranged in groups in such a way that excessively long process pipes shall not be necessary.

All samples shall be adequately cooled and pressure reducing devices shall be provided where necessary. The sample coolers / chillers shall be designed to provide samples to various analysers at 25°C or at temperatures as required by the analysers. Wherever necessary two stage cooling/chiller units shall be provided. The sizing calculations for the coolers / chillers shall be submitted for approval during engineering. The Primary coolers shall be located near the sampler tapping points. Each sample cooler shall be protected by a built-in shell relief valve. As per the quality of cooling water and recommended standards, material of sample coolers shall be either SS316 or Inconel. If chloride level of water is at higher side then material of sample coolers shall be Inconel only.

Each sample cooler should have an inlet (isolation) and outlet (isolation) valves. All cooling water flow adjustments should be made with the outlet valve so that maximum available cooling pressure is available to sample coolers.

Necessary pressure reducing element shall be provided for pressure reducing purpose and as required by the analysers. The sizing calculation and selection of these elements shall be subject to approval during engineering. At the outlet of the pressure reducing element suitably sized pressure relief valves shall be provided to protect the sample lines in case of failure of pressure reducing element. The sizing and selection of these pressure relief valves shall be subject to approval during engineering. Body and Internal material shall be of SS316 of suitable rating as per process requirement. Only in the case of very low pressure and temperatures, transmitters for measurements such as conductivity, pH, dissolved oxygen, $SiO_2$ content etc. be installed directly in the pipe. Suitable cartridge type filter with 316 SS body shall be provided on the sample line to remove particulate of size 40 micron and above. The filter element shall be removable for cleaning. In order to provide samples at a constant flow rate to the analysers, a constant head chamber shall be envisaged. The chamber shall be of 316 SS with toppings for pressure and temperature gauges

To ensure operator safety and prevent analyser failure due to overheating, the addition of a thermal protection device to interrupt sample flow if an overtemperature condition occurs is highly recommended. Self-contained temp.control valve with manual reset feature, or temp controllers with an appropriately rated automatic shutoff valve, are the preferred method of providing this protection. Some remote indication of this event (contact closure to an alarm and/ or computer system) is also recommended.

In order to monitor the sample flow rate to individual analysers, a rotameter type flow indicator with adjustable needle valve is envisaged. The graduations and the needle valve shall be accessible from the front plate of the wet section of SWAS panel. As a minimum pressure and temperature gauges shall be provided at the sample outlet line of the sample coolers and at the inlet and return line of the cooling water. In addition a flow switch and flow rotameter shall be provided at the inlet of the cooling water line. Pressure and temperature gauges shall be with 150 mm. dials, stainless steel body, socket and movement. Each gauge shall have a dial engraving or separate phenolic nameplate to identify the service.

Pressure and flow regulation for on-line analysis is essential for proper instrument performance. This is achieved by establishing constant pressure zone where the sample line feeds the analysers branch line.to achieve the constant pressure zone in conjunction with upstream pressure reducer, a backpressure regulator is required.

In order to eliminate the influence of ammonia on the conductivity measurement, cation filters shall be provided. The cation filters shall have visible colour indicators to show when they have to be regenerated.

For all analyzers, temperature compensation shall be provided, with the temperature sensor being an integral part of the probe.

For cation conductivity measurements, wherever specified, suitable cation exchange columns shall be provided. Two (2) noscation exchange columns for each stream shall be provided, one (1) working and one (1) standby. Necessary switching valves for switching to the standby column shall also be provided. The switch over shall be possible from the front of the panel. Also one (1) conductivity cell for each stream shall be provided after the cation exchange column.

The sampling system shall include all probes, valves, filters, coolers, drainage facilities, flow regulators, flow meters, piping and pumps as necessary, to give the analyser a representative and suitably conditioned sample. Interconnecting pipe work and accessories shall be of stainless steel. The arrangement shall permit testing of the entire assembly before dispatch to site and shall be arranged for convenient removal from on-line operation to facilitate routine maintenance and calibration.

Each automatic analysis sampling point shall be provided with a manual sampling point to permit a sample to be easily taken. Manual sampling shall not interrupt automatic sampling. All sampling lines shall run to common sampling racks on which all the analysis associated equipment shall be fitted.

The following samples shall be provided with necessary SWAS analysers as a minimum:

| Sl.No | Service Description | Sp.Cond | Cat.Cond | pH | Do2 | Sio2 | Eliminox | Na | Grab |
|---|---|---|---|---|---|---|---|---|---|
| 1. | HP Steam (Superheat) | √ | √ | √ | | √ | | √ | √ |
| 2. | HP Steam (Saturated) | √ | √ | | | | | | √ |
| 3. | HP Drum Water | √ | | √ | | √ | | | √ |
| 4. | IP Steam (Superheat) | √ | √ | √ | | √ | | √ | √ |
| 5. | IP Steam (Saturated) | √ | √ | | | | | | √ |
| 6. | IP Drum Water | √ | | √ | | √ | | | √ |

| Sl.No | Service Description | Sp.Cond | Cat.Cond | pH | Do2 | Sio2 | Eliminox | Na | Grab |
|---|---|---|---|---|---|---|---|---|---|
| 7. | LP Steam (Superheat) | √ | √ | √ | | √ | | √ | √ |
| 8. | LP Steam (Saturated) | √ | √ | | | | | | √ |
| 9. | LP Drum Water | √ | | √ | | √ | | | √ |
| 10. | Deaerator outlet | √ | | √ | √ | √ | | | √ |
| 11. | HP-BFP outlet | √ | | | √ | | √ | | √ |
| 12. | LP-BFP Outlet | √ | | | √ | | √ | | √ |
| 13. | CEP discharge | √ | √ | √ | | | | √ | √ |
| 15. | DM makeup to condenser | √ | √ | √ | | | | | √ |
| 16. | Condenser Hot-well (in line conductivity) | √ | | | | | | | |
| 17. | Condenser cooling water | √ | | √ | | | | | √ |

Sp.cond – specific conductivity, Cat. Cond – cation conductivity, Do2 – Dissolved oxygen, Sio2 – silica, Na – Sodium.

4.14.18 **Stack Emission Monitoring System (SEMS)**

A fully certified continuous on-line emission monitoring system shall be provided for stack to determine emissions of SOx, O2, Opacity/particulate matter, NOx and CO. Accuracy of the analyzers shall be minimum+/-1% of the calibrated span. One operator station(24")with all the software, hardware, interface and other accessories shall be supplied for report generation and calibration purposes. Provision of online signal monitoring at pollution control board shall be provided, but it **shall be in disable form**. Required software and hardware shall be provided by bidder for the same.

The equipment shall be constructed for operation in dusty and humid environments at high ambient and flue gas temperatures.

Analyzers provided shall have auto-calibration for zero and span as well as self-diagnostic functions and provision for manual calibration also.

Flue gas analysers for emission monitoring shall be TUV approved or it shall be as per EPA and USA regulations.

Generally, the analysers and the analyser probe equipment shall be suitable for mounting in ambient plant conditions, e.g. within a standard cubicle. However, if not feasible, the equipment shall be mounted in an air-conditioned room or container.

Power failure and system failures of analyzers shall be monitored in the central control room by a group alarm.

All stack analyzers output signals shall be repeated in DCS for alarm & monitoring.

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Calibration Gas Cylinder/ Consumables: All calibration cylinders and other necessary items for analyser calibration shall be provided by the contractor, considering the requirement of start-up / commissioning warranty period plus two years normal operation. The cylinders shall be located outside the cabinets and contractor shall provide suitable mounting accessories for the same. Cylinders shall be provided in two sets, one shall be used and the other for storage and filling.

The location of Analyzer shelter for stack monitoring system and analyzerroomfor other analysers shall be in safe area and exact location shall be decidedbased on:

i) Allowable transportation time for each sample point.
ii) Available space requirement for analyzer shelter/ room.
iii) Accessibility with respect to approaches & obstructions.
iii) Space required for equipment maintenance and calibration.

In no case, the transportation time should exceed the recommended figuresindicated in the Process package. In case no value is indicated the transportationtime should be considered less than one minute.

4.14.19 **Vibration Monitoring & Analysis System**

Vibration monitoring & analysis system shall be provided with vibration transducers, low noise flexible cables in flexible conduits, terminated in JBs, all interconnecting cables, racks/cabinets, power supplies, calibration equipment, indicators, integrating units, signal conditioning devicesfor Vibration monitoring & analysis system and all accessories required for completeness of work. Apart from GTG, STG, Vibration transducers shall be provided for all major HT equipment / auxiliaries like motor, pump/ fans bearing on both X & Y direction driven, non-driven ends and key phasor. Vibration monitoring & analysis system shall be in accordance with API 670 standard. All outdoor mounted vibration pick-ups, amplifiers, junction boxes and other equipments shall be provided with IP-65 protection class.

4.14.20 **Panels**

Panels and control desk shall be freestanding type and fabricated preferably from 2.5 mm thick cold rolled steel sheet. Angle iron framework shall use a minimum section of 50 × 50 × 6 mm angle. The finish shall include sand blasting, grinding, chemical cleaning, and surface finishing by suitable filter and two coats of high-grade lacquer with wet sanding between coats. Two coats of paint in panel color shall be given for non-glossy high stain finish. Panel face final colour in general shall be RAL 7035.

Panels and control desk shall have removable hinged doors, generally at the back for easy maintenance and accessibility of the instruments. Doors shall be double leaved type with handle and shall be provided with lock and key. Adequate illumination shall be provided inside the panel.

The local panel construction shall be suitable for the site condition and shall meet IEC requirements in accordance with electrical area classification.

Pressurization or purging shall be as per NFPA 496 or equivalent.

No process fluid except air shall be piped to the control panel.

Mounting heights

1. Annunciators (top row)
2. Miniature and subminiature instruments (next 3 rows)
3. Electric push buttons (last row)

Control room panels shall have IP protection of IP 42 if mounted in an air- conditioning room and IP-65 if mounted inside a room and outside.

4.14.21 **Cable Laying And Termination**

The accessories like double compression cable glands, cable lugs, cable tags (SS), cable ties and accessories required for the cable termination shall be included in scope of supply. Insulated lugs and ferrules with proper identification shall be used for all I&C cables.

4.14.22 **Cable Trays**

All I&C cables / tubes shall run on perforated cable trays. These cable trays shall be made out of galvanized MS and shall be of sheet steel of 2.5 mm thick. The width shall be so selected that 60% of tray space is available for future use of the complete installation.

Suitable cable clamps shall be supplied for binding the cables / tubes at every 500 mm. Cable tray shall be provided with Hot dip galvanized finish. Cable tray shall be provided with the perforation as per manufacture standards. Suitable cable tray cover shall be provided for all trays.

Cable tray shall be continuous and solid grounded. Cable tray shall not have sharp edges, Burrs or projection which is injurious to insulation or outer sheath of the cable.

The supporting arrangement of cable tray system shall be able to withstand the weight of the cable and cable tray system. The supporting interval shall not be more than the recommended span for the above loading for the type cable tray selected. The tray shall not overhang by more than one meter from the support at the dead end.

4.14.23 **Process Impulse Lines /Tubes & Fittings**

Impulse lines for instruments shall be ½" OD tubing of SS316 material according to ASTM A-269. All fittings to be used for tubing shall also be SS316, double compression type of standard make. Impulse pipes for high pressure applications shall be used with material and rating as same as that of the process line. Size and thickness of piping/tubing shall be suitable for the design pressure and temperature conditions as per ANSI16.11. Compression tube fittings are used in low pressure process systems. Socket weld tube fittings shall be used in high pressure process systems

For impulse pipes/tubes and fittings, IBR certificate shall be provided as applicable. The contractor shall provide thermal insulation (preferably mineral wool) for sampling pipes for the purpose of personnel protection so that temperature outside the insulation is 60 deg. C. Tubing shall be complete with union connections and end fittings at supply and receiving ends. Nipple shall be provided for root valves size more than ½" and the nipple size shall be same as the root valve size. Reducer / adapter shall be provided to suit instrument connection, where nipple, root valve size is more than ½". Bulk head fitting socket welded type to be provided at instrument rack/enclosure.

Impulse pipes, fittings and air supply and signal piping/tubing shall be supplied for all the instruments under the scope of this specification. Instrument piping shall be designed for maximum design pressure and temperature of the process. Pressure measurement connection shall be ½'' or 12mm pipe depending on the temperature and pressure conditions of the fluid. Instrument on Vacuum system at CEP inlet should have vent lines connected to high point in the condenser. Instrument air tubing shall be SS316.

Minimum bending radius of instrument sensing line is 3 times the tube diameter.

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Instrument sensing lines are sloped in their horizontal runs, a minimum of ½" per foot. In general, liquid and steam lines slope from their process tap connection down to the instrument. In general, gas and non-condensing vapor lines slope from their process tap connection up to the instrument.

Instrument sensing lines shall be routed as directly as practicable from the process root valve to the instrument. The length of instrument tubing from the root valve to the instrument shall be limited to maximum of 12 meters for compressible fluids and 15 meters for non-compressible fluids. Wherever it is not possible to access the main root valve an additional root valve shall be provided near to the instrument.

Instrument sensing lines shall be grouped together as much as possible to benefit from the use of common support members and to present a finished installation that is routed in a neat and orderly manner.

The maximum process temperature for all transmitters shall be limited to 80°C. To dissipate the excess heat, a minimum of 1 meter of tubing for each 30°C of excess heat shall be installed to isolate the process media from the instrument. An additional isolation valve shall be used at the instrument for isolation on those instruments without valve manifolds

Funnel with drain header shall be provided in the racks for blowing/draining out the process fluid in the impulse tubing. The size of the drain header shall be 1". When instruments are mounted local to the tapping point and are not mounted in the rack, or panel or enclosure, the drains shall be connected to the nearest floor level or plant drain.

4.14.24 **Instrument Valves And Manifolds**

Bidder shall supply instrument valves and valve manifolds as per the Instrument Installation / Mounting diagrams.

Body material and rating shall be SS316 whichever is better and shall be forged type. Valve trim material shall be SS316.

Double root valve shall be provided under the conditions of pressure > = 40bar.

4.14.25 **Instrument Support / Structural Steel**

Bidder shall supply instrument stands (stanchions) and other structural steel material required for supporting the Junction boxes, cable trays, impulse lines and instruments.

4.14.26 **Junction Boxes / Local Instrument Racks / Local Instrument Enclosures**

Bidder shall supply junction boxes wherever required. These shall be of Industrial grade Fibre glass Reinforced Polyester (FRP) to weather proof, with cable entering on bottom and side entry shall be provided.

Junction boxes provided in the GTG enclosure, shall be provided with explosion proof enclosure/intrinsic safety and certified for the applicable area classification.

These boxes shall have terminals suitable for min 2.5 mm² cable termination (klip on) mounted on rails. 20% spare terminals shall be supplied in each junction box.

Junction box shall be provided with double compression glands. All field junction boxes, which are installed outside the building, shall have protective canopies to protect from rainwater and sunlight. Cable entry to the JB shall be from bottom. JB/Instrument enclosure shall have drawing holder and enclosures shall have non UPS fused power outlet.

Separate Junction boxes shall be provided for signals such asintrinsically safe and non-intrinsically safe 4-20 mA DC, thermocouple, RTD,shutdown (for solenoid valves), switch contacts alarm, power etc.
All the shield wires shall be terminated in the JB as per Cable Schedule. Separate JB shall be used for PLC inputs and outputs. JB shall be earthed through GI flat. Separate JB shall be provided for intrinsic safe circuits.

Telephone socket shall be provided in junction boxes. Each junction box shall have a minimum of 20% or 2 nos., whichever is more, spare entry duly provided with plugs (weather proof/explosion proof, as applicable). Protection class shall be IP-65 minimum for JB and enclosures.

The instrument enclosures are freestanding, enclosed type and shall be offered with protection class of IP65. The Enclosures shall be constructed of 3mm CRCA. Earth bus bar 25 X 6 mm tinned copper shall be used. Base frame shall be made up of ISMC -100 pained with black. 15 mm thick anti vibration pad shall be provided. All enclosures shall be provided with grounding facility. SS Legend plates shall be provided on the cabinet front and back. All mounting accessories, interior CFL, U-clamps, nuts bolts shall be provided as required.

The instrument racks are freestanding type and shall be constructed of suitable 6mm thick channel frame of steel. The Instrument racks shall be provided with a canopy to protect the instrument provided n he rack from falling objects, water etc. All racks shall be supplied as standard with base plates and collar with pinch bolt to suit 2-inch NB pipe stands or I-Channel.

Height of the panel (racks and enclosures) shall be 2.1 Mtrs. Inside the panel instrument shall be fitted within a height of 900mm to 1500mm. Sufficient spacing among adjacent transmitters shall be maintained to offer easy accessibility and operational convenience. Bulk head connection shall be provided to receive and terminate the impulse pipes from root valves.

The instrument racks and enclosures material should be suitably constructed for saline atmosphere. Hinged doors to be provided for junction boxes and enclosures.

Nameplates shall be installed to designate the service, Tag no's of all switches instruments, meters, fuse blocks, relays, amplifiers etc. both internally and externally located on the panels.

Nameplates shall be fastened with two rust resistant machine screw.

4.14.27 **Instrument Air Supply System**

Dry instrument air shall be distributed to various equipment of I&C system like control valves, Analyzer purging, pneumatic On-Off dampers. The Bidder shall supply total Instrument air requirement Calculations, and design of Air compressor system along with the bid

4.14.28 **Piping Supports**

Piping and tubing shall be adequately supported and fixed at distances not exceeding those in the following table:

All field mounted instrument tubing shall be supported with steel angles/channels of a minimum 1/8" thickness fabricated to present a neat appearance. Sharp corners in the support material to be avoided.

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4.14.29 **Instrument Lab**

The laboratory instruments & equipment provided shall be reliable and sufficient to meet the industry standards. The offered equipment shall be proven type and shall incorporate latest design & performance. The list of laboratory instruments & equipment required are indicated below,

- Pneumatic test bench

  The test bench shall be furnished as per the following:

  High quality steel construction with suitable laminated bench top surface for easy operations. Complete with Built-in selector for read out in five engineering units i.e. kg/sq. cm, psi, mmwcl, bar, mm Hg. Complete with regulated air supply outlet of 0-20 psi and 0-30 psi, display plate with two four and half digit digital pressure indicator of range vacuum to 20,000 mm WG and 0-30 psi, accuracy ± 0.05% of full scale.

  Complete with overload protection valve.

  Complete with control plate with mimic panel incorporating three precision pressure regulators, filter reducing unit for the air supply, three 150 mm dial pressure gauges having ranges 0-2, 0-4 & 0-6 Kg/cm² respectively and accuracy of ± 0.25% full scale, standard rotameter, necessary fittings to connect instrument to test bench, electric vacuum pump with digital vacuum indicator.

  Complete with two 0-30V 0.5A max. Stabilized DC sources

  Complete with current source of 0 to 55 mA, and mV source of 0-100 mV.

  Complete with set of supports for the instrument under test, desk with drawers and all other necessary accessories.

  Simulation and measurement from –8000 mmWC to 700 bar of pressure

- Electronic test bench

  The Test bench made of high quality steel construction with suitable laminated bench top surface for testing and repair of electronic instruments and gadgets shall be furnished. It shall be modular in design enabling easy change of arrangement. Test bench shall be furnished with thick laminated top and mimic engraved.

  Bench shall include the following module.

  | | |
  |---|---|
  | Main Power supply module | It includes main switch for whole workstation 3 ground socket for other instrument, 230V 5A AC low voltage output, earth leakage circuit breaker etc. |
  | Isolated supply module | It shall include main switch, circuit breaker, 230V AC ±0.5%, 1 phase, 50 Hz, 3 kVA supply socket no. of socket - six<br><br>230V AC, 10 Amp, 50 Hz supply socket no. of socket - two |

Variable AC power supply — It shall include 0-260V AC*, 1 phase, 50 Hz, 10 Amp, socket and terminal, 0-50V AC/2A, terminals. Digital meter for current (resolution 0.01A) and voltage (resolution 0.1V)
no. of socket - one

Variable DC Supply — Module shall include 0~30V, 0~60V, DC* 1A/2A/3A stabilized output voltage supply No load/full load regulation shall be ± 0.02% or better, Digital display for voltage and current
no of socket - Two

Constant DC Voltage supply ± 48V DC*, 3A
no. of Socket - Two

± 24V DC, 6A
no. of Socket - Two

± 12V DC*, 10A
no. of Socket – Two

± 5V DC*, 10A
no. of Socket – Two

Each unit shall include Digital meter for Volts and Ampere.

The following facilities shall also be provided.

(1) One DC voltage stabilizer : (0 to 60V, 1A) — Regulation ± 0.02% for 0-100% load variation

(2) One AC voltage stabilizer : (230V AC nominal) — Regulation ± 0.5% for 0-100% load variation

The above voltage level is tentative and shall be matched to supply requirements of Contractor's range of products.

The test bench shall include socket holders, where the electronic gadgets under test may be plugged. The front equipment shall include multi point connectors and test jacks for inter-connection. There shall be connection between the connector and holder in which device under test shall be plugged in.

The standard high accuracy resistors shall be included to load and measure the current output of devices. Necessary control devices for voltage and current adjustment/control, switches for power supply to feeders, isolation etc., shall be included. All electric circuits shall be protected against overload by fuses, whose holders are located on front of the panel. All electrical circuits and metal structure shall be properly grounded.

- Multi-function Calibrator

  3 nos. microprocessor based multi-function calibrator with provision to use rechargeable as well as dry batteries and on-board memory to store calibration data that can later be downloaded to a PC. Its functions shall include the following:

a. Current calibrator

It is used to test and calibrate 0-20mA instrumentation. It is used as source, simulates and also for measurement also.

| | | |
|---|---|---|
| Input output ranges | : | 0~24mA |
| Accuracy | : | ±0.05% ±1LSD |
| Power supply | : | Batteries |
| Operating temperature | : | 0~50°C |

b. mV calibrator

It is used as millivolt calibrator, as source and as measuring device.

| | | |
|---|---|---|
| Input output ranges | : | 0~20.0V, 0~200mV |
| Accuracy | : | ±0.05% ±1LSD |
| Power supply | : | Batteries |
| Operating temperature | : | 0~50°C |

c. TC calibrator / simulator

It is used to calibrate the thermocouple by simulation method. Devices shall be capable of simulating the mV values along with the cold junction compensation for the selected thermocouple.

Measurement & Simulation of TC Signal

| | | |
|---|---|---|
| Suitable to | : | J, K, R, S, T, E, N, B Type |
| Accuracy | : | ±0.05°C. |
| Resolution | : | ±0.1°C |
| Display | : | °C / ° F selectable |
| Power supply | : | Battery |

d. RTD calibrator / simulator

It is used to calibrate the RTD by simulation method. Devices shall be capable of simulating Pt-100 equivalent resistant valves. Ranges shall be selected on the graduated read out dial.

Measurement & Simulation of RTD Signal
Suitable to Pt -100
Compatible to 2, 3, 4 wire RTD

| | | |
|---|---|---|
| Accuracy | : | ±0.025%FS |
| Resolution | : | 0.1°C |
| Display | : | °C/Ohm selectable |
| Power supply | : | Battery |

- Portable pressure calibrator

It is used for calibration of pressure gauges, pressure switches and pressure transmitters. It should be a microprocessor based with display resolution of five digits. It shall have on-board memory to store calibration data that can later be downloaded to a PC.

| | | |
|---|---|---|
| Measurement | : | Pressure with multiple units selection |
| Range – Pressure | : | -1 to 2 bar (2 nos) |
| | : | -1 to 20 bar (2 nos) |
| | : | 0-200 bar with in-built pump (2 nos) |
| Electrical Input | : | mA / V / Potential free switch contact |
| Current - mA | : | 0 - 20 mA / 0 - 50 mA (Selectable) |
| Volt – mV / V | : | 0 - 20 V / 0 - 50 V (Selectable) |
| Pressure Medium | : | Hydraulic fluids (Oil / Water) |
| Accuracy | : | ± 0.05 % |
| Protection | : | Weather Proof |
| Power supply | : | Battery & 230 V AC |
| Connection | : | ½ " NPT |
| Connector | : | ½" NPT (M) x ¼" NPT (F) |
| | | ½" NPT (M) x ¼" BSP (F) |
| | | ½" NPT (M) x ½" BSP (F) |
| | | ½" NPT (M) x $^3/_8$"NPT (F) |
| | | ½" NPT (M) x $^3/_8$" BSP (F) |

- Portable hand pump used for pressure calibration

  It is used to produce the required pressure value for the calibration purpose of the instrument.

| | | |
|---|---|---|
| Measurement | : | Pressure |
| Range | : | 0 -200 Kg/cm2 |
| Accuracy | : | *+/ (-)* 0.10% of range |
| Type of Medium | : | Hydraulic fluids (Oil / Water) |
| Connection | : | ½" NPT (F) |
| Connector | : | ½" NPT (M) x ¼ " NPT (F) |
| | | ½" NPT (M) x ¼ " BSP (F) |
| | | ½" NPT (M) x ½ " BSP (F) |
| | | ½" NPT (M) x 3/8" NPT (F) |
| | | ½" NPT (M) x 3/8" BSP (F) |

Accessories

Reference Gauge of 6 " dial ( 0-2 Kg/cm², 0-6Kg/cm², 0-10Kg/cm², 0-25Kg/cm², 0-40 Kg/cm²,

0- 100 Kg/cm², 0 -200 Kg/cm²), release Valve, 2 No of high Pressure hose suitable to above adapter, fin regulator additional to main pump for small pressure changes, battery, Test leads for mA & switch contac.

Display : 4½ digit -digital Display

Display / indication for switch contact and input voltage.

- Portable vacuum calibrator

  It is mainly used for calibration and testing of vacuum measuring gauges and transmitters.

| | | |
|---|---|---|
| Measurement | : | Pressure / Vacuum |
| Electrical Input | : | mA / V / Potential free switch contact |
| Range -Pressure | : | 1 -10 Kg/Cm² |
| Current | : | 0 - 50 mA |
| Pressure Medium | : | Air |
| Accuracy | : | ± 0.05 % |
| Protection | : | Weather Proof |

Connection : ½" NPT
Connector : ½" NPT (M) x ¼" NPT (F)
½" NPT (M) x ¼ " BSP (F)
½" NPT (M) x ½" BSP (F)
½" NPT (M) x $^{3}/_{8}$" NPT (F)
½" NPT (M) x $^{3}/_{8}$" BSP (F)

Tuning facility to increase / decrease

Display : 4 ½digit -digital Display

Display / indication for switch contact input.
Accessories : Battery -alkali
Output : Vacuum
Range : 0 -10000 mmwc
Body : Aluminum
Connection : 1/2 " NPT (F)
Accessories : Vacuum Gauge, Range:0 -10000 mmwc,
Accuracy : 0.1 % at any point
Vent Valve

All items should be of SS material.

Test leads for mA & Switch contact

- Portable vacuum hand pump

Vacuum hand pump shall be used for the generation of vacuum. The shape of the pump shall be such that it assures maximum grip for the user. It shall be provided with valve to relieve the vacuum. It shall be light and totally sealed construction.

Output : Vacuum
Range : 0 -10000 mmwc
Body : Aluminum
Connection : ½ " NPT (F)
Accessories : Vacuum Gauge, Range : 0 -10000 mmwc,
Accuracy : 0.1 % at any point

Vent Valve

All items should be of SS material.

- Portable flue gas analyzer

Portable flue gas analyser for determining the individual quantities of SOX, NOX, CO, CO2 and O2 in the flue gas samples shall be provided. The portable gas analyser shall be complete with hardware, calibration software/ tools, power supplies, filters, drives and other accessories.

Specification
Sensor: Oxygen (O2), Range:0 to 25.0 % Vol., Accuracy:±1 %, Resolution:±0.1 % Vol.
Sensor: Carbon Monoxide (CO) (low), Range: 0 to 2000 ppm, Accuracy: ±2 %, Resolution: ±1 ppm.
Sensor: Sulphur Dioxide, SO2, Range:0 to 2 000 ppm, Accuracy:±2 %, Resolution:±1 ppm.
Sensor: Nitric Oxide, NO, Range: 0 to 1 000 ppm, Accuracy: ±2 %, Resolution: ±1 ppm.
Sensor: Nitrogen Dioxide, NO2, Range: 0 to 100 ppm, Accuracy: ±2 %, Resolution: ±1 ppm.

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Sensor: Hydro carbons, CxHy – Pellistor /Catalytic.
Sensor: Range: 0 to 200 ppm, Accuracy: ±2 %, Resolution: ±1 ppm.
Sensor: Carbon Dioxide, CO2 – IR sensor, Range:0 to 25.0 % Vol., Accuracy:±0.5 % Vol, Resolution:±0.1 % Vol.
Sensor: Flue Gas/Ambient Temperature , Range:0 to 300 deg. C, Accuracy:±1 %, Resolution:±1 deg C.
Sensor: Flow (velocity), Range: 1 to 50 m/s, Accuracy:±1 %, Resolution:±0.1 m/s
Probe Length: 3m
Display: Full function alphanumeric/graphic LCD with backlight
Keypad: 40 x 8 Matrix Liquid Crystal Tactile membrane (integral with display) functions keys and cursors.
Indicators LED type for ON (Power), Stand-by, Service, Charge, Low Batt., Fault.
Power Supply: 95-265 V a.c. ±10%, 50-60 Hz, 30 Watts Rechargeable battery
2 x 6 V 4 Amp. Hours, Typical 8 hr. operation
Ambient Temperature -5 °C to 45 °C (+23 °F to 113 °F)

Accessories:
Integral water catch pot and filters
Rechargeable lead acid battery (internal)
Mains power supply cable
Probe handle, Hose and Probe pipe
Carrying case
Printer
Data logging etc.

- Digital multi-meter

Multimeters are indicating instruments capable of sensing and displaying measurements of basic electrical quantities. They shall be IS certified and of true RMS type with recording facility.

| | | |
|---|---|---|
| Type | : | Hand Held 4½ Digit, LCD Display |
| Measurement | : | AC Voltage : 10 microV -1000 V |
| DC Voltage | : | 100 microV -1000 V |
| AC/DC Current | : | 0.1 microA -10A |
| Resistance | : | 0.1 Ohms-40 Mohms |
| Capacitance | : | 20nF -999.9 microF |
| Frequency | : | 1Hz -20 KHz |
| Diode Check | : | required |
| Other Features | | |
| Range | : | Auto / Manual |
| Touch Hold | : | Required |
| Continuity Test | : | With Beeper |
| Over Load | : | Protection Req. |
| Battery | : | 9 Vdc |
| Construction | : | Splash, EMI /dustProof |
| Accessories | | |
| Spare Test Leads | | |

- Dead weight tester(accuracy of 0.1%)

Dual range dead weight pressure gauge tester with combined high range and low range position unit, allowing an automatic change of scale of 10:1 ratio, with dual area screw press with ball thrust and axially located hand wheel shall be furnished. Piston cylinder assembly unit shall be made of special grade die steel or any other suitable material. The tester shall be provided with pressure instrument, leveling screws and relief valves to prevent damage. The

measuring range shall be 1-600 Kg/sq cm with accuracy better than ± 0.015% of the pressure being measured. It shall be suitable for gauges having 1/8", 1/4" and 1/2" NPT connection.

Dead weight tester to be provided with following weights:

4 weights corresponding to 10 or 100 kg/sq.cm,
1 weight corresponding to 9 or 90 kg/sq.cm,
1 weight corresponding to 5 or 50 kg/sq.cm,
2 weights corresponding to 2 or 20 kg/sq.cm,
1 weight corresponding to 1 or 10 kg/sq.cm,
1 weight corresponding to 0.5 or 5 kg/sq.cm,
2 weights corresponding to 0.2 or 2 kg/sq.cm,
1 weight corresponding to 0.1 or 1 kg/sq.cm,
1 weight corresponding to 0.05 or 0.5 kg/sq.cm,
2 weights corresponding to 0.02 or 0.2 kg/sq.cm,
1 weight corresponding to 0.01 or 0.1 kg/sq.cm,

Accessories: To be furnished with spirit level, 8 bonded seals, pointer remover and punch, 2 spanners, one tool roll containing adapters for 1/4" & 1/2" NPT sizes, bottle of technical grade oil, dust cover, wooden carrying case etc.

Test certificate for accuracy and perfect cylindrical shape of the piston unit shall be furnished. Test & calibration certificate Traceable to National Standard.

Software shall be provided to correct for effects of environmental factors such as gravity and temperature to determine the pressure generated by dead weight testers.

| | | |
|---|---|---|
| Range | : | LOW : 1 -100 Kg/Cm² |
| HIGH | : | 10 - 300 Kg /Cm² |
| Accuracy | : | ± 0.015 % |
| Type of medium | : | Hydraulic Oil |
| Material of Weight | : | SS |
| Increment of weight | : | Min. increment of 0.5 Kg/cm² for Low range<br>Min. increment of 5 Kg/cm² for High range |
| Gravity Calibration | : | Standard |

- Test manometer (hg well type)

| | | |
|---|---|---|
| Range | : | 0 - 2000 mmHg |
| Medium | : | Mercury |
| Scale | : | True scale |
| Graduation | : | 1mmHg |
| Mounting | : | Table top with level adj screw at the bottom |
| Connection | : | ½" NPT (F) |
| Facility for zero adjustment | : | Required |
| Accessories | : | Drain plug, Aspirator with connectors |

- Digital manometer

Bidder to provide digital manometer with all accessories required for measurement as mentioned below

Specifications:

| | | |
|---|---|---|
| Range | : | 0 - 2000 mbar |
| Accuracy | : | ± 0.2% FS ±1 digit |
| Resolution | : | 0.1 mbar |
| Max Load Capacity | : | 7000 mbar |
| Measuring media | : | Inert gases and instrument air |
| Media compatible rel. /abs. | : | All media, which are compatible with stainless steel 18/8 (DIN 1.4305) Range from 1 bar to 90 bar |
| Units of measurement | : | mbar, bar, Pa, hPa, kPa, MPa, kg/cm2, kg/m2, mmHg, cmHg, mHg, inHg, $mmH_2O$, $cmH_2O$, $mH_2O$, $inH_2O$, $ftH_2O$, psi, $lb/in_2$, $lb/ft_2$, torr, atm |
| Temperature calibration | : | 0°C... 50°C |
| Operating temperature | : | 0°C... 50°C |
| Power supply | : | Battery |
| Pneumatic connection | : | hose Ø 4/6 mm, NPT 1/8" (from 10 bar), |
| Case, type of protection | : | IP 54 |

- Master pressure gauges (Accuracy 0.1 % of FSD)

| | | |
|---|---|---|
| Pressure Element | : | Bourdon Gauge |
| Element Material | : | SS 316 |
| Accuracy | : | ± 0.1% of any point of rising or falling pressure |
| Mounting | : | Direct |
| Connection | : | ½" NPT (M) (SS316) |
| Window | : | Glass (3mm thick) |
| Ring | : | Standard |
| Pointer | : | SS with knife edge tip |
| Case | : | Aluminium |
| Zero adj facility | : | Required |

| **Range** | **:** | **Dial** |
|---|---|---|
| Vacuum | : | 10" size with mirror finish |
| 0 - 20 $kg/cm^2$ | : | 10" size with mirror finish |
| 0 - 60 $kg/cm^2$ | : | 10" size with mirror finish |
| 0 - 100 $kg/cm^2$ | : | 10" size with mirror finish |
| 0-200 kg/cm2 | : | 10" size with mirror finish |

- Temperature calibration bath

Temperature calibration bath is used for calibrating all types of temperature sensors. They heat up quickly, but cool very slowly, so they work best if left at a constant temperature.

| | | |
|---|---|---|
| Range | : | 0° to 250°C (Oil), 0° to 1000°C (Powder) |
| Display Resolution | : | 0.1°C |
| Accuracy | : | ±0.5°C |
| Immersion Length | : | 250 mm |
| Suitable to sensor dia | : | 3mm, 4mm, 6mm, 8mm, 10mm, 12 mm, 15mm, 19.5mm |
| Heat up Time, Max | : | 5-15 Minutes |
| Cooling Time, Max. | : | 20-30 Minutes |
| Ramping | : | Required |

- Digital oscilloscope

Two channel digital storage oscilloscopes shall be supplied for the instrument shop. The storage oscilloscopes shall be able to store the waveforms in a memory and it shall be possible to view the same for later analysis. The unit should be capable of storing two waveforms per channel. These shall incorporate latest state of art design.

Low watt dissipation and light weight shall be preferred. Simple direct reading controls arranged functionally shall be there in the front of the instrument. Intensity/brightness, trace rotation, beam find, focus, storage/read-out intensity shall be controlled from the front. Oscilloscope shall have a band-width from DC to 100 MHZ (minimum) at 50 Deg. C.

The oscilloscope shall have vertical sensitivity of 2mV/div to 5V/div (1-2-5 sequence). High input impedance (of at least 1 M ohm) and low rise time shall be provided. Acceptable maximum voltage to the oscilloscope shall be 400 V (dc + peak AC) and 800 V (p-p ac at 1 kHz).
A brief specification for oscilloscope is enumerated below:

| | | |
|---|---|---|
| a) Sweep Speed | : | 0.05 micro second/div to 0.5 sec/div (1, 2, 5 sequence).<br>Maximum sweep rate 5ns/div x 10 magnifier.<br>0.05 microsecond/div to 5 sec./div in store mode. |
| b) Accuracy | : | ±4% or better for non-store mode; ± 0.1% or better for store mode. |
| c) Triggering Mode | : | Internal / External at Positive / Negative slope with auto / manual mode selection. |
| d) Line Voltage | : | 90 to 250 V AC Range |
| e) Line | : | 48 Hz to 440 Hz Frequency |
| f) Display | : | 8x10 cm LCD display with 14 kV nominal voltage. |

Control such as intensity, trace rotation, beam find, focus etc. shall be provided on front. The line voltage range shall be 90V AC to 250 V AC with line frequency range of 48 Hz to 52 Hz.

| | | | |
|---|---|---|---|
| g) Accessories | : | a) | one trolley is envisaged for carrying the oscilloscope from one point to other. |
| | | b) | High voltage grade probes with suitable screening etc. |
| | | c) | The RS-232 C communication cable with necessary interface requirements. |
| | | d) | 40 kV EHT probe, 10A current probe |
| h) Display | : | | 80 x 100-mm internal graticulate with 8 x 10 division |
| Display Mode | : | | CH1, CH2, INV, CH1 / CH2 X-Y |
| i) Vertical Deflection | | | |
| Sensitivity | : | | 7 mV / Div to 20V / Div |
| Accuracy | : | | ± 3 |

| | | |
|---|---|---|
| Mode | : | CH1, CH2, Add, Dual, Alt, and Chop |
| Bandwidth | : | 20 MHz |

j) Horizontal Deflection

| | | |
|---|---|---|
| Accuracy | : | ± 3 % |
| Time base | : | 40ns-0.2s |

k) Trigger System

| | | |
|---|---|---|
| Mode | : | Automatic /Normal with level control |
| Source | : | CH 1 / CH2 /Line / Ext. |
| Calibration | : | Provides Square wave Output for Probe |
| Power Supply | : | 230 V AC / 50 Hz |
| Accessories | : | Attenuator Probe 2 Input Leads |

- Function generator

| | | |
|---|---|---|
| Frequency Range | : | 0.002 Hz to 20 MHz selectable |
| Function Output | : | |
| Waveforms | : | Sine, Triangle, square, Negative square. |
| Amplitude | : | 0 – 30V P-P Variable |
| Control Mode | : | Continuous Triggered |
| Output Impedance | : | 50 Ohms |
| D.C Output | : | Adjustable with signal peak |
| D.C Offset | : | Limited to ±15 V |
| TTL Output | : | Required. |
| Display | : | Digital display |
| Input supply | : | 230 V AC, 50 Hz |
| Frequency Counter | | |
| Frequency Range | : | Up to 20 MHz |
| Input | : | Max. Amplitude 50 V Peak, 10 V RMS |
| Impedance | : | 1 M ohms / 22 pF |
| Sensitivity | : | 20 mV RMS |

- Digital portable Vibration Analyzer

The instrument shall meet the following requirement as a minimum.

- The Analyser shall be able to perform easy condition monitoring of equipment with high resolution of 12,800 lines, high accuracy of 0.01% of measured value & high speed of processing of 16bit (96db) dynamic range using the latest technology. It shall have a tri-axial probe to measure vibration in 3 directions.

- The Analyzer shall be provided with data collector as an integral part of the instrument, which is capable of collecting various user defined data and shall have interface to communicate with PC for data backup.

- The Analyzer cum data collector shall also be provided with Predictive maintenance software which shall store and manipulate data. Also user defined upload communication and down loading data to condition monitoring software shall also be provided.

- Digital/Analog amplitude and frequency meter with digital display of measurement. The database of software shall have machine problem diagnostic data, equipment bearings data etc to facilitate machine vibration analysis. It shall be capable of doing spectrum analysis and shall generate expert report containing remedial action.

Acceleration range of 0.1 to 199.9 m/s peak, velocity range of 0.01 to 19.99cm/s RMS, displacement range of 0.001 to 1.999 mm peak to peak, frequency range 10 to 1000 MHz and 1000-15000Hz, AC signal output, digital display and analysis software.

The instrument shall be powered by a self-contained rechargeable battery pack and shall be designed to operate from either a 230V, 50 Hz Single phase power supply or with battery. It shall be dual channel instrument with minimum 8 GB memory with a built-in display of minimum 14" size.

- Soldering

| | | |
|---|---|---|
| Ranges | : | 160 to 480°C |
| Stability at Idle | : | ± 3°C |
| Power Supply | : | 230V AC, 50 HZ |
| Accessories | : | Tip adaptor |
| Sponge | | |
| Quantity | : | 2 nos. |

- De-soldering station

| | | |
|---|---|---|
| Temp. range | : | 160°C ~ 480°C |
| Power supply | : | 230V AC, 50Hz |
| Accessories | : | De-soldering iron assembly with tip |
| | | Glass solder collector |
| Quantity | : | 2 nos. |

- Digital Tachometer

| | | |
|---|---|---|
| Type | : | Portable, handheld, contact/non-contact type |
| Speed measurement | : | 0.5 –20,000 rpm |
| Measuring units | : | RPM, RPS, RPH, FPS |
| Display | : | LCD display |
| Power supply | : | Batteries |
| Memory system | ; | Required |
| Accessories | : | Contact adapters (small & large) |
| | : | Master wheel (with rubber tips) |
| | : | Carrying case |
| Quantity | : | 1 nos. |

- Potentiometer / rheostat

| | | |
|---|---|---|
| Range | : | 1 ohm to 100 M ohm |
| Low step | : | 1 ohm |
| High step | : | 10M ohm |
| Power rating | : | 1 watt |
| Maximum operating | : | 100 VDC |
| Voltage | | |

- Wet and dry bulb hygrometer

| | | |
|---|---|---|
| Range | : | Relative humidity 10~95%, Temperature 10-110°F |
| Accuracy | : | ±0.3°F |

The hygrometer shall be powered for convenience such that twirling and bulb wetting for measurements are carried out automatically

- Sound level meter

  Sound Level Meter – Specification (EXTECH Instruments or Superior)
  Applicable Standard IEC 651 & 804 Type 2, ANSI S 1.4 Type 2
  Accuracy: +/- 1.5dB (ref 94 dB @ 1 kHz)
  Resolution: +/- 0.1dB
  Digital Display: 4 Digital LCD
  Measurement Parameters : SPL, Leq, SEL, MaxL, MinL.
  Measurement Range : 30dB to 130dB
  Measurement Frequency Range : 31.5Hz to 8kHz
  Frequency Weighting : A and C
  Response Impulse: Fast and Slow
  Microphone : ½" Electret Condenser Microphone
  Bar graph: 4dB steps, 100dB range, 100mS update
  Analog AC/DC output : 2Vrms 9at full scale), 10mVDC/dB
  Power Supply : Alkaline batteries with Optional AC adaptor
  Accessories: All to be included
  Optional items: To be listed

  The sound level meters shall check the sound levels of targeted areas and find suspected locations. Instruments shall be capable of surveying noisy industrial areas for excessive dB exposure. Instrument should have in built data logger to enable unattended recording for minimum of 30 hours. Facility shall be available for taking average and peak durations.

- Standard tool box

  4 nos. standard tool box have following tools as a minimum and they shall be provided with insulated handles and good grip to prevent phase over, shocks and burns.

  - 8" pipe wrench
  - 6" Nose plier
  - Set of 'D' spanners
  - Set of 'Ring' spanners
  - Set of Allen key mm and inches
  - Hacksaw with frame
  - Round file
  - 9" combination pliers
  - Needle house pliers
  - Wire stripper
  - Screw drivers (2", 4½", 6")
  - magnetic screw driver set
  - Crimper
  - Nut driver
  - Hammer
  - Socket spanner set (inch and mm)
  - Cutting plier
  - Watchmaker screw driver set
  - Adjustable spanner set (6" to 12")
  - Needle file set
  - Cable stripper
  - Tweasers

- Common Tools

  The following common lab tools in adequate quantity shall be provided:

- Drill Machine (up to 13mm drill size)
- Hole saw cutter
- Hole punch
- Tap set
- Tube bender
- Tube cutter/de-burring tool
- Machine saw
- Torque wrench
- Circlip pliers
- Table vice
- Tile puller for false floor
- Antistatic and normal vacuum cleaner
- Hot air gun
- Air blower
- Tube ferrule marker with sufficient quantity of cartridges and tubes
- Tape sticker making machine with sufficient quantity of cartridges and tapes

- Test Instruments

  The following common lab tools in adequate quantity shall be provided:
  - Drill Machine (up to 13mm drill size)
  - Decade resistance box (2 nos.)
  - Digital Verniercalipers (2 Nos of different ranges)
  - Pitch gauges for inches and mm
  - Digital screw gauge
  - Portable digital thermometer, Non-contact type temp measuring instrument, barometric pressure measurement instrument
  - Glass thermometers
  - PC with laser printer for lab with required calibration software with necessary interface with all test instrument/calibrators
  - HART Communicators 475 or latest (3 Nos.)
  - Digital multichannel recorder filler gauge
  - One panel mounted pressure calibrator and one multifunction calibrator to kept as standard instrument in lab

- Digital stop clock

| | | |
|---|---|---|
| Type | : | Mechanical |
| Resolution | : | 1/5 of second |
| Reset facility | : | required |
| Recording period | : | 0-30 minutes with a 60 second sweep |

- DC regulated power supply

  Bidder shall supply D.C. Regulated power supply designed with latest state of the art electronics and IC technology. It shall have the following minimum features.

| | | |
|---|---|---|
| Voltage Range | : | 0 to +60V DC, 1 Amps (Floating) & (Continuously adjustable) |
| Current Range | : | 0 to 60V / 0 – 1.2A |
| Display | : | LCD |
| Power Supply Connection | : | 230V AC, 50 Hz |

| | | |
|---|---|---|
| Meter Accuracy | : | +/- 2% FSD |
| Output Impedance | : | 50m Ohm or less |
| Load Regulation | : | 0.1% Variation in Voltage<br>0.2% Variation in Current |
| Drift in 8 hours | : | 0.1% Variation in Voltage<br>0.2% Variation in Current |
| Ripple and Noise | : | Less than 1 mV |
| Setting resolution | : | 20mV / 20mA |
| Temperature co-efficient | : | 0.05% per Deg C |
| Accessories | : | Test cords and clips as required |

- Adjustable AC power supply.
- Portable gas leak detector
- Tong Tester

Electronics type Tong Tester of the following specification shall be supplied. Tong Tester shall be suitable for measuring the current ranges of 0-5/ 10-15/30 Amps AC and DC. It shall have swivelling joint between tongs and meter to facilitate easy reading.

4.14.30 **Cables And Extension Cables**

All instrumentation cables shall be stranded tinned copper conductor, PVC insulated, shielded with Mylar aluminium tape with 100% coverage and 25% overlap and drain wire shall be in continuous contact with the aluminium side of the shield. All the cables shall have distinct extruded PVC inner sheath and FRLS PVC outer sheath and with GI wire armour. Cables shall be 1100V grading & 85 °C continuous rating. All cables shall be twisted with minimum 10 twists per meter. All cores shall be identified with core identifier (each core to be numbered for easy identification) printed on Al shield. Conductor size of signal cable shall be 1.0 $mm^2$& control cables shall be 1.5 $mm^2$ as minimum.

Analogue cables shall be individually and overall shielded. Digital and power cables shall be overall shielded. No shielding is required for core cable.

All thermocouple cable shall be extension type and shall be suitable for respective thermocouple. All RTD cable shall be triad type.

| | | |
|---|---|---|
| Signal cable | : | 1100V, 1.0 Sq.mm for single pair, screened<br>1100V, 1.0Sq mm for multipair, individual pair and overall Shielded. |
| Control Cable | : | 1100V Screened with overall screen<br>1100V 1.5 Sq mm for 2 Cores<br>1100V 1.5 Sq mm for multi core |
| Power cable | : | 2.5 Sq.mm for 2/3 Cores |

Wiring within desks and panels shall be supported on trays and shall be segregated according to voltage level. Wire carrying AC and DC voltage shall also be segregated.

All desks, panels, cubicles and racks shall be factory-wired. Where desks or panels shall be supplied in more than one section, electrical connections between the sections shall be via terminal strips provided for this purpose.

Spare cores shall be terminated at terminal strips and shall be ferruled in such a way as to indicate that they are spare cores.

After commissioning 20% of the conductors of multi core cables shall be available as spare.

All instrument cables shall be laid on cable trays. Cable trays shall be sized to have 20% spare space as a minimum.

Fiber optic cables shall be routed in GI conduits.

All panel wiring shall have sufficient spares for future expandability.

4.14.31 **Pressure Reducing and Desuperheating Station (PRDS) :**

Wherever pressure reduction is required along with Desuperheater, a combined PRDS (Pressure Reducing and Desuperheating Station) shall be preferred. However PRDS design with separate pressure reduction valve shall also be acceptable provided the valve is specially designed for high differential pressure, high temperature and high pressure steam application. In case combined PRDS design is selected Bidder must ensure that PRDS body has been designed considering stresses generated because of steam quenching. This should also be ensured in case of Desuperheater design. Desuperheater design should ensure that the temperature at the outlet shall be maintained with ± 5° C of the desired outlet temperature, unless otherwise specified by the process licensor. Separate liquid injection valve and steam valves, if provided, must be installed along with block and bypass valve. The body and trim material of construction shall be suitable for the service. In general trim including spray nozzles shall be stellite. The PRDS/ DS in steam application shall be IBR certified. Hand wheel or isolation & bypass arrangements shall also be provided.

4.15.0 **POWER SUPPLY SYSTEM AND GROUNDING**

4.15.1 **Power Supply And Fusing**

| | | | |
|---|---|---|---|
| a) | Computers/monitors/O.S | : | 110 VAC UPS |
| b) | Control panels | : | 110 AC, UPS |
| c) | Package units panels | : | 110AC UPS |
| d) | PLC based systems | : | 110 AC UPS |
| e) | Solenoid valves relays) | : | 24 V DC/110VAC (Driven through interposing |
| f) | Input contact interrogation voltage / Transmitters power supply | : | 24 V DC(From DCS) |
| g) | SWAS & stack analyzers | : | 110 AC UPS |

| | | | |
|---|---|---|---|
| h) | Panel lightings | : | 110V AC/ 230V AC |
| i) | Plant DCS | : | 110AC UPS |
| j) | Printers | : | 110AC UPS |
| k) | GTG control system | : | 110AC UPS |
| l) | STG control system | : | 110AC UPS. |

The respective suppliers of the above system shall derive the other required voltage levels.

Uninterrupted power supply for the I&C equipment must be ensured by redundant systems.

Preferably all I&C equipment shall be fed from the 110 V AC, UPS.

If the Contractor wishes to use a different voltage level e.g. 24V DC, the Contractor shall justify this and shall design, supply and install all necessary equipment including DC/DC-converters or inverters, decoupling diodes, bus bars etc. for this system.

Regardless whether converters or inverters are used, the Contractor is responsible to make sure that switching from one bus bar to the other one under no circumstances affects the electronic equipment.

The main power supply fuses shall be located in functional groups within separate power distribution cabinets.

Fuse ratings and time characteristics shall be such that in all cases, a fault within an individual item or module shall cause the fuse associated with that item, to rupture and thus disconnect that item from the power supply, before the main fuse is affected.

Failure of a main fuse shall affect the overall operation of the plant as little as possible.

Failure of a main control fuse shall be indicated in the CCR by means of an alarm. This alarm shall state the identity of the failed main fuse.

Failure of an individual module or component fuse shall be indicated by a general alarm and a detailed diagnostics message.

The section of the Control Cabinet in which the fuse is located shall be indicated. It shall also be possible to locate visually the fuse that has failed.

The design of the electrical power supplies and fusing system must ensure that any faults in modules or other devices, which may block logic interlocks or control systems, are restricted to the system in which the fault has occurred.

All electronic devices shall be protected against RF /EMI (As per the IEC), transient voltage levels, which would otherwise damage the device.

Equipment in hazardous areas shall be provided with an intrinsically safe barrier or other explosion proof system, in order to ensure that the energy transmitted to the hazardous area equipment is restricted to a level insufficient to cause ignition. Such barriers however shall not interfere with the normal operation of the system.

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The supply voltages for the control cabinets must be arranged as separately fused in feeds. The individual feeders can serve either a single cabinet or several cabinets combined as a logical group.

All measuring circuits must be separately fused.

Surge arrestor shall be provided to avoid the high voltage spikes which may damage the devices.

4.15.2 **Grounding**

The proposed instrument grounding scheme to be submitted by the Bidder. There has to be separate earthing for DCS/other control systems earthing and shield earthing with the required earth resistance. Separate power / panel earthing shall also be provided by the Bidder for all the Control building / local control rooms system earthing shall be <0.5 ohms and cabinet earthing shall be <1 ohms. I&C system earth shall be isolated from the plant earth. Earthing scheme and calculations shall be submitted to the Owner/Owner's representative for review.

4.16.0 **ERECTION, FIELD TESTING AND COMMISSIONING**

4.16.1 The Bidder shall select and adopt methods and procedures for equipment erection to suit the nature of equipment and erection, involved according to the best modern industrial practice and his own experience.

4.16.2 The Bidder shall arrange for the transportation and handling of cabinets and desks from stores to work site suitably without any damage. If any damage is observed before handling, this shall be brought to the notice of the Owner/Owner's representative.

4.16.3 Before installation of cabinets and desks, the necessary openings and inserts required to be made on the floor by the Bidder shall be checked and then after proper alignment, the cabinets and desks shall be installed on the floor by the Bidder. All necessary civil work to be carried out for this shall be in Bidder's scope of supply. The cabinets and desks shall be cleaned by blowing air to remove dust or foreign particles.

4.16.4 All cables shall be tested for insulation level. Cable ends shall be properly cleaned. The entry to and exit from pipes shall be smooth and free from burr where cables are run through pipes. Cable shall be pulled into the pipes in such a way that there shall be no damage to the cables. Flexible conduits shall be provided wherever necessary. Cable in hot areas shall have proper heat protection. A minimum distance of 300 mm shall be kept between instrument / signal cables and power cables. Each tray shall be filled with a maximum of two layers for instrument and control cables and one layer for power cables providing 20% spare space in the number of layers specified. Instrument Cable Trays, shall be erected vertically as far as possible to avoid dust accumulation. All the cables laid shall be tied individually to the Tray. Thermocouple cables shall be run completely independent of all other cables with minimum separation as per relevant standard and with cross over at right angles. The cabling accessories shall include terminal blocks, splicing materials, crimping tools, cable support grips, insulating tapes, GI flexible conduits, conduit fittings, GI perforated covered trays, supports, accessories, and cadmium plated trays & cable glands.

4.16.5 The Bidder shall get prior approval as per approved quality assurance plan of the Owner/Owner's representative before any installation work starts. If any work is carried out by the Bidder before prior approval from Owner/Owner's representative and modification is sought by Owner/Owner's representative later, then the work shall be redone by Bidder without any cost / material implications to the Owner/Owner's representative. Impulse / sample piping, air supply and pneumatic tubing, cable trays and equipment shall be supported rigid enough to prevent vibration and anchored sufficiently to prevent strains on equipment installed. Supporting clamps shall be provided at least at every one meter distance for better rigidity. Impulse / sampling piping shall be

provided with adequate slope, (preferably 1:10). Hanger and supports shall be so installed as not to interfere with free expansion and contraction of the piping and tubing between anchors. Suitable vibration dampeners, etc., shall be provided wherever necessary. In addition, care shall be taken that the arrangement of impulse / sampling piping, air supply and pneumatic tubing from detrimental sagging, mechanical injury, abuse due to unusual service conditions from sources other than those due to pressure, temperature and vibrations. All impulse lines of joints shall be welded type unless otherwise specified.

4.16.6 The Bidder shall set up his own instrument laboratory. The calibration equipment shall cover complete range and shall have the desired accuracy of less than 0.1% or better. The Bidder shall follow the standard procedures for calibration of various instruments and as set by the manufacturer of instruments and as instructed by the Owner/Owner's representative, including any requirements of field calibration. First, the calibrations shall be carried out independently by the Bidder and later in the presence of Owner/Owner's representative who shall certify the same. Proper documentation in this regard shall be maintained and handed over to the Owner/Owner's representative.

4.16.7 All the instruments shall be calibrated for the entire range of the instrument for which it is designed. Calibration shall include test for repeatability. After first commissioning, the instruments shall be tested for calibration again to check whether the instrument maintains its zero and maximum of the range. All instruments and control equipment shall be calibrated to read correctly to the satisfaction of Owner/Owner's representative. All switches shall be tested for the actuation of both normally open and normally closed contacts at the desired set points and also for the fixed / differential settings. All the float / displacer operated level switches shall be tested for the movement of the float and linkages to make to break the switch contacts by filling up with water before installation. For such tests, necessary testing set up required shall be arranged by the Bidder. Air leak tests shall be performed on all flue gas impulse / sample lines, air supply and pneumatic lines. Necessary equipment such as portable compressor, connecting pipes, materials, cables and test gauges shall be provided by the Bidder. All the welding shall be carried out as per the relevant codes with electrodes approved by the Engineer-in-Charge. Only qualified welders approved by the Engineer-in-charge shall carry out the welding. IBR grade of welder shall be required wherever IBR grade welding is involved. After IBR welding, radiography as per the required standard to be done by qualified welder. All threaded joints shall be jointed using teflon tapes and no other pipe jointing compound shall be used except on higher temperature services where graphite sealing compounds shall be used. Brand of Teflon tape, insulation tape, graphite compound is to be approved by the engineer in charge. Tubing shall be bent with correct size tubing bender whenever possible to avoid the use of fittings. Tubing cutter shall always be used to cut tubing. The use of short length of tubing in long runs shall be avoided. All tubing shall be run in such a manner as to give the maximum protection against mechanical damage. Tubing runs shall be grouped together where possible. Tubing shall be arranged so that couplings can be tightened without disturbing lines. Pipes or tubes installed but not connected, shall have the ends closed in an approved fashion to prevent the entry of foreign material such as caps or plugs. All cables finally entering JBs / cabinets shall run through flexible PVC conduits for approximately 500mm. Field mounted instruments shall be mounted on brackets, subpanels, or placed on a suitable pedestal. They shall be easily accessible from grade, ladder or platform. All local indicators shall be readable from grade or operating level, and if used for manual control, shall be visible from the related valve. Wherever possible, local mounted instruments shall be mounted at approximately 1.35 meters (4' 6") above the platform or floor in an accessible position. When an instrument is located at a distance of 2.5 meters or more from its pressure connection, an additional block valve and a vent valve shall be provided adjacent to the instrument. Vent valves shall be arranged, if necessary, with drain lines to ensure that operation of these valves does not create a hazard. If the pressure piping is of such length that the isolating valve is inaccessible from the instrument location, a suitable valve shall also be fitted at the instrument itself. All pressure instruments shall be installed vertically. Those for steam must be tapped directly from above, for pressure transmitters and switches, there shall also be a condensing leg. The same applies to gas and vacuum measurements, but adequate provision

should be made to ensure no condensation can take place along the line, i.e. the slope shall be adequate to drain any condensate back to the main lines (sloping upwards from the sensing point). Tapping points for liquids shall made at an angle of 45° from the bottom of the main pipe and these are to be sloped downwards from the sensing point. An exception is made in the case of the tapping point for fuel oil or corrosive fluid in which the pressure instrument shall not have direct contact with the process fluid. Glycerine or other suitable liquid shall be used as a medium to separate the fuel oil from the pressure instrument. When the pressure impulse line is liquid filled, the measuring unit shall be compensated for static head. The head correction shall be stated on the unit.

4.16.8 For high pressure applications, impulse line shall be complete piping only. Piping material required for installation hook up shall be as per Piping Material Specifications.

4.16.9 The instrument tube fittings shall be of Swagelok or Parker make only.

4.16.10 Pipes shall be bent using pipe benders and any hot bending shall be totally rejected. Pipe shall be cut, using pipe-cutting devices. Hot cutting shall not be allowed.

4.16.11 Hydro test shall be performed for all other impulse lines / sampling lines / sensors. Necessary equipment such as hydro test pumps and temporary piping to the required point, fill pump etc., materials such as temporary gaskets, miscellaneous fasteners, etc. tools and tackles including test pressure gauges, etc. are to be provided by the Bidder. For all electrical actuators of the valves, functioning, setting and performance of limit switches / torque switches of various positions shall be checked before and after installation of the actuators. The position transmitters for inching applications shall also be calibrated. Pneumatic actuators shall be calibrated at site. PG test points shall be provided on the process line at various locations by the Bidder.

4.16.12 **Loop Testing**

The action of the controller is set as prescribed. Controller settings for various modes of operation (Proportional band, reset and rate action) are at nominal value. For current signals, 4 – 20 mA shall be injected and checked the loop for 0%, 25%, 50%, 75% and 100% of full-scale inputs. For temperature loops with thermocouples, a known milli volt signal shall be injected and the output display shall be checked for input signals of 0%, 25%, 50%, 75% and 100%. For temperature loops with RTDs, a known resistance shall be injected in the control cable through decade resistance box and Output display shall be checked for 0%, 25%, 50%, 75% and 100%. For field mounted switches for alarms / interlocks, the action shall be simulated by disconnecting the wires / shorting the terminals and the function of the associated system shall be checked. Any equipment required by the Bidder for testing, calibration and commissioning shall be brought by the Bidder at site. The list of such equipment shall be furnished along with the offer

Prior to taking the instruments in service, all impulse lines, sampling lines and air supply lines shall be blown as required with the establishment of adequate line pressure and temperature conditions to keep the lines thoroughly clean. On-line i.e., without removing control valves from the pipe, calibration of the positioners and stroking of control valves / control dampers shall be carried out as required during control system tuning. Pre-commissioning checks, individuals loop checks, power initialisation, verification of system functioning, troubleshooting final solutions to application and / or instrument problems, etc., is Bidder's responsibility. All the required software and hardware changes shall be incorporated as required for successful commissioning to Owner/Owner's representative's satisfaction. Any other tests as may be directed by the Owner/Owner's representative. After delivery of the equipment, the Bidder shall locate all the equipment including electronic cards in its final position, check all the power wiring, grounding and interconnection cables, all in accordance with manufacturer's recommendations. The Bidder shall perform initialisation of system power, field loading of system configuration / software and data base, demonstration of system functionality to verify conformance with manufacturer's instructions and

specifications, tuning of control loops, implementation of any configuration changes including hardware, software and additional tapping's / instruments, cabinets as required and providing general trouble shooting and final solutions to application and / or instrument problems.

The Bidder shall take care to complete all pre-commissioning activities and simulation tests after erection to suit the overallstart-up of respective plant equipment. The controllers shall be tuned as per the process requirement. The list of set points, alarms / Interlocks, settings for the controllers shall be furnished in the standard format and handed over to the Owner/Owner's representative. Control loops shall be put in auto mode as per the operational requirement of different phases. Processor, Bus Worst loading conditions calculation and other control system performance requirements shall be proved at the time of commissioning. Before taking over of the plant by the Owner/Owner's representative,all the system and auto control loops shall run satisfactorily for at least one month at varying loads without disturbing any adjustment. During this period, supervision and maintenance of the system shall be the scope and responsibility of the Bidder. The performance test shall be carried out for the system offered and certificates to these effects shall be approved by the Owner/Owner's representative.

4.17.0 **INSPECTION, TESTING, GUARANTEE & SPECIAL TOOLS / TACKLES**

4.17.1 After manufacturing all I&C equipment / instruments shall be factory tested and calibrated. All the required test certificates, calibration certificates for I& C equipments / instruments to be submitted to the Owner/Owner's representativefor approval before the dispatch of the same is allowed from the factory. As a minimum hydro-test, accuracy & repeatability test, over-range test, leak test, HV test, insulation test, functional tests, temperature rise test shall be conducted as applicable for the instruments and the control system. The electronic equipments shall be subjected to burn in test and tests as per IEC 68. The detailsof the test to be carried out for the I& C equipment shall be submitted for the Owner/Owner's representative's consent/approval before proceeding with the test. Bidder shall submit a detailed quality assurance program for individual I & C equipment / instruments for Owner/Owner's representative's approval.

4.17.2 Tests for DCS / GTG control / STG control / PLC system/analysers and other C&I systems shall include the following:

Factory Acceptance Test (FAT):

To be carried out at BIDDER's/Sub-Vendor's works and witnessed by Owner/Owner's representative, successful completion of which shall be the basis for 'Authorization for Shipment to Site'. FAT shall be a complete integrated test of the system and carried out at BIDDER's / Sub-Vendor's works on completion of manufacturing of the system. The test shall be performed with the completely assembled system and performing all the functions, it is expected to perform while in actual service. The BIDDER shall submit a detailed "Factory Acceptance Test Procedure" in line with the above specified guidelines for Owner/Owner's representative's approval. The FAT shall be conducted as an integrated test of plant I&C system integrating the control system supplied by Other Vendors.

FAT shall be preceded by a 'Pre- FAT Inspection/ Test' to be carried out by Bidder/Vendor. Pre-FAT inspection / test shall be carried out as per approved FAT procedure detailed above and shall submit 'Pre- FAT Inspection/ Test' report for Owner/Owner's representative's review and approval. Owner/Owner's representative shall witness the actual FAT on the basis of successful completion of 'Pre- FAT Inspection/ Test'.

**Site Acceptance Test (SAT):**

Involves tests for site commissioning, calibration of monitoring and control equipment, Integrated loop test wiring, Trial Operation of the system functioning. Site guarantee tests for system

performance & availability to be conducted in the presence of Owner/Owner's representative. The reliability run shall be conducted for one month period. During the reliability run if the I&C system fails to meet the specific requirements, then the Bidder shall take immediate remedial actions and the procedure shall be restarted again for the reliability run. After the competition of the reliability run with full satisfaction of the Owner/Owner's representative, the system shall be deemed for take over and this shall mark the commencement of warranty period.

4.17.3 Special tools and equipment for the maintenance, inspection and repair of the individual main equipment and auxiliary equipment shall be supplied by the Contractors in sufficient quantity to equip the shift personnel, maintenance personnel and workshop craftsman. All necessary special tools in adequate quantity to access/modify/configure logic in control system or field instruments, considering population of equipment and future maintenance requirements shall be provided.

The special tools and equipment for maintenance and repair shall be delivered by the contractor in lockable steel boxes and they shall be marked in an approved manner for identification purposes and a corresponding tool chart shall be supplied with the steel boxes

The I&C systems offered by the Bidder shall be provided with guarantee period which shall start from the date of handing over to the Owner/Owner's representative and Bidder to indicate the same in his offer.

4.18.0 **TRAINING**

DCS/PLC/GT control system/STG control system/stack analysers and other C&I control systems and equipment:

Requirement of training for operators/maintenance Personnel/engineers for the above systems shall be given by contractor as per client's requirement.

Unless specified otherwise the following shall be provided by contractor for system training for Owner/Owner's representative. Contractor shall arrange training for Owner/Owner's representative's personnel. Different type of courses shall be offered for operation/ process engineers and operators, instrument maintenance engineers and technician. Contractor shall indicate a detailed proposal for training in the offer. Travel and living expenses of the Owner/Owner's representative's personnel shall be borne by the Owner/Owner's representative. Contractor shall also offer operation training basically meant for operating personnel. The various facilities available in the system for operation, actions required during emergencies and identifying the various diagnostic messages shall be main contents of operation training.

- Hardware and Software maintenance training - At system vendor's works.
- Operation Training - At system vendor's works
- Site Training - Operation and maintenance

The Bidder shall include in his scope of work for training of Owner/Owner's representative . CONTRACTOR shall provide comprehensive training program at vendor's workshop as well as at client's site. Minimum No. of persons and duration shall be as given below for the training.

| Sr. No. | Subject | Duration | No. of participants | Type of Training |
|---|---|---|---|---|
| **A** | **Suppliers workplace Training:** | | | |
| 1 | Control System (Engineers) | 5 Days each batches | 10 (in two batches) | Workshop+ Class room |
| B. | **On Site Training** | | | |
| 1 | Field Instruments | 2 days | 5 | Hands- on+ class room |
| 2 | Lab Instruments- Operating and Calibration procedures | 1 days | 5 | Hands- on+ class room |
| 3 | Opacity Analyser | ½ day | 4 | Hands- on+ class room |
| 4 | Control System (Operators and Engineers) | 3 days for each batch | 10 (in two batches) | Hands- on+ class room |
| 5 | SWAS System | 1 Day | 5 | Hands- on+ class room |
| 6 | Gas analyser | 2 day | 5 | Hands- on+ class room |
| 7 | GTG | 1 day | 5 | Hands- on+ class room |
| 8 | STG | 1 day | 5 | Hands- on+ class room |
| 9 | HRSG and BOP | 1 day | 5 | Hands- on+ class room |
| 10 | Governor(STG+GTG) | 1 day | 4 | Hands- on+ class room |
| 11 | Air Conditioner | 1 day | 4 | Hands- on+ class room |
| 12 | Fire Alarm system | 1 day | 4 | Hands- on+ class room |

# VOLUME - III

# SECTION - 5.0

# DETAILED TECHNICAL SPECIFICATION

# CIVIL, STRUCTURAL AND ARCHITECTURAL WORKS

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## SECTION - 5.0

## CIVIL, STRUCTURAL AND ARCHITECTURAL WORKS

### 5.1.0 GENERAL

This specification covers the design, detailing, supply, construction / erection, testing and commissioning of all Civil, Structural and Architectural Works for the Power Plant.

If any provision of this specification departs from the Bidder's standard design and construction practice sufficiently to materially increase the cost of construction without in his opinion providing corresponding increase in quality/reliability or if he considers that his usual design and construction would provide better quality/reliability, he shall offer the particular work/system based on his standard design and construction method. The proposed deviations from this tender shall be specifically highlighted in a standard format for technical deviations & only agreed deviations will be a part of the contract. Deviations mentioned elsewhere in the offer will not be accepted. In case such offer with deviations is made, the Bidder shall state very clearly the merit of his offer and the demerits (in his opinion) the specified design has. However, the Contractor shall stick to the same design and construction philosophy that he has offered, if accepted by the Owner/Owner's representative and shall not make any changes during execution.

The design and construction specifications included in this section are intended to cover the general design and construction quality requirements. It is not intended to cover the minute details. The Standard Technical Specifications for Construction included under Clause 5.5.0, cover the quality and workmanship requirements for the various materials and types of work. The specific material and type of work to be adopted for this project are specified in Clause 5.4.0 hereunder. In case the same is not specified, the Contractor shall indicate in his offer, the material and specification he proposes to adopt for such works and get the same approved. In case construction requirements for any item specified in Design Specifications are not covered in the Construction Specifications, the manufacturer's specification / recommendations, other International Standards or good Owner/Owner's representative's practice (but not contradictory or inferior to Indian Standards), as approved by Owner/Owner's representative, shall be followed. In case of any contradiction between the provisions of Clause 5.5.0 and Clause 5.4.0, the more stringent of the two shall govern. In all cases, the decision of the Owner/Owner's representative shall be final & binding.

Any reference to unit rates, Schedule of Item, Bill of Quantities, etc. if found, in the Standard Technical Specification under Clause 5.5.0 shall be considered as not applicable, as this is an EPC tender on lump sum basis. Units of linear dimensions, sizes etc. referred in this specification shall be in millimeters (mm) unless otherwise specified.

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## 5.2.0 SCOPE OF WORK

### 5.2.1 General

This section sets out the scope of necessary surveys and investigations, design, supply, construction, installation, testing and commissioning of Civil, Structural and Architectural works, without excluding necessary components and services not mentioned.

The scope shall include the demolition and removal of existing underground structures or any obstructions which are necessary for the execution of work.

The scope shall include other related works although they may not be specifically mentioned in the subsequent clauses and all such incidental items not mentioned, but are necessary for completion of the work as a whole. The Contractor shall supply all materials including cement, reinforcement steel and Structural steel. Each consignment of materials shall be tested at Government approved laboratory. All costs, royalties, taxes & duties, octroi, transportation etc. towards building materials shall be paid by the Contractor. Since this is an EPC contract, no work or supply shall be done by other agencies including the Owner/Owner's representative.

The scope also includes supply of all labour, technical personnel, materials and equipment for execution of work and getting all materials tested at site laboratory or approved laboratory outside, submitting test reports, arranging supervision of manufacturer for specialized items. After award of work the Contractor shall submit for Owner/Owner's representative's approval a detailed quality assurance programme for all the materials and types of works.

The intending Bidders are advised to visit the site to have a firsthand information about the site conditions such as access to site, access for construction and erection, clearance available, availability of material (e.g. aggregate, sand, bricks etc.) and all other relevant details before submission of tender. Non familiarity with the site conditions will not be considered a reason either for extra claims or for not carrying out work in strict conformity with time schedule, drawing and specifications.

### 5.2.2 Buildings, Structures and Facilities covered in the scope

- Chain link fencing around transformer yards including Gate
- Earthwork and filling in proposed power plant area as per grading drawing.
- Micro Site Grading and levelling
- BM main approach road from the existing road to the proposed plant area.
- Plant Internal BM roads and paved areas
- RCC Storm Water Drainage System on both sides of road along with pre- cast RCC covers and interconnection of drains to existing system wherever applicable.
- Gas Turbine and Generator / STG Building shed
- Gas Turbine Foundations
- Gas Turbine Area Equipment Foundations
- HRSG Foundations
- Steel Chimney and foundation.
- Steam Turbine Foundations
- Switchgear and Control Buildings
- Transformer Foundations
- Gas Insulated Switchyard Structure and Foundations, cable trenches, roads, gravel filling etc
- Fuel Gas Conditioning Station
- Blackstart cum Emergency DG Set Building
- CW Pump Shed and forebay

- Mechanical Induced draft Cooling Towers
- Civil works related to Water Pipeline and Effluent disposal line
- Compressor house
- Service Water and Potable Water overhead tank
- Neutralization pit
- Chemical Laboratory
- Chemical House.
- HRSG Blowdown sump
- Pipe and Cable Racks
- Pipe and Cable Trenches
- Air washer room
- Sewage Disposal System
- Guard pond and with associated pumps and piping structures up to existing pit
- Lighting towers minimum 4 nos. of suitable height.
- Green belt area as per Statutory norms
- Any other buildings / structures required from system considerations.
- Watch towers with security lights
- Floor drains and sump with associated pumps.
- Temporary barricades/structures to protect the existing plant

Scope of work shall cover, but not limited to the following major items.

**5.2.3 Survey and Investigation**

Topographical survey & Geo-technical Report on the investigations carried out by Owner/Owner's representative shall be made available to intending Bidders for information with no liability on the accuracy of the information furnished in the reports. Additional investigation shall be carried out to substantiate the results of the investigation already carried out or to obtain specific soil properties not covered in the specification or soil report shall be carried out by Contractor during detailed engineering stage at no extra cost to Owner/Owner's representative. Contractor will be required to carry out investigation as per the decision of the Owner/Owner's representative, without any price implication. Such report/Investigation carried out by the Contractor shall be submitted to the Owner/Owner's representative for approval before proceeding with further engineering.

Plant grading, levelling, tree cutting, thorny jungle clearance as required. The grade level shall be maintained considering the elevation of the existing Plant level.

The surplus earth material after excavation shall be disposed in a lead of 5.00 KM radius without any extra cost.

- Fencing shall be provided to all areas where there is risk to human life or entry restriction is essential for safety purpose.

Chain link fencing at critical area as identified in the plot plan and as specified in specification.

**5.2.4 Design and Engineering**

- Preparation and submission of design calculations and construction drawings and getting the same approved by the Owner/Owner's representative.

  a) Design criteria for Civil, Structural and Architectural works.

  b) Design Calculations for road and drains

c) Structural calculations including analysis for structures and foundations.

d) Hydraulic calculations for drains.

e) Static and Dynamic analysis for machine foundations

f) Calculations for piles

g) General Arrangement and Reinforcement drawings for concrete works

h) Architectural and joinery details for buildings

i) Layout and details for outdoor facilities - Roads, Paving, drainage, sewerage, cable / pipe trenches, duct banks etc.

j) General Arrangement and fabrication drawings for steel structures

k) Architectural floor plans including conceptual interior/ equipment and furniture arrangement, elevations, cross sections and perspective view in colour of all buildings (i.e.) for GT/ST common control room etc., including provision of natural light for GT / ST buildings. Bidder shall submit two different schemes along with a report elaborating the underlying philosophy of the proposed architectural concepts.

- Preparation and submission of design and drawings for statutory approvals from local Municipal / Panchayat authorities, Factory Inspector, Civil Aviation Authorities and other authorities, as applicable.

Obtaining necessary details, permission and approvals from statutory authorities for carrying out the work. Owner/Owner's representative will issue necessary authorization letter and extend necessary help for the above to the extent possible.

**5.2.5 Construction**

- Construction of, Fences and Gates

The demolition and removal of existing (above ground / underground) structures or any obstructions which are necessary for the construction/execution of work.

- Tree cutting, thorny jungle clearance as required to the site, Earthwork in filling and site grading of the Power plant area to the finished ground level shall be as per drg no **10-5111168-C-002** (Rev **B**) – **Site grading plan** (Ref **Volume IV** & **Section No. 06** of **Technical specification**).

- Construction of temporary buildings and structures for Contractor's use, such as Site Office, Cement Godowns, and Storage yards, Canteen, Construction Material Testing Laboratory and other facilities as required.

- Construction of roads, peripheral walkways, drainage, sewerage, culverts, duct banks etc. within the Power Plant. Interconnection of above systems to existing systems wherever applicable.

- Earthwork in excavation including rock quarrying/blasting if required, identifying borrow pits, transportation of soil from borrow pits, backfilling, disposal of excavated soil to designated areas within and outside the plant boundary etc. Archeological findings, if any, shall be reported to the Owner/Owner's representative.

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- Installation of trial piles, test piles and permanent working piles if required as per Geo-technical Report and its recommendations / interpretations.
- Pre-constructional Anti-termite treatment as specified.
- Civil, Structural and Architectural and finishing works for all buildings and structures.
- Sanitary and plumbing works for all buildings.
- Construction of all foundations and structures in RCC and steel work for all the buildings and facilities of the Power Plant.
- Construction of all equipment and machine foundations
- Construction of Steel chimney
- All other works required for completion of the project in all respects.

### 5.3.0 Design Criteria for Civil, Structural and Architectural Works

This subsection covers the general design requirements related to Civil, Structural and Architectural works

### 5.3.1 Design Criteria - Codes and Standards

The following Indian Codes and Standards shall be generally used for design of civil and structural works. In all cases, the latest revisions with amendments, if any, shall be followed. For work not covered by Indian Standards, other International Standards, as applicable shall be followed. In case where either Indian or International standards, are not available, good engineering practice, as approved by the Owner/Owner's representative shall be followed.

Reference of only some of the codes in this document and various clauses of design criteria shall not limit or restrict the scope or applicability of other relevant codes. It shall be ensured that all other codes relevant to a specific job, in addition to those already mentioned, are followed wherever applicable.

In case of any deviation / conflict between provisions of IS codes and the design criteria, the provisions that are more stringent shall be followed unless specifically directed otherwise.

The Codes and Standards listed below are applicable for the design of structures and buildings in general. Codes and Standards applicable for specific design and construction are listed elsewhere in respective sections.

**General**

IS: 875 Code of practice for design loads (other than earthquake) for buildings and structures.

IS: 1893 Criteria for earthquake resistant design of structures.

IS: 4326 Earthquake design and construction of buildings - Code of Practice.

**Foundations**

IS: 1080 Code of practice for design and construction of shallow foundations in soils (other than raft, ring and shell).

IS: 1904 Code of practice for structural safety of building foundations.

IS: 2950 Code of practice for design and construction of raft foundations.

IS: 2974 Code of practice for design and construction of machine foundations.

IS: 6403 Code of Practice for determination of bearing capacity of shallow foundations.

IS: 8009 Code of Practice for foundation settlement calculations.

IS: 13301 Guidelines for vibration isolation for machine foundations

**Concrete Structures**

IS: 456 Code of practice for plain and Reinforced concrete.

IS: 3370 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: 4326 | Code of Practice for earthquake resistant design and construction of buildings |
| IS: 5525 | Recommendation for detailing of reinforced concrete works |
| IS: 6313 | Code of practice for anti-termite measures in buildings |
| IS: 13920 | Ductile detailing of Reinforced Concrete Structures subjected to Seismic forces. |

**Steel Structures**

| | |
|---|---|
| IS: 800 | Code of practice for use of structural steel in general building construction. |
| IS: 802 | Code of Practice for use of Structural Steel in over Head Transmission Line Towers. |
| IS: 806 | Code of practice for use of steel tubes in general building construction. |
| IS:808 | Dimensions for hot rolled steel beam, column channel and angle section |
| IS:813 | Scheme of symbols for welding |
| IS:816 | Code of Practice for use of metal arc welding for general construction in mild steel |

**Miscellaneous**

| | |
|---|---|
| IS:1172 | Code of basic requirements for water supply, drainage and sanitation |
| IS:1742 | Code of Practice for building drainage |
| IS:1905 | Code of Practice for structural use of un-reinforced masonry |
| IS:2470 | Code of Practice for installation of septic tanks |
| IS:3067 | Code of Practice for general design details and preparatory works for damp proofing and water proofing of buildings |
| SP:6 | Handbook for structural engineers (all parts) |
| SP:7 | National Building Code of India |
| SP:16 | Design Aids for reinforced concrete to IS:456 |
| SP:20 | Handbook on masonry design and construction |
| SP:22 | Explanatory handbook on codes for earthquake engineering |
| SP:24 | Explanatory handbook on Indian Standard Code of Practice for plain and reinforced concrete |
| SP:25 | Handbook on causes and prevention of cracks in buildings |
| SP:32 | Handbook on functional requirements of industrial buildings |

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SP:34 Handbook of concrete reinforcement & detailing (SCIP)

IRC:37 Guidelines for design of flexible pavements

IRC:58 Guidelines for the design of rigid pavements for highways

IRC:73 Geometric design of roads

### 5.3.2 Design Criteria – Architectural and Finishing Works

**Architectural Design**

Architectural design of the buildings shall be in conformity with the following:

- Architectural design basis.
- National Building Code of India
- Local Municipal or other authority by-laws.
- Relevant state Government Factory Acts.
- Tariff Advisory Committee (TAC) recommendations
- Any other relevant information included elsewhere in this tender.

**Space Requirement**

Space requirement shall be based on one or combination of the following depending upon the specific situation.

a. Occupancy

b. Equipment layout

c. Storage / operational requirement

**Layout**

Layout and detailing shall be developed in compliance with the relevant statutory regulations and good industry practices.

**Design Consideration**

Architectural design shall be developed within the frame work of space availability and layout taking into account of load conditions as well as local Architectural practices.

Architectural design of all buildings shall fully meet the functional requirement. Buildings shall be adequately sized and provided with sufficient passageways and access, ventilation and natural lighting for carrying out the desired activity and operations smoothly. An overall architectural control and harmony shall be maintained among all the buildings of the project. All plant and non-plant buildings shall have minimum two accesses.

**Circulation**

All buildings and open plant areas must be approachable by roads / paved pathways of required widths to suit the openings / approach to the buildings and shall lead up to entry points. Necessary car parking space shall be provided near the buildings. All internal corridors / passage inside the building shall have a clear width of minimum 1800 mm unless otherwise specified. All firefighting equipment etc. shall be provided in suitable niche as per requirements.

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**Ventilation**

Provision for natural ventilation and lighting as also for mechanical ventilation, pressurization, air conditioning shall be provided taking into consideration the local conditions, the activity and equipment in the building, statutory requirements and specific requirement, if any. Generally openable windows of area not less than 20% of the floor area shall be provided for natural ventilation. All outside doors, windows shall be adequately protected by sunshade (min.750 mm projection sunshades shall be provided with drip mould). The area of ventilation shall not be less than as specified / statutory requirement. Exhaust fan shall be provided in Toilet & battery room areas. 50 mm thick R.C.C. jali / ventilators / louvers shall be provided in cellar areas for ventilation.

**Acoustic Treatment**

Suitable acoustic treatment shall be incorporated in the architectural design to ensure that the noise generated shall satisfy the ambient noise level standard prescribed by the Pollution Control Board.

**Architectural Requirements**

**Toilets**

Toilets shall be provided near work areas, but isolated from main areas. Unless otherwise shown in drawings or specified, the dimension of the toilet blocks shall be decided by the number of sanitary fixtures, which shall be based on number of users in accordance with IS: 1172. Provisions of Factories Act / Local regulations with respect number of toilets and separate toilets for Ladies shall be complied with.

Toilets shall be provided with all necessary approved Indian Standard fittings. The floor of toilet shall have a drop of 15 mm from general floor level and shall have sufficient slope towards drain trap. Sufficient natural light and ventilation shall be provided as per requirement. Unless specified each toilet shall be provided with minimum one W.C. (water closet), one urinal, one washbasin, towel rail, mirror and liquid soap container, glass shelves etc. Western/Indian style water closets shall be provided as specified / directed by the Owner/Owner's representative. Urinals shall be without photovoltaic control flushing system.

**Ramps**

Ramps shall be provided for equipment entry. Slope shall not be steeper than 1:7, unless otherwise specified.

**Stairways**

All buildings must have access to roof by means of stairs / cage ladder. Access to roof shall be through stairways for multistoreyed buildings and for single storeyed buildings which require frequent access. All R.C.C. staircases shall have a minimum stair width of 1200 mm with hand railing on one or both sides as per requirements. Tread and riser shall be properly maintained to ensure comfortable climb. The nos. of stairs to be provided shall be as per statutory requirement / TAC recommendations. All approachable terraces shall be provided with 1000 high parapet wall. Non-approachable terraces or terraces where access is provided by ladders only, shall have min. 115 thick, 350 high parapet wall.

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**Layouts of plant buildings**

The layout of the buildings shall be developed considering the equipment layout, such as electrical panels, mechanical equipment etc. with due consideration for working space, maintenance space requirement, statutory clearances, etc. All buildings shall be protected with 1000 wide plinth protection all around the building.

The height of the buildings shall be provided as per the statutory requirements and equipment / crane / mono-rail requirement.

The location, numbers, dimensions and types of access doors, windows / rolling shutters shall be decided based on equipment layout, ventilation, operational and maintenance requirements. Fireproof doors shall be provided at fire exits with fire rating of 2 hours. Cable galleries shall be provided with fireproof wall rated for 2 hours.

Generally the building floors shall be 500 mm above the finished ground level of the respective areas.

**Masonry walls**

The external brick wall for the buildings shall be 230 mm thick and internal walls 230/115 mm thick as per requirement. The requirement of fire barrier wall between transformers shall be as per Electricity Rules and TAC recommendations but shall not be less than 350 mm thick. In case wall heights are more than 5 metres, RCC walls shall be provided and minimum thickness of the same shall be 230 mm. Internal plastering shall be 12 mm thick in mortar 1:3 and external plastering shall be 20 mm (in two layers) in cement mortar 1:3 for 230mm thick brick wall. 115mm thick brick wall will be plastered with 12mm thick cement mortar 1:3. Half brick internal walls shall be provided with 2 nos. of 6 mm dia steel bars reinforcement at every fourth layers. Damp proof coarse 40 mm thick in PCC 1:2:4 using 6 mm down stone shall be provided in the external brick walls at grade level. Ceiling plastering shall be 6mm thick with cement mortar 1:3.

**Architectural and Finish Specification**

The specification furnished below shall be applicable for architectural works as well as for finishes to concrete surfaces wherever specified.

Minimum size of single shutter door shall be 1200 mm x 2100 mm. For higher widths double shutters shall be provided. Maximum size of double shutter doors shall be restricted to 2000 mm x 2500 mm beyond which Rolling shutters shall be used.

**a. Doors, Windows, Ventilators, Louvers and Rolling Shutters**

**Steel Door**

- Double plated flush doors 45 mm thick with 18 gauge pressed steel frames conforming to IS: 4351 and 18 gauge plain steel sheets on both faces.

- Fixtures and other details as per specifications.

**Timber Door**

- Teakwood frames.

- 38 mm thick solid core teakwood flush shutters conforming to IS: 2191 with commercial quality teak ply and vision panel for flush doors.

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- 38 mm thick paneled shutters with 15 mm marine board panels (and plastic sheet on inside face for paneled doors for toilets. Minimum width of toilet doors can be 800 mm.

- Fixtures and other details as per specifications.

**Aluminum doors, partitions & windows**

- Extruded aluminum box section for frame and shutter with minimum thickness of 2.5 mm

- 4 mm thick plain glass for openable shutters

- 6 mm thick plain glass for fixed shutters.

- 6.3 mm thick laminated safety glass for fixed glazed partitions.

- Fixtures and other details as per specifications.

**Steel Windows / Ventilators**

- Steel windows of standard dimensions conforming to IS: 1361.

- 4 mm thick plain glass for openable shutters

- 6 mm thick wired glass for fixed shutters.

- 12 mm sq. MS safety bars @ 100 mm c/c.

- Fixtures and other details as per specifications.

**Steel Louvers**

- Pressed steel louvers from 18 gauge steel sheets and MS rolled channel frame.

- Fixtures and other details as per specifications.

**Rolling shutter**

- PVC Coated shutter made from 18 gauge steel sheets, suitable for saline weather conditions. Guides 75 mm x 25 mm steel channel.

- Details as per IS:6248,

**b. Floor finishes**

**Indian Patent Stone (IPS) flooring**

- 28 mm thick under bed in PCC 1:2:4 with 10 mm downgraded granite stone chips
- 12 mm thick topping. One (1) part of metallic hardener shall be mixed dry with 4 parts of cement by volume. To this mixture, 6 mm nominal size stone chips shall be added in portion of 1:3 (mixture of hardener & cement : stone chips) by volume.

**Cast-in-situ terrazzo flooring**

- 25 mm thick under bed in PCC 1:1.5:3 with 10 mm downgraded granite stone chips.

- 15 mm thick terrazzo topping with 6 mm down marble chips of approved color.
- Panel size 1000 mm x 1000 mm with 40 mm x 3 mm thick glass dividing strip.

**Precast Terrazzo tiles**

- 20 mm thick underbed in PCC 1:1.5:3 with 10 mm down granite stone chips.
- 250 mm x 250 mm x 20 mm tiles.

**Carborundum tiles**

- 20 mm thick underbed in PCC 1:1.5:3 with 10 mm down granite stone chips.
- 250 mm x 250 mm x 20 mm tiles.

**Acid Resistant Tiles**

- 15 mm thick underbed in cement mortar 1:3.
- Intermediate layers of 3 mm thick bitumen and 6 mm thick acid proof mortar.
- 25 mm thick acid resistant tiles conforming to IS:4457.

**Glazed Tiles**

- 15 mm thick underbed in cement mortar 1:3
- Earthenware glazed tiles conforming to IS:777.

**Heavy duty Ceramic Floor Tiles**

- 15 mm underbed in cement mortar 1:3
- Ceramic floor tiles 600x600x10.

**PVC Tiles**

- 37 mm thick underbed in PCC 1:2:4 in areas without false flooring.
- To be directly installed over particle board tiles in false floor areas.
- 2 mm thick PVC tiles over false flooring and 3.02mm in other areas conforming to IS:3461/IS:3462.

**Granite tiles**

- 15 mm underbed in cement mortar 1:3
- 20 mm thick black color premium quality hard polished granite.

**Vitrified Floor Tiles**

- 12 mm underbed in cement mortar 1:3
- 300 mm x 300 mm x 6 mm or 300 mm x 200 mm x 6 mm Vitrified floor tiles (MARBONITE or approved equivalent).

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**Epoxy coating**

- Details as per detailed specification covered in Clause 5.5.0.

**c. Roof finishes**

**Roof waterproofing with pressed flat tiles**

- 80 mm (min) thick layer of brick jelly lime concrete 1:2:4 using 20 mm downgraded brick bats.
- 20 mm thick underbed for tiles in cement mortar 1:3 with waterproofing admixture.
- 20 mm thick pressed flat tiles

**Roof waterproofing with polymeric membrane**

- 40 mm (min) thick screed layer in PCC 1:2:4 using 20 mm downgraded brick bats.
- Bituminous polymeric membrane as per specification or approved equivalent.
- 20 mm thick cement mortar 1:3 with chicken mesh over membrane.

**Basement damp proofing with polymeric membrane**

- Bituminous Polymeric membrane or approved equivalent as per specification.
- Vertical faces protected with 115 mm thick brick wall.

**d. Painting**

**Oil bound distemper**

- One priming coat of cement primer or any other suitable primer as per manufacturer's recommendation.
- Two final coats of paint conforming to IS:428 to obtain even finish and uniform color.

**Synthetic enamel**

- One coat of Red oxide zinc chromate primer 25 microns thick.
- Two final coats of paint conforming IS:2932 each 25 microns thick.

**Acrylic Plastic Emulsion**

- One filler coat with plaster of Paris 3 mm thick.
- Two coats of suitable primer as per manufacturer's recommendation.
- Two final coats of paint to obtain even finish and uniform color.

**Waterproof Cement Paint**

- One coat of paint as primer
- Two finish coats of paint to obtain even finish and uniform color.

**Apex Ultima/Exterior weather shield**

- One coat of paint as primer
- Two finish coats of paint to obtain even finish and uniform color.

**White washing / color washing**

- Three coats of white washing or color washing to obtain a uniform finish or shade.

**Chlorinated Rubber Paint**

- Two coats of high build chlorinated rubber zinc phosphate primer each 30 microns thick (for steel surface). One coat of chlorinated rubber paint (for concrete/masonry surfaces).
- Two final coats of chlorinated rubber paint each 40 microns thick.

**High build Epoxy paint**

- One coat of epoxy zinc phosphate primer 35 microns (for steel structure). Thin coat of epoxy high build paint (for concrete structure).
- Two finish coats of epoxy high build paint.

**High build Coal Tar Epoxy Paint**

- Two coats of epoxy red oxide zinc phosphate primer each 30 microns thick for (steel surface). One coat of epoxy sealer (for concrete surface).
- Two finish coats of high build coal tar epoxy paint.

**Chemical Resistant Phenolic based enamel**

- One coat of red oxide zinc chromate primer 25 microns (for steel surfaces).
- One thin coat of chemical resistant phenolic based enamel (for concrete surfaces).
- Two finish final coats of chemical resistant enamel each 25 microns.

**Acrylic Polyurethane Paint**

- Two coats of epoxy, zinc chromate primer each 35 microns thick (for steel surfaces)
- One coat of epoxy sealer (for concrete surfaces)
- Two finish coats of Acrylic Polyurethane paint each 30 microns thick.

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**e. Underdeck Insulation**

- 40 mm thick bonded mineral wool conforming to Group I of IS: 8183 with aluminium foil facing.

**f. False Ceiling**

LUXALON suspended by galvanised stud wire hangers.

**g. False Flooring**

600x600x32 mm cement fill metallic false flooring panel with 1.2 mm antistatic high pressure laminate tile on top.

| | | |
|---|---|---|
| Base Plate size | - | 100x100x10 mm |
| Seamless pipe | - | 25 mm OD |
| Support Stud size | - | M18x 100 mm |

**h. Sheeting**

**Permanent colour coated sandwiched insulated metal cladding and roofing system**

Troughed zinc - aluminum alloy coated (both sides) MS sheet having 0.8 mm minimum thickness (or high tensile steel sheet of 0.5 mm minimum thickness) shall be used on external face (outer face) of cladding system. Weight of coating shall not be less than 150 gm /sq.m. The outer side (exposed face) shall be permanently colour coated with Polyfluro Vinyl Coating (PVF2) of Dry Film Thickness (DFT) 40 microns (min) over primer. Inner side of external sheet shall be provided with suitable pre-coating of minimum 7 microns.

Double dip Galvanized (475 gsm) MS sheets of minimum 0.8 mm thickness shall be used as inner liner (internal face) of cladding system. The exposed face shall be permanently colour coated with silicon modified polyester paint of DFT 40 microns (min) over primer. Inner face of external sheet shall be provided with suitable pre-coating of minimum 7 microns. The rate of galvanization shall not be less than 150 gm /sq .m.

The permanent colour coated sheet shall meet the general requirements of IS: 14246 and shall conform to class 3 for the durability.

Inner sheet shall fixed directly to side runners and Z spacers made of at least 2 mm thick galvanized steel sheet of grade 375 as per IS : 277. Inner sheet shall be fixed at the rate not more than 1.50 m center to center to hold the insulation and external sheeting.

The insulation shall be of bonded mineral wool of minimum thickness 50 mm conforming to IS : 8183, having a density of 32 kg / cu.m for glass wool & 48 kg /cu.m for rock wool.

For roof sheeting the specification remains the same as that of side cladding except the thickness and galvanization. The minimum thickness of roof sheeting shall be 0.8mm with galvanized rate of 275 gm/sqm.

Prefabricated sandwiched polyurethane PUF panel system may also be used for side cladding and roof sheeting.

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**Permanent colour coated (non-insulated) metal cladding system**

Troughed zinc aluminum alloy coated not less than 150 gm/sq.m M.S sheets having 0.6 mm minimum thickness (or High tensile steel sheet of 0.5 mm minimum thickness) shall be used for the cladding system. The outer side (exposed face) shall be permanently colour coated with PVF2 paint of minimum DFT 20 microns over primer and the inner side (internal face) shall be coated with same paint of minimum DFT 12 microns over primer. These shall be fixed directly to runners. The sheets shall meet the general requirement of IS: 14246 and shall conform to class 3 for the durability. For roof sheeting the specification remains the same as that of side cladding except the thickness and galvanization. The minimum thickness of roof sheeting shall be 0.8mm with galvanized rate of 275 gm/sq.m.

**Flashings, caps, trim closures etc.**

All flashings, trim closures, caps etc. required for the metal cladding system shall be made out of plain sheets having same material and coating specification as mentioned above for the outer face of the sandwiched metal cladding.

### 5.3.3 Design Criteria - Plumbing and Sanitary Works

**a. Water Supply**

**Materials**

- Water supply pipes shall be composite pipes of food grade quality
- Isolation valve (up to 50 mm) shall be of gun metal conforming to IS: 778 (Class II).

Valve pits for gunmetal valve shall be in brick construction.

**System**

- A water supply connection shall be made from nearby potable water main and the size of the same shall be decided based on fixture units.

**Fixture unit value for peak discharge**

| Type of Fixture | Fixture Unit Value |
|---|---|
| 1 Water closet | 1 |
| 1 Bath | 1/2 |
| 1 Wash Basin | 1/2 |
| 1 Kitchen sink | 1/2 |
| 1 Urinal | 1/2 |

Fixture unit value = 9 liters/min.
Before entering the building, an isolation valve shall be provided on water supply line.

**Flushing Tanks**

- Provision of flushing tanks for each toilet shall be made having following storage capacities.

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| Fixture | Storage Capacity (Litres) |
|---|---|
| Per WC | 15 |
| Per Urinal | 5 |

**b. Sanitary Fixtures**

Each toilet block shall have the following minimum sanitary fittings/facilities shall be of approved brand of the following sizes and specification. All fittings shall be of chromium plated brass (fancy type) unless specified.

| | | |
|---|---|---|
| Indian Water Closet (IWC) | - | Orissa pan of size 580 mm conforming to IS: 2556. |
| European Water Closet (EWC) PVC Cistern of 15 litres capacity. | - | Conforming to IS: 2556 with plastic seats and low level |
| Urinals | - | Flat back half shell of size 610 mm x 410 mm x 380 mm including a pair of 250 mm x 125 mm white ceramic foot rest and shall be without photovoltaic control flushing system |
| Wash basin | - | 550 mm x 400 mm conforming to IS: 2556 with chromium plated bottle trap. |
| Mirror | - | 600 mm x 450 mm x 6 mm beveled edge mirror |
| Glass shelve | - | 600 mm x 127 mm x 4 mm with chromium plated brackets. |
| Towel Rail | - | Stainless steel 600x20 mm. |

Toilet paper holder shall be provided for each European closet

| | | |
|---|---|---|
| Soap Holder | - | Stainless steel liquid soap holder cum dispenser |

Janitor room

Provision of installation of water cooler outside the toilet

Provision of ventilation shaft.

**c. Sewerage**

**Materials**

- All horizontal buried soil and waste pipes shall be of stoneware or PVC, socket and spigot and shall conform to relevant IS.
- All vertical soil, waste and vent pipes shall be of PVC conforming to relevant IS.
- Manholes and gully trap chambers shall be in brick construction.

**System**

- The system shall be designed on the principle of "TWO PIPE SYSTEM" having two separate vertical pipes namely Main Soil Pipe (MSP) and Main waste Pipe (MWP) receiving waste from number of Branch Soil Pipes (BSP) and Branch Waste Pipes (BWP)

- A BSP either shall have only one WC. to be connected to MSP or it shall receive discharge from number of urinals to be connected to MSP.

- A BWP shall receive waste from wash basins, baths, sinks, cooler areas, etc.

- Floor traps shall be provided to receive waste from waste pipes of various fixtures (except from WC. which shall be directly connected to MSP) and at locations where waste water is to be drained out.

- A MSP shall be directly connected to first manhole of an outside sewer.

- A MWP shall be discharged into first manhole through a gully trap.

- All vertical stacks and ventilating pipes shall be carried to a height of at least 1.5 meters above parapet and shall be provided with cowl on top.

- Gradient of the sewage piping shall be at least 1:200.

**Sizing**

The soil and waste pipe diameters shall be based on fixture units as given below:

**Fixture Units for Different Sanitary Appliances**

| Type of Fixture | Fixture Unit Value as Load Factor |
|---|---|
| Water closet, tank-operated | 4 |
| Water closet, valve-operated | 8 |
| Urinal | 4 |
| Showers (group) per head | 3 |
| Wash basin ordinary | 1 |
| Kitchen sink, domestic | 2 |
| Floor trap | 1 |
| Drinking fountain | 1/2 |

**Recommended Pipe Sizes for Branches and Main Vertical Pipes (STACKS)**

| Diameter of pipe (mm) | Max. Number of Fixture Units that may be connected to | |
|---|---|---|
| | Any Horizontal fixture branch | One stack of 3 stories in Height or 3 intervals |
| 1 | 2 | 3 |
| 30 | 1 | 2 |
| 40 | 3 | 4 |
| 50 | 6 | 10 |
| 65 | 12 | 20 |
| 80 | 20 | 30 |
| 100 | 160 | 240 |
| 150 | 620 | 960 |

- Minimum size of BSP receiving discharge from WC. shall be 100 mm up to MSP/first manhole.
- Minimum size of BWP shall be 80 mm.
- Minimum size after gully trap up to first manhole shall be 100 mm.

**Gradients**

- The gradient of a horizontal branch shall be such that non-silting & non-scouring velocity is maintained.

**Disposal**

- Treated sewage can be used for horticulture. Treated solid wastes can be used as manure.

### 5.3.4 Design Criteria – Loads & Load Combinations

All structures shall be designed for the most critical combinations of dead loads, imposed loads, equipment loads, crane loads, steam piping (static & dynamic) and other piping loads, wind loads, seismic loads as per IS 1893 (**all parts**) and any other loading conditions which can occur during the design life of the facility.

Design loads shall comply with the requirements of IS: 875 & IS: 1893 as a minimum, unless more stringent requirements are specified herein. The following types of loads shall be considered in general for the analysis and design of structures and foundations.

**Dead Loads (DL)**

Dead loads consist of the weights of the structure complete with finishes, fixtures, partitions, wall panels and all equipment of semi-permanent nature including tanks, partitions, roofing, piping, cable trays, bus ducts etc.

Self-weight of materials may be calculated on the basis of unit weights given in IS: 875 (Part 1). The following unit weight of material shall be considered for computation of loads:

| Materials | Unit Weight |
|---|---|
| Plain Cement Concrete | 24 kN/m³ |
| Reinforced Cement Concrete | 25 kN/m³ |
| Structural Steel | 78.5 kN/m³ |
| Brick work | 20 kN/m³ |
| Cement Plaster | 21 kN/m³ |
| Floor finish | 24 kN/m³ |

**Equipment loads (EQL)**

Equipment causing heavy concentrated loads shall be considered separately. Loading data shall be initially estimated from suppliers' catalogues or from similar equipment supplied for other projects and the same shall be later verified based on certified manufacturer's drawing. Where both concentrated and uniform loads cannot act simultaneously, the structure shall be checked for each condition of loading separately and shall be designed for the more critical condition. The loading considered for tanks and piping shall include hydraulic test load. Crane girders and supporting columns shall be designed for vertical and lateral loads as furnished by the manufacturer. In the absence of data from manufacturer, wheel loads are estimated from crane weights and capacity of the crane and lateral loads and impact factors are arrived at based on the recommendations furnished in IS:875. Laydown areas in the turbine and generator halls shall be designed for concentrated loads resulting from storage of equipment components during erection and maintenance, and such areas shall be identified by permanent marking.

Static and dynamic loads of major equipments shall be based on the manufacturer's data of the specified equipments. However, where the uniform floor live load adequately accounts for the equipment moving weight, the weight of such equipment as a dead load shall not be considered e.g. switchgear and control room floors are usually designed for a live load that includes the equipment weight.

While arriving at seismic forces, the equipment loads should be accounted as dead loads.

All equipments, tank and piping design loading shall include hydraulic testing loads. Weight of equipments, ducts, tanks, pipes, conduits etc. supported by structure shall include maximum possible loading conditions i.e. flooded material contents and associated impacts, test loading, anchorage and constraint effects.

Air duct loads shall include weight of insulation, duct attachments, dust accumulation loads, seismic or wind whichever is applicable and other loads as applicable.

**Imposed Loads (IL)**

**General**

Imposed loads noted below are the general equivalent uniformly distributed loads to account for equipment/piping/cable tray/erection loads etc. and personnel movement. Where the actual loads of the equipment exceeds in specific areas due to concentration of facilities, the same shall be substituted in lieu of the above loads, in which case a nominal live load of 5 kN/m² shall be considered in the adjacent areas not covered by the equipment.

Imposed loads in different areas shall include live loads, minor equipment loads, cable trays, small pipe racks/ hangers, erection loads, operation / maintenance loads etc. The loads considered shall not be less than that specified in IS: 875 (Part II).

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The loads listed hereunder are minimum live loads for the areas involved. Special use areas shall be investigated and loads revised upward as necessary. Floors and supporting members which may be subjected to heavy equipment live loads shall be designed on the basis of the weight of equipment or specifically defined live loads, whichever is greater.

**Roofs**

| | | | |
|---|---|---|---|
| a. | Flat Roof | : | 1.5 kN/m² for accessible roofs |
| | | : | 0.75 kN/m² for non-accessible roofs |
| | | : | 5.0 kN/m$^2$ for accessible roofs with HVAC equipment |
| b. | Sloped Roof | : | As per IS : 875 |

**STG, GTG, Switchgear and Control Buildings**

| | | |
|---|---|---|
| Ground floor | | |
| - General | : | 15 kN/m² |
| - Unloading bay | : | Actual |
| - Heavy equipment storage area | : | 50 kN/m2 |
| Cable spreader rooms | : | 5 kN/m² |
| Operating floor | | |
| - General | : | 15 kN/m² |
| - Laydown area | : | 30 kN/m² |
| - Rotor removal area | : | 30 kN/m$^2$ |
| Switchgear floor | : | 15 kN/m² |

| | | |
|---|---|---|
| Deaerator floor and platform around deaerator | : | 10 kN/m$^2$ |
| Control room | : | 10 kN/m² |
| Battery Rooms | : | 20 kN/m² |
| AHU, AC & Ventilation plant floors | : | 10 kN/m² |
| PLCC, relay room | : | 15 kN/m² |
| Platform & Stairs | : | 5 kN/m² |
| Other floors | : | 10 kN/m² |
| Chequered Plate & Grating floors (Including opening covers) | : | 5 kN/ m² |
| Precast concrete covers | : | 12 kN/m$^2$ |

**Other Plant Buildings and Areas**

| | | |
|---|---|---|
| Ground floor/Operating floor | : | 15 kN/m² or as required by the equipment supplier whichever is higher |
| Switchgear floor | : | 15 kN/m² |
| Stores | : | 15 kN/m² |
| Control Room | : | 10 kN/m² |
| Stairs and balconies | : | 5 kN/sqm |
| RCC floors, laboratories. Conference rooms and other floors | : | 5 kN/m² |

The above loads are applicable for slabs & secondary beams. 75% of the above load may be considered for design of columns & foundations as it is unlikely that the entire tributary area of the slab will be fully loaded at all levels at the same time.

However, for design of slabs and beams, in addition to the above loads, a live load of 2.5 kN/m² and concentrated load of 10 kN at the worst location shall be considered in Operating floor, Switchgear room & Control room to cater for hung loads due to piping and cable trays. Loads due to critical piping shall be taken at actual and checked for local effects.

A minimum UDL of 1.0 kN/sqm shall be considered as Hung loads for ventilation & air conditioning and miscellaneous piping in other floors as applicable.

For areas not covered above and for Non-plant buildings, the relevant loadings furnished in IS:875 (Part 2) shall govern.

**Piping Anchor and Restraint Loads**

Piping load shall be as per load plan drawings unless otherwise mentioned.

Piping anchor and restraint forces of major piping shall be obtained from piping analysis results, and be considered as live load in the structure design.

**Miscellaneous**

Culverts and allied structures including buried RCC Pipes shall be designed for IRC Class "AA" loading and checked for Class 'A' loading.

Covers for trenches & tunnels that are not exposed to vehicular traffic shall be designed for Live Load of adjoining areas or **10 kN/m²** whichever is higher. Where trenches / tunnels channels are likely to be exposed to vehicular traffic, the requirements of Code of Practice for Road Bridges shall be adhered to.

For design of walls of basement, trenches, channels etc. below ground, lateral pressure due to a vertical surcharge of 15 kN/m² shall be considered in addition to earth and ground water pressure etc. In case of heavy wheel loads, lateral surcharge due to actual wheel loads shall be substituted. When a portion or whole of the adjacent soil is below free water surface, computations shall be based on submerged weight of soil plus full hydrostatic pressure.

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Live Loads reduction shall be in accordance with the provisions of IS : 875 & IS : 1893.

**Crane Loads (CRL)**

Crane girders and supporting columns shall be designed for vertical and horizontal forces (including impact forces) as per crane vendor's data. All lifting beams and monorails shall have their design loads increased for impact factor as mentioned hereinafter.

Loads including impact factor for cranes, hoists and elevators shall be taken as per IS: 875 (Part 2).

**Wind loads (WL)**

Wind load shall be in accordance with IS: 875 (Part-3). The wind shall be assumed to blow in any direction and most unfavorable condition shall be considered.

The external / internal pressure co-efficient shall be as per respective clauses of IS 875 (Part-3)

In design of structures, wind force on equipments supported on frame including all fixtures, piping, staircases, ladders, handrails etc. shall also be considered.

**Seismic load (SL)**

Seismic loads shall be in accordance with IS1893 latest revision covering all parts, corresponding to Zone - III. The following factors as per the code shall be considered to arrive at the seismic loads.

| | | |
|---|---|---|
| Zone factor (Z) | - | 0.16 |
| Importance factor (I) | - | 1.75 for power plant buildings |
| | - | (As per provisions of IS:1893, Part I & IV) |
| Response Reduction Factor (R) | - | As per the provisions of IS 1893. |

Shear enhancement as per provisions of IS: 1893, Part IV. Seismic analysis shall be carried out by Response Spectrum method for critical structures like GTG/STG building and structures more than one storey high. Single storey buildings / structures may be analysed by equivalent static load method.

Seismic loads for structures not covered in IS: 1893-2002, shall be evaluated based on 1984 version of the code.

Dynamic increment of water pressure and earth pressure due to Seismic Loads shall be evaluated using IS: 1893: 1984 or other relevant Indian / International codes.

**Temperature load**

The structure will be designed to withstand stresses due to fifty percent of the total temperature variation. The total temperature variation for temperature loading should be taken as two thirds (2/3) of the average annual variation in the temperature. The average maximum annual variation for this purpose will be taken as the difference between the mean daily minimum temperature during the coldest month of the year and the mean daily maximum temperature during the hottest month of the year.

Suitable expansion joints will be provided in the longitudinal direction wherever necessary with provision of twin columns. The maximum distance of the expansion joint will be as per provisions of IS: 800 and IS: 456 for steel and concrete structures respectively.

**Earth Pressure**

Earth pressure for design of underground structures shall be based on co-efficient of active earth pressure and earth pressure at rest for cantilever and propped cantilever / two way supported walls respectively.
In addition to earth pressure and ground water pressure etc a minimum surcharge load of 15kN/m2 shall be considered for all underground structures including channels, sumps, cable trenches etc to take into the account the vehicular traffic in the vicinity of the structure.

**Load Combinations**

The individual members of the structures shall be designed for worst combination of forces such as bending moment, axial force, shear force and torsion.

Wind load and Earthquake load shall be assumed not to act simultaneously. The effect of both the forces shall be considered separately in each direction (along and across).

Some of the load combinations to be considered for the design of the main power house are given below.

1. DL + LL + EQUIP
2. DL + LL + EQUIP + Cb + CtLA + CS ± TL +CT
3. DL + LL + EQUIP + Cb +CtLB + CS ± TL+CT
4. DL + EL 1± TL +CT
5. DL + WL1± TL +CT
6. DL + WL2 ± TL +CT
7. 0.75 (DL+0.5 LL + EQUIP+Cb+Ct ±EL2) ± TL +CT
8. 0.75 (DL+ LL + EQUIP+Cb+Ct L1±(CS1 + WL1)) ± TL +CT
9. 0.75 (DL+ LL + EQUIP+Cb+Ct L1±(CS1 + WL2)) ± TL +CT

The following load combinations will be used for getting maximum tension of column base which will be used for the design of holding down bolts.

1. 0.9 DL + 0.9 EQUIP ± EL1
2. 0.9 DL + 0.9 EQUIP ± WL1
3. 0.9 DL + 0.9 EQUIP ± WL2

Notations for above loads are:

| | | |
|---|---|---|
| DL | - | Dead Load of structure, Floors, walls etc |
| LL | - | General Live Load on floors |
| EQUIP | - | Equipment Loads |
| Cb | - | Crane Bridge |
| Ct | - | Crane Trolley positioned at middle of bridge |
| CtLA | - | Crane trolley + Load near one row |
| CtLB | - | Crane trolley + Load near other row |
| CtL1 | - | Crane trolley + Half load lifted at centre of bridge |
| CS | - | Crane surge for full load |
| CS1 | - | Crane surge for half load lifted |
| WL1 | - | Wind load with internal wind co-efficient negative |
| WL2 | - | Wind load with internal wind co-efficient positive |

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EL1 - Earthquake load for DL only
EL2 - Earthquake load for DL + 0.5 LL
TL - Temperature load
CT - Conductor tension load
SL1 - Seismic Load from left to right
SL2 - Seismic Load from right to left

**Note**

1. If equipment load is taken at actual, live load of 5 kN/m² only shall be considered.

2. Equipment loads shall not be considered as a part of DL for checking the stability of the structure.

3. 0.9 times DL shall be considered for checking stability.

4. Wind load and Seismic load shall be assumed not to act simultaneously. The effect of both the forces shall be considered separately in each direction (transverse and longitudinal).

For buildings with GI sheet roof on structural steel truss & open sides

DL + IL
DL + WL1
DL + WL2

**Underground Structures**

Following loading conditions shall be considered in addition to the loading from super structure for the design of substructure of pump house, channels, sumps, tanks, reservoirs, trenches and other underground structures.

Only liquid pressure from inside and no earth pressure & ground water pressure and surcharge pressure from outside (applicable only to structures which are liable to be filled up with water or any other liquid).

Earth pressure, surcharge pressure and ground water pressure from outside and no water or liquid pressure from inside.

Base slab of the sump shall be designed for the condition of different combinations of pump sumps being empty during maintenance stages with maximum ground water table. Intermediate dividing piers of pump sumps and partition walls in channel be designed considering water on one side only and the other side being empty for maintenance.

**Note :**

a. Liquid pressure and surcharge load shall include Seismic effects also as applicable.
b. The underground structures shall be checked for buoyancy due to ground water pressure during construction phase (without superstructure loads).

**Loading Criteria for Pipe and Cable Rack Structures**

**a. Design Loads**

Loads due to self-weight of piping, insulation, valves etc. and the self-weight of structures constitute the Dead Loads. In the absence of exact loading, general uniformly distributed loading as indicated below shall be considered depending on the pipe size and spacing.

| Category | Udl | Equivalent Pipe Size |
|---|---|---|
| Light | 1.5 kN/m² | 150 mm dia, schedule 40 @ 250 C/C |
| Medium | 2.0 kN/m² | 200 mm dia, schedule 30 @ 300 C/C |
| Heavy | 3.0 kN/m² | 250 mm dia, schedule 20 @ 300 C/C |

In case larger size pipes are supported, additional point loads shall be considered in addition to the above loads.

Cable tray loads shall be taken as 100 Kg/m per layer for 600 mm wide tray and proportionately for other sizes. Cable tray supports shall be generally provided at 1.5 m c/c.

The above loads shall be compared with actual piping and cable tray loads and highest loads shall be considered for final design.

The main beams shall be designed to cater for 100% of UDL indicated above, unless intermediate beams are provided, in which case, the load on the main beam can be reduced by 20%.

The intermediate beams and longitudinal beams shall be designed for 25% of UDL, provided pipes are supported only on main beams. In addition the longitudinal beam shall be designed for the reaction from the intermediate beam and concentrated load due to branch / loop pipe above 200 mm dia supported on them.

Unless otherwise specified, friction/temperature loads, shall be taken as 15% of the vertical load and assumed to act on the main beams as UDL, in a direction parallel to the pipes, and perpendicular to the pipes as concentrated load applied at the beam level. Both transverse and longitudinal friction shall be considered together.

Anchor forces shall be as per piping layout and pipe stress analysis. All anchors shall be located on the main transverse beams only.

Wind force acting on the rack frames shall be estimated based on the wind pressure arrived at from the design wind speed and force coefficients for windward frame and shielded frame respectively.

**b. Load Combinations**

The following load combinations shall be considered for Pipe Racks

DL ± FL ± AL
DL ± FL ± AL ± WL
DL ± WL

Where,
DL = Dead Load
FL = Friction Load
AL = Anchor Load

In case Seismic Load (SL) is governing, WL shall be substituted with SL in the above combinations.

**Increase in Allowable Stresses**

Appropriate increase in allowable stresses as per applicable IS Codes shall be considered under wind / seismic loading if design is carried out by Elastic/Working Stress method. If Limit State method of design is used, partial safety factors/load factors shall be applied to the loads as per relevant IS Codes.

### 5.3.5 Design Criteria - Reinforced Concrete Structures and Foundations

**General**

All structures, building foundations, machines / equipment foundations, water retaining structures, trenches, pits etc. shall be designed as per relevant IS Codes in general.

All designs of RCC structures shall be carried out by limit state method as per IS: 456 unless use of working stress method is specifically mentioned. Design strength of materials and design loads shall be calculated using appropriate partial safety factors over characteristic strength and characteristic loads as per IS: 456. For reinforcement detailing IS: 5525 and SP: 34 shall be followed.

Water Retaining structures shall be designed as uncracked sections by working stress method as per IS : 3370.The walls of liquid retaining structures shall be provided with reinforcement on both faces for sections 200 mm or more, even if not required from design consideration.

**Increase in Stresses**

Where stresses due to wind (or seismic) are combined with those due to other loads, the allowable stresses in concrete and reinforcement steel may be increased by 33.33% in case of working stress design.

Where the bearing pressure on soil due to wind load alone is less than 25% of that due to dead load and imposed load, it may be neglected in design. Where this exceeds 25%, foundation may be so proportioned that the pressure due to combine effect of dead load, imposed load and wind load does not exceed the allowable bearing pressure by more than 25%. When seismic loads are included, the permissible increase in allowable bearing pressure shall be as per IS: 1893. No increase in allowable stress is allowed when DL is alone is combined with wind/seismic load.

Appropriate increase in allowable stresses as per applicable IS Codes shall be considered under wind / seismic loading if design is carried out by Elastic/Working Stress method. If Limit State method of design is used, partial safety factors/load factors shall be applied to the loads as per relevant IS Codes. The above references are only guide lines and not limiting criteria.

**Foundation**

**a. General**

The foundation type and depth shall be decided based on the final soil investigation to be carried out by the EPC Contractor and recommendations based on the same. Minimum depth of foundation shall be 1500 mm below the natural ground level.

Settlement criteria for shallow foundations shall be generally as follows, or more stringent as per specific equipment requirement & differential settlement criteria.

- 25 mm for plant buildings and structures.
- 40 mm for non-plant buildings and structures.
- 150 mm for steel storage tank foundations (floating roof)
- 200 mm for steel storage tank foundations (fixed roof)

Settlement criteria for pile foundation shall be as per IS: 2911.

75 mm thick lean concrete 1:4:8 shall be provided below footings, base slab etc. as mud mat. For water retaining structures mud mat shall be of mix. 1:3:6 and minimum 100 mm in thickness.

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The Factors of safety for stability of foundation and underground structures shall be as per IS: 456 & IS: 3370.

Additional depth of excavation shall be filled up with PCC 1:5:10.

Piles shall be checked for vertical and lateral loads. Vertical load capacity shall be calculated based on soil bearing capacity (as per IS: 2911) and structural capacity. Lateral capacity shall be evaluated based on horizontal sub-grade reaction approach as per IS: 2911. Structural design of pile shall consider the worst loading (minimum vertical load and maximum moment due to design lateral loads or maximum vertical load capacity combined with maximum moment capacity). Structural load capacity of piles shall be evaluated based on limit state method. The structural capacity shall be calculated for working as well as test piles (load factor for test pile shall be equal to the ratio of test load to design load).

**b. Foundations for Vibrating Machinery**

Design of foundations for vibratory Equipment such as GTG, STG, Boiler feed pumps etc. shall be done in accordance with IS:2974 and they shall be isolated from other foundations for vibration control. To avoid resonance, natural frequencies of the foundations shall be kept at least 20% away from the operating frequency and amplitudes shall be kept within the allowable limits specified by the respective equipment manufacturer or in absence of manufacturer's specified value, as specified in the IS Codes/DIN Codes.

The design of machine / equipment foundation shall be as per IS: 456 and IS : 2974.

All block foundations resting on soil shall be analysed considering dynamic properties of soil. The mass of the RCC block shall not be less than the three times the mass of the machine. Dynamic analysis shall be carried out to calculate natural frequencies in all the modes including coupled modes and to calculate vibration amplitudes. Frequency and amplitude criteria as laid down by the relevant codes and / or machine manufacturers shall be satisfied. Minimum reinforcement shall be governed by IS: 2974 and IS : 456.

For the foundations supporting minor equipments weighing less than one ton or if the mass of the rotating parts is less than one-hundredth of the mass of the foundation, no dynamic analysis is necessary. However, if such minor equipment is to be supported on building structures, floors etc. suitable vibration isolation shall be provided by means of springs, neoprene pads etc. and such vibration isolation system shall be designed suitably.

All such foundations shall be separated from adjoining part of building and other foundations. Joints at floor / slab shall be suitably sealed. All appendages to such foundations shall be reinforced suitably to ensure integral action.

**c. Foundation for Chimney**

The stability of the foundation as a whole shall be investigated and weight of foundation shall be so proportioned that the least resisting moment shall be not less than 1.5 times the maximum overturning moment due to dead load and wind load / seismic load in shell alone case and 2.0 for the completed chimney. Foundation shall be in the form of rigid mat.

No increase in bearing capacity or in stress shall be allowed for wind loads.

No Loss of contact shall be allowed for the foundation raft for any of the load combinations.

**Concrete**

For structural concrete items, Cement to be used shall be either Portland slag cement with minimum 50 % slag or Portland pozzolana cement since the site is exposed to severe environmental condition due to marine environment,

Additionally if the detailed soil investigation calls for more severe protection, the same shall be considered for construction.
In case of any contradiction between the provisions of cement with any other clause, the requirement specified here in clause no 5.3.5 shall govern.

All structural concrete shall be made dense and nonporous with water cement ratio not exceeding 0.45. Plasticizers shall be used, if required, to maintain the required slump.

The following minimum grades of concrete as per IS: 456 shall be adopted for the type of structures noted against each.

M20 - Base plate encasement, paving including plinth protection, encasement of structural steel etc.

M20 - Grade slab, drain, pipe trenches, cable trenches, culverts, roads,

M25 - All RCC members except where other grades are specified.

M30 - For GTG, STG, Chimney foundations

M30 - Piles

M30 - Precast concrete

1:3:6 - Mud mat below tank foundations

1:4:8 - Plain Concrete Footing, base slab of drains.

1:5:10 - Fill concrete.

However requirement of table 4 & 5 of IS 456 shall be satisfied depending on the exposure condition. As per IS 456, the environmental exposure condition of “severe” shall be considered for design condition.

However requirements as per design mix shall be finally followed for the construction.

Intermixing of grades of concrete in the same structure shall not be allowed in a particular structural element.

All precast slabs for trenches shall be provided with MS edge protection angles on all sides with minimum size as 50x50x6 mm.

The RCC trench edge shall be provided with suitable MS angle for protection. All concrete edges shall be protected with MS angle of size 65x65x6 mm minimum with MS lugs of size 25x6 mm.

Underground structure painting: Irrespective of soil report recommendations, for concrete substructures two coats of ERPB (Epoxide resin based anticorrosive and chemical resistant paint) over a coat of CPCI (concrete penetrating bipolar corrosion inhibitor) shall be applied with 300 to

325 micron DFT for protection of concrete against carbonation & chloride penetration in saline/marine environment.
IP Net coating system will be applied to the external surfaces of columns, beams, fan deck slabs and all other exposed concrete structure. The total DFT of 370 microns will be applied as per manufactures instructions

**Reinforcements**

TMT/High Yield Strength Deformed steel bars of grade Fe-500 bars conforming to IS-1786. painted with fusion bonded epoxy coating as per IS: 13620 shall be used for reinforcement. Binding wire shall be PVC coated binding wire.

**Minimum Thickness of Structural Elements**

The following minimum thickness shall be followed:

| | | | |
|---|---|---|---|
| a. | Suspended floor slab / roof slab / walkways / Canopy slabs etc. | - | 125 mm |
| b. | Ground floor slab (non - suspended) | - | 150 mm |
| c. | Water Retaining Slab / Walls | - | 200 mm |
| d. | Cable / Pipe Trenches / Underground pit / Launder walls and base slab | - | 150 mm |
| e. | All footings (including raft foundations) | - | 300 mm |
| f. | Tapered footings | - | 150 mm (Min. at edges) |
| g. | Parapets / Chajjas | - | 125 mm |
| h. | Precast louvers / fins | - | 50 mm |
| i. | Precast trench cover slabs / floor slabs Louvers | - | 75 mm |
| j. | Precast beams | - | 150 mm |
| k. | Paving | - | 150 mm |
| l. | Basement walls and base slab | - | 150 mm |
| m. | Pilecaps | - | 300 mm |

**Minimum Cover to Reinforcement**

Clear cover to reinforcement shall be as follows:

| | Top (mm) | Bottom (mm) | Sides (mm) |
|---|---|---|---|
| Footings (Raft and Isolated) | 50 | 75 | 50 |
| Pile caps | 50 | 100 | 50 |
| Grade beam | 40 | 40 | 40 |
| Grade slab | 25 | 25 | 25 |
| Columns & Pedestals | 50 | - | 50 |
| Beams above ground level | 35 | 35 | 35 |
| Lintel beams (Size < 300 x 300) | 25 | 25 | 25 |
| Block foundation including GTG/STG foundation | 50 | 100 | 50 |
| Slabs & staircases | 25 | 25 | 25 |
| Cable trenches | | | |
| Base slab | 20 | 35 | 35 |
| Roof slab | 15 | 35 | 35 |
| Walls | 20 | 35 | 35 |

| | | | |
|---|---|---|---|
| Liquid retaining Structures | | | |
| Base raft | 40 | 40 | 40 |
| Side Walls (Water face) | 30 | - | 30 |
| Side Walls (Soil face) | 50 | - | 50 |
| Precast Units | 15 | 25 | 20 |
| Surface Drains (Base slab and walls) | 25 | 25 | 25 |

**Minimum Cover for Foundation Bolts, Base Plates and Pockets**

a. Clear distance from the edge of the base plate / base frame to the outer edge of the pedestal shall be minimum 50 mm.

b. Clear distance from the face of pocket to the outer edge of the pedestal / foundation shall be 75 mm.

c. Clear distance from the edge of the sleeve or anchor plate to the edge of pedestal shall be 75 mm.

**Minimum Heights for Pedestals of Steel Columns**

**Pedestals to Steel columns for building structures**

Top of RCC foundations (pedestals) shall normally be kept at a height of 300 mm above the floor level.

**Other Pedestals and Foundations**

| | | | |
|---|---|---|---|
| i. | Stair and ladder pedestal | - | 200 mm above the finished floor level |
| ii. | Equipment in open area | - | as required (300 mm min.) |
| iii. | Equipment in covered area | - | as required (150 mm min.) |
| iv. | Structures / equipment supplied by vendors | - | as per vendor's data subject to minimum as specified above |

In case the top of pedestal is kept at a lower level so that the column base plates together with gussets and stiffeners remain below finished floor level (FFL), the column bases as well as column sections shall be encased in concrete above FFL as per following:

| | | | |
|---|---|---|---|
| i. | Open area | - | 300 mm above FPL/FGL, whichever is higher. |
| ii. | Covered area | - | 150 mm above the finish floor level |

FPL = Finished Paved Level
FGL = Finished Grade Level

**Grouting**

Cement mortar (1:1 or 1:2) grout with non-shrink additive shall be used for grouting below base plate of columns. For grouting of base of machine foundation, high strength ready mixed non shrink grout of approved brand (approved by OEM and Owner/Owner's representative) shall be used.

Crushing strength of the grout shall generally be one grade higher than the base concrete. Minimum grade of grout shall be M30.

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Nominal thickness of grouting shall be at least 50 mm for building columns and pedestals of major equipments. For secondary posts, stair and ladder base etc. grouting shall not be less than 25 mm thick.

**Deflection Criteria**

The following deflection criteria shall be considered in sizing of structures as per IS: 456.

i. The final deflection due to all loads including effects of temperature, creep, and shrinkage, measured from as cast level of the supports of floors, roofs & all other horizontal members shall not exceed span/250.

ii. The deflection including effects of temperature, creep & shrinkage occurring after erection of partitions and the application of finishes shall not exceed span/350 or 20mm whichever is less.

Under transient wind load the lateral sway at the top should not exceed H/500, where H is the total height of the building.

The maximum horizontal relative displacement due to seismic forces between two successive floors shall not exceed 0.004 times the difference in level between these floors.

**Water Retaining Structures / Basements**

Water Retaining structures shall be designed as uncracked sections by working stress method as per IS: 3370.

Dry basements for which external water proofing is not provided and subjected to ground water pressure from outside may be designed in accordance with the recommendations of IS:456. Crack width shall be restricted to 0.1 mm.

Minimum thickness of structural elements for water retaining structure with two layers of reinforcement shall be 200 mm.

All construction joints in underground structures will be provided with 250 mm wide, 8 mm thick PVC water stop of approved make.

**CW Pump House and Forebay**

The dimensions of the Pump house shall be decided by the Bidder based on Equipment Layout considerations.

Forebay walls shall be designed as counterfort retaining walls. Forebay base shall be provided with pressure relief valves to prevent uplift due to buoyancy effects. The pump house and forebay have to be investigated for necessary factor of safety against uplift during various stages of construction.

### 5.3.6 Design Criteria - Steel Structures

**Framing**

All steel framed structures shall generally be of rigid frame in the generally transverse direction and braced frame in the longitudinal direction with bracing confined to selected bays.

Lateral forces shall be resisted by stiff jointed moment connections in rigid frame design. The column bases shall generally be fixed to concrete pedestal / column by providing moment resistant base detail.

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**Design Methodology**

The design of steel structures shall be done by working stress method in accordance with the provisions of IS : 800 and other relevant IS codes as applicable to specific structures.

Crane gantry girders shall be a rolled section with flange plate and or welded construction with bearing and intermediate stiffeners. Crane girder shall be designed as simply supported and of single span length.

Permissible stresses for different members shall be allowed to exceed by 33-1/3% under wind and seismic conditions. However, permissible stresses in bolts and welds shall be allowed to exceed up to 25% only.

For design which requires the use of the minimum column load (such as, uplift on anchor bolts, column axial tension etc.) 90% of Dead Load along with uplift forces if applicable shall be considered.

Base plates shall be placed on foundation pedestal with grouting. For large base plates necessary grout holes shall be provided. Generally anchor bolts for fastening steel columns on foundation shall be embedded in foundation during concreting itself using suitable templates for correct positioning. No anchor pockets in foundation shall be allowed for anchor bolts in tension. Design of base plates shall be based on design pressure on foundation, which shall not exceed the appropriate bearing values given in IS: 456.

The total horizontal shear force at the base of column is transferred to the column pedestals through friction between the base plate and the grout. A co-efficient of friction of 0.30 shall be used in conjunction with the minimum column load, as defined above. If the horizontal shear force exceeds the frictional resistance force shear may be transmitted through bolts or shear keys. If the column is subjected to a net uplift load, the total force shall then be transmitted through shear bars / shear keys welded to the base plate. Necessary recesses shall be kept in the foundation concrete for shear lugs.

Minimum height of the encasing of structural columns shall be 300 mm to 500 mm.

Angle sections shall not be used as flexural members except for roof trusses, purlins, side girts and walkway runners.

For axially loaded members in framework, minimum angle section to be used shall be ISA 50x 50 x 6.

End connections for rolled beams, built-up beams etc. shall be designed for a minimum of 75% of their shear capacity and 100% of moment capacity (for moment connection).

Moments shall be considered for design of columns arising due to eccentricity of floor beam connections with column. Minimum eccentricities on column shall be considered as per IS: 800.

For edge protection alround cutouts / openings in floor slabs. Minimum angle section to be used shall be ISA 50 x 50 x 6 with suitable anchor lugs.

Toe guards shall have a minimum depth of 100 mm and a minimum thickness of 6 mm.

Hand railing shall be of hot dip galvanized construction out of 40 mm NB pipes of medium class conforming to IS: 1161 with threaded ends and necessary bends, tees, elbows, sockets etc. Hand railing shall be 1000 mm high with two horizontal rails one at 500 mm and another at 1000 mm above the base level along with vertical posts spaced at not more than 1500 mm centres.

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Where floor beams form part of the vertical bracing system, additional loads from floor beams transferred to bracing shall be taken into consideration in the design.

Minimum width of steel staircase shall be 1000 mm. Minimum width of treads without nosing shall be 250 mm. Maximum height of riser shall be 200 mm and they shall be limited to 16 per flight. Staircases shall be provided with hand railing. Staircase step shall be made out of chequered plate or gratings of presswelded construction designed for a live load of 500 Kg/Sqm.

For any structural steel member, a minimum of 2 nos. 16 mm dia black bolts shall be used for permanent bolted connection and 1 no. 16 mm dia erection bolt for site welded connections.

All foundations bolts shall be provided with one nut and one locknut.

Base plate arrangements of all structural steel columns in buildings shall be so provided that the entire base assembly is below finished floor level. The base plate assembly shall be suitably encased in RCC. For open structures, base plate shall be rest on RCC pedestals, which are 300 mm above finished ground level.

All grouting work below stanchions / bases of equipment shall be with, branded premixed non-shrink free flow grout of approved manufacture which shall have a minimum crushing strength of 450 Kg/cm.Sq. at 28 days.

Minimum thickness of color coated GI sheets to be provided as roofing and cladding shall be 0.5 mm Minimum slope of color coated GI sheet roofs shall be 10 degrees.

**Materials**

Structural steel shall conform to IS : 2062.

Chequered plates shall conform to IS : 3502. Pipes for handrail shall be as per medium grade of IS: 1161. Crane rails and transformer track rails shall conform to IS: 3443.

**Connections**

Generally all shop and field connections shall be welded except for field connections. All moment connections, if bolted shall be of High strength friction grip bolts. Shear and other minor connections, if bolted may be made with mild Steel / High strength bearing bolts.

IS: 816 and IS: 9595 shall be followed for welding of structures. Electrodes of approved makes shall be used.

For high strength friction grip (HSFG) bolt connections, IS: 4000 shall be followed. High strength friction grip bolts shall be of property class 8.8 and shall conform to IS: 3757 and shall not be less than 20 mm in diameter. High strength bolts shall be installed as bearing type joint except where loads are reversible.

All other (other than HSFG) bolted connections shall have bolts of minimum 16 mm dia. The connections of stairs and hand railing shall be made with 16 mm diameter threaded fasteners conforming to IS: 1363. Erection bolts shall be black bolts of minimum 16 mm dia.

All bolts and nuts have property class compatible to each other. Bolts carrying dynamic or fluctuating loads and those in direct tension shall be provided with an additional double coil helical spring washer conforming to IS: 6755.

Where a steel beam or member is to be connected on RCC structure, it shall be connected using an insert plate and preferably through shear connection.

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For crane girders, full penetration of weld between web plate and top flange shall be ensured.

The working point of the bracing connection shall be the centre of column and girder to which it connects, where practical. The connections of gusset plates to column and girders shall be made to include provisions for eccentricity in connection. The double angle back-to-back with gusset plates in between shall not be used in dust-laden areas. Where double angles are not adequate, beam sections with web in the plane of bracing are to be used.

Horizontal bracings shall be angle / tee section located at the bottom of framing beams. Field welding of bracing at the underside of beam as required to meet slenderness requirement of bracing member shall be indicated on the drawings. Horizontal bracing shall be arranged to avoid framing into the beams at columns locations.

Intermittent welding shall not be permitted.

**Permissible Deflections**

The permissible deflection of various steel members under normal loading conditions shall be as specified below. For calculation of deflections in structures and individual members dynamic effects shall not be considered, unless specified otherwise. Also, no increase in deflection limits shall be allowed when wind or seismic loads are acting concurrent with normal loading conditions.

**Vertical Deflection**

| | | |
|---|---|---|
| Beam and Girders | : | Span / 325 or 20 mm whichever is lesser. |

For crane gantries or any member subjected to working loads, the maximum deflection under dead load and live load excluding impact shall not exceed the following values:

| | | |
|---|---|---|
| For manually operated cranes & monorails | : | Span / 500 |
| For EOT Cranes < 5OT | : | Span / 750 |
| For EOT Cranes > 5OT | : | Span / 1000 |
| Horizontal deflections | | |
| Columns | : | 1/325 of height |
| Crane Supporting Columns | : | 1/1000 of height for horizontal surge load. |

The maximum horizontal relative displacement due to seismic forces between two successive floors shall not exceed 0.004 times the difference in level between these floors.

**Minimum Thickness**

The minimum thickness of various components of a structure and hot rolled sections shall be as follows. The minimum thickness of rolled shapes shall mean flange thickness regardless of web thickness. Structural steel members exposed to marked corrosive environment shall be increased suitably in thickness or suitably protected otherwise as per good practice and sound engineering judgment in each instance.

| | | | |
|---|---|---|---|
| a. | Trusses, purlins, girts and bracing | : | 6 mm |
| b. | Columns and beams | : | 8 mm |
| c. | Gussets | : | 8 mm |
| d. | Stiffeners | : | 8 mm |
| e. | Base plates | : | 10 mm & above |
| f. | Chequered plates | : | 6 mm o/p & above |
| g. | Grating flats | : | 5 mm |
| h. | Minimum thickness of structural members, other than gratings and chequered plate, directly exposed to weather and inaccessible for painting and maintenance shall be | : | 8 mm. |

**Minimum sizes**

The flange width of purlins supporting roof sheeting and wall cladding shall not be less than 50 mm.

Width of steel rolled section connected to other member shall be at least 50 mm.

**Slenderness and Depth Ratio**

The slenderness ratio of main members in tension, compression or bending shall be in accordance with IS : 800.

The following limiting ratios of depth to span shall be considered as general guide.

| | | |
|---|---|---|
| a. | Truss | 1/10 |
| b. | Rolled beams and girders for ordinary floors and rafters | 1/24 |
| c. | Supporting floor beams for vibrating machinery / equipments | 1/15 |
| d. | Roof purlins and girts | 1/45 |
| e. | Gable columns | 1/30 |

**Painting and Corrosion Protection Measures**

Structural steel shall be painted after sand blasting as per specification.

For galvanised structures, rate of zinc coating shall be not less than 0.710 kg/m², unless mentioned otherwise.

### 5.3.7 Design Criteria for Chimney

**General**

The Steel Chimney shall be designed for all loads including the weight of chimney, accessories, temperature and wind or earthquake. Due consideration shall be given to loadings during the construction/erection phase and accounted for in the design.

**Dead Load**

All permanent loads due to the weight of chimney shell, platforms, ladders, flue ducts and other accessories.

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**Imposed Load**

Imposed load on service platforms around chimney shall be taken as 300 kg/m2. Design live load during construction/erection shall be computed as per actual condition.

Imposed loads from the duct joining the chimney.

**Wind Load**

The wind loading shall conform to IS-875, Part III - 1987. Dynamic analysis shall be carried out as per relevant standards and stability ensured under such condition. If two or more chimneys are spaced at less than 20 times the diameter of bigger chimney at 2/3 of their height or when the chimney is located close to other structure of comparable height, special consideration shall be taken into account for carrying out wind loading analysis due to aerodynamic interference.

**Earthquake Load**

Earthquake forces acting on the chimney and analysis for the same shall be carried out as per IS-1893. The horizontal design seismic coefficient shall be worked out by response spectra method as per IS-1893 with an Importance Factor of 1.75.

**Thermal Effect**

Effect of temperature stresses due to flue gas temperature shall be considered.

**Local Loads**

The effect of following local loads shall also be considered.

- Local moment due to platform.
- Local buckling of shell (For steel chimney).

**Load Combination**

Chimney shall be designed for the most unfavorable load combination during construction, operation and shut down conditions. Various load combinations for calculation of stresses shall be as under.

a) Dead load + Wind load.

b) Dead load + Earthquake load.

c) Dead load + Load due to lining + Imposed load on service platforms + Wind load.

d) Dead load + Load due to lining + Imposed load on service platform + Earthquake load.

The thickness of lining shall not be assumed to increase the section modulus of the shell nor to resist overturning due to lateral bending action or strutting action from wind/seismic forces for stability checking.

**Design and Detailing Requirements**

Design and construction of various components and systems of the chimney shall be in accordance with the relevant Indian Standards. For provisions not covered in the Indian Standards, reference shall be made to.

Latest editions (except as specified) of Indian and/or other international standards shall be followed for design. Some of the relevant available codes are listed hereunder.

| | |
|---|---|
| IS: 6533 | Code of Practice for Design and Construction of Steel Chimneys |
| IS: 800 | Code of practice for use of structural steel in general building construction |
| ICAO | International Civil Aviation Organisation (ICAO). |
| DGCA | Instructions of Director General of Civil Aviation, India. |
| BS: 4076 | Specifications for steel chimneys |
| CICIND | Model code for concrete chimneys |
| ASCE | Design and Construction of steel chimney liners prepared by Task Document committee on steel chimney liners. Fossil power committee (Power division published by ASCE-1975). |

In case of any conflict between this document and the Indian and international standards, the stipulations of this document shall prevail.

Imposed loading for design of all chimney components shall not be less than 5 KN/Sq.m

The chimney and its components shall be designed to resist the most severe forces resulting from all the possible combinations of the various loadings.

All design calculations shall be submitted to the Owner/Owner's representative for approval, and construction work shall commence only after the design has been approved.

### 5.3.8 Design Criteria – Outdoor Facilities

**Roads**

All roads shall be well designed Bitumen Roads. Berms shall be minimum 1m wide and elevated 300 mm above grade level (FGL). Red murrum, minimum 150 mm thick shall be provided for berms. Approach roads to the plant site shall be provided to access from existing road network. Roads as required for plant operation & maintenance inside the proposed plant boundary shall be provided. The layout concept of roads is shown in plot plan. The peripheral roads along the Compound wall shall be of single lane.

The crown of the road shall be minimum 150 mm above FGL. The final finished roads shall have a camber of 1 in 60. Camber on top of compacted crushed stone soling surface shall be 1 in 40.

Wherever drains or other underground facilities cross the roads, concrete pipe culverts of class NP3 or RCC box culverts shall be provided. All culverts carrying storm water shall be cast-in –situ RCC box culverts.

Roads shall be provided with kerb stones and the same shall be painted as per specifications.

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The minimum recommended road section is as follows :

| | |
|---|---|
| Sub-base | : A layer 300 mm thick coarse sand liner sub-base. Sub base shall consist of stones of 150 mm maximum size in two layers compacted to a thickness of 230 mm. |
| Base | : 2 layers of Water Bound Macadam (WBM) each 83 mm thick rolled to 150 mm depth. |
| Finish | |
| Semi-grout | : 75 mm thick |
| Premix carpet | : 50 mm thick |
| Seal coat (coarse sand and binder) | : 25 mm thick |

(All thickness are compacted thickness)

Initially only water bound macadam surface shall be constructed and after completion of the project but before COD, the damaged portions of the road shall be repaired and the bitumen topping shall be carried out.

The thickness given above is the minimum requirement and it shall be checked and confirmed by the Contractor as per design requirements based on CBR value of the subgrade. All roads should designed in accordance with IRC 37-2001 for a traffic intensity of 1500 vehicles per day.

**Drainage**

Surface drainage system shall be designed based on maximum rainfall intensity (meteorology report of proposed site area) or 100 mm/hr whichever is maximum. Run-off coefficients for paved areas and unpaved areas shall be assumed to be 0.9 and 0.6 respectively.

A network of open drains shall be provided to carry surface run off which would run along the sides of roads and lead to the nearest natural drain surrounding the plot.

Buildings shall be provided with plinth protection all around, sloped towards side drains. Garland drains shall be provided around all buildings to receive the drainage water from roof and floor connected to the main drains on either side of the roads. 160 mm down take pipes shall be provided for the buildings to carry rain water from roof.

For pipe drains, concrete pipe of class NP2 conforming to IS: 458 shall be used. However for road crossing, class NP3 pipe shall be used. If sufficient clearance cannot be provided between the top of pipe and road top, the pipes shall be encased in RCC.

The maximum velocity of drain shall be limited to 2.4m /sec and 1.8m /sec for pipe drains and open drains respectively. However a minimum self-cleansing velocity shall not be less than 0.6m/sec.

For process drains, catch pits shall be provided at the source locations and they shall be interconnected by buried RCC pipelines and connected to oily water system.

No bends and branches shall be allowed in underground pipes. Where change of direction and/or branches are required manholes shall be provided. Distance between Manholes shall not exceed 30m.

Acid cleaning water shall not be discharged into the storm water drains.

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Interconnection of the drains to the existing system shall be planned at applicable locations

**Sewerage System**

The sanitary sewage system shall be conveyed through underground pipelines by gravity and designed accordingly. Manholes shall be provided at all bends, intersection and in straight stretches more than 30 m long. Sanitary system within the buildings shall be provided as per standards and connected to sanitary disposal system specified elsewhere.

Sewers shall be designed for a minimum self-clearing velocity of 0.75 m / sec. Maximum velocity shall not exceed 2.4 m / sec.

**Effluent treatment System**

A Network of drains consisting of PVC pipes within the buildings and stoneware pipes outside (encased in concrete as required) shall be provided to convey oily water / waste water from the various buildings, transformer outlets, etc. The drains shall discharge into one or more oil water separators. The clear water from the oil water separator shall be let off into the Effluent treatment plant.

### 5.3.9 Design Calculations and Drawings

Detailed design calculations / design drawings shall be commenced by Contractor only after approval is obtained from the Owner/Owner's representative to the basic design criteria submitted by the Contractor. No deviation from the approved design criteria will be permitted unless specifically approved again by the Owner/Owner's representative in writing, prior to its adoption.

Civil scope drawings for structural system showing all equipment loads, cut-outs, embedment, etc. based on approved mechanical general arrangement (GA) drawings shall be submitted by the Contractor and these shall be accompanied by detailed design calculations. Drawings and design calculations submitted without prior approval of relevant mechanical GA drawings will not be considered for review.

After the approval of the Contractor's GA drawings, Owner/Owner's representative shall identify the structure for which detailed design calculations need to be submitted by the Contractor. Normally, Owner/Owner's representative shall review and approve design calculations for one typical structure / foundation of each type. However, Owner/Owner's representative reserves the right to call for design calculations for any additional structure and the Contractor shall have to submit these and obtain Owner/Owner's representative's approval. Contractor shall have to ensure that all the balance structures of the system are designed as per the approved designs of typical structures / foundation.

Designs and drawings shall be submitted sequentially in a phased manner and Contractor shall ensure that design calculations / drawings for several structures are not submitted at one time. For this purpose, design / drawing submission schedule shall be furnished by the Contractor for Owner/Owner's representative's review and approval. Owner/Owner's representative will review and furnish comments / approval to the designs and drawings, generally within a period of four weeks from the date of receipt of the same in the Owner/Owner's representative's office. Timely submission of designs / drawings to the Owner/Owner's representative for review / approval is the sole responsibility of the Contractor and postal or other delays as reasons for late / non-submission will not be entertained by the Owner/Owner's representative.

Designs and drawings submitted by the Contractor shall be thoroughly checked and approved by the Contractor's authorized engineers before submission for approval. Any unchecked / unsigned documents will not be reviewed by the Owner/Owner's representative. No claim from the Contractor

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for extension of time or extra cost on this account shall be entertained by the Owner/Owner's representative under any circumstances.

No check will be specifically carried out by the Owner/Owner's representative to verify arithmetical / numerical accuracy of the calculations, which shall remain entirely the Contractor's responsibility.

All design calculations and drawings shall be in English and shall be in SI units.

All modification suggested by the Owner/Owner's representative to meet specification requirements and sound engineering practice shall be incorporated by the Contractor at no extra cost to the Owner/Owner's representative. In this respect, the decision of the Owner/Owner's representative shall be binding on the Contractor.

Should there be a requirement for preparation of separate drawings to show enlarged details to facilitate construction / erection, then such drawings shall also be prepared by the Contractor at no extra cost.

Design drawings showing typical connections and details conforming to design assumptions shall be submitted for approval of the Owner/Owner's representative by the Contractor.

Design drawings for steel structures shall indicate structural arrangement, member size, member forces, splice location, details of base plate, anchor bolts, typical connection details, etc. so that the drawing indicates clearly all the necessary information brought out in relevant design calculations. Proposed bracing patterns shall be subject to approval by Owner/Owner's representative duly considering system requirement point of view. Changes in structural sections on approved drawings shall be got ratified with necessary supporting calculations and reason for the change.

Contractor shall note that all values / dimensions / elevations etc. without supporting break up of data adopted / assumed in his calculations / drawings shall be taken by Owner/Owner's representative to be correct unless these have been specifically indicated in the specification. Any problems later met in this regard shall be made good by the Contractor at his own cost and no extension of time on this ground shall be granted by the Owner/Owner's representative.

The designs shall clearly spell out the erection scheme for various structures envisaged by the Contractor and resulting additional loadings, if any, shall be duly accounted for. Before taking up actual erection work, detailed erection scheme proposed to be followed by the Contractor shall be submitted for Owner/Owner's representative's approval.

Approval / comments conveyed by the Owner/Owner's representative neither relieves the Contractor of his contractual obligations and his total responsibility for correctness of dimensions, materials of constructions, loadings, quantities, design details, assembly fits, performance particulars, safety and stability of the structures including foundations / appurtenances, and conformity of supplies with the statutory laws as may be applicable, nor does it limit the Owner/Owner's representative's right under this contract. No change in the approved designs / drawings shall be permitted without prior written approval of the Owner/Owner's representative.

Preparation of structural steel fabrication drawings is entirely the responsibility of the Contractor.

Detailed civil construction drawings including bar bending schedule for all concrete works shall be prepared by the Contractor and submitted to the Owner/Owner's representative for their review and approval. Construction work at site shall commence only after obtaining written approval to the drawings by the Owner/Owner's representative.

For framed structures, computer analysis shall be adopted and the computer output listing should include all input data covering the design loads and other particulars as specified. The calculations

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shall be supported by all back up documents and references including explanatory sketches and general arrangement drawings.

Computer analysis will be accepted only when the trust worthiness of the program used is established to the satisfaction of the Owner/Owner's representative.

Contractor shall submit typical hand calculations for a few important structural elements to be chosen by the Owner/Owner's representative to validate the computer programs used for the designs.

The Contractor shall submit 2 sets of final calculations/ computer output and 4 sets of drawings and soft copies of design and drawings also for Approval/Stamping by the Owner/Owner's representative and to be distributed after marking 'Approved for Construction' on each drawing. No construction shall proceed at site without 'Approved for Construction' drawings.

## 5.4.0 SPECIFIC TECHNICAL REQUIREMENTS AND FUNCTIONAL REQUIREMENTS

### 5.4.1 Topographical / Contour Survey

Site is not graded but Earthwork in filling grading/levelling required for the construction shall be done by the Bidder. However Bidder shall carry out the same before carrying out engineering activities with no cost liability on the Owner/Owner's representative and the same shall be submitted for the approval of Owner/Owner's representative.

### 5.4.2 Geo-Technical Investigation

Preliminary Soil Investigation has been carried out near the Power Plant Area premises. Copy of the same is attached to the tender. This is intended to give an idea of the soil conditions prevailing at site. However, a detailed Soil Investigation shall be carried out by the Contractor to verify the data provided and to finalise the foundation concept and type of foundations for design work and the report shall be submitted to the Owner/Owner's representative for approval and the approval report shall become the basis for the design. Any variation in soil conditions and foundation parameters from those indicated in tender documents shall be incorporated in the final design without any cost or time implication. If the soil stratum requires pile foundation, the same shall be done by Bidder without any extra cost.

The investigation shall cover sufficient no. of bore holes in each area to get a longitudinal section of the soil profile, cone penetration tests and laboratory tests to obtain the engineering properties of soil including dynamic properties for areas where GTG, STG, Boiler Feed Pumps etc are to be located. Wherever the structures are to be supported on piles, the boreholes shall extend upto hard rock. The investigation and report shall be in line with the technical specification for soil investigation covered in Clause 5.5.0.

### 5.4.3 Fencing

The Cl 6.1.3 of General Technical Specification shall be followed for the areas to be considered for fencing.

### 5.4.4 Site Grading

The area shall be suitably cut and filled to suit the layout requirement.

Fill if any shall normally be made up of Cohesive Non swelling material capable of being compacted upto 95% Modified Proctor density. Filling may also be made using dredged sand in which case a relative density of 85% shall be achieved. In case earth has to be borrowed from outside the plant boundary, the same shall be arranged by the Contractor himself. Earth from Swamps, marshy as well as logs, expansive type of clays, peats, organic material, material susceptible for combustion, material which will react with other material already used in work shall not be used as borrow material.

### 5.4.5 Roads & Paving

**Roads**

The details of the road network shall be in line with the plot plan with the suitable integration with the existing road layout of the Power plant. The arrangement shall be as specified in the Cl 6.1.3 of General Technical Specification. For the details of the design and construction Design criteria of roads shall be considered.(refer Cl 5.3.8).

**Paving**

HRSG area shall be paved with RCC slab, 150 mm thick in grade M20. 230 mm thick rubble soling shall be provided below the paving. Higher thickness as per design shall be provided in areas of vehicular movement. Top of paving shall be kept 100 mm below FFL. All pavings shall be RCC, no PCC paving is allowed.

### 5.4.6 Pre constructional Anti termite treatment

Pre-constructional anti termite treatment shall be given to all vulnerable areas susceptible to termite attack and shall include column pits, wall trenches, foundations filling bellow the floors etc. as per IS : 6313 and other relevant Indian Standards.

### 5.4.7 Underground structures painting

Irrespective of soil report recommendations, For all concrete substructures two coats of ERPB (Epoxide resin based anticorrosive and chemical resistant paint) over a coat of CPCI (concrete penetrating bipolar corrosion inhibitor) shall be applied with 300 to 325 micron DFT for protection of concrete against carbonation & chloride penetration in saline/marine environment.

IP Net coating system will be applied to the external surfaces of columns, beams, fan deck slabs and all other exposed concrete structure. The total DFT of 370 microns will be applied as per manufactures instructions.

### 5.4.8 Construction Facilities

**Construction Water & Power**

For the provision of Construction water and Power **Clause 5.18** of "**General condition of contract**" shall be referred.

**Site office and other facilities**

Limited ware house and godown facility shall be given to the Contractor. However he has to make his own arrangement for additional requirements like site office, quality control laboratory, stores and other facilities in the available space. Contractor shall construct the above buildings and facilities at his own cost. Temporary construction shall be adopted so that these buildings can be demolished after commissioning of project.

Necessary temporary roads shall also be constructed by the Contractor. The quality control laboratory shall have facilities for testing all construction materials and other necessary tests to ensure field quality control.

All amenities to Contractor's workers, such as canteens, toilets, drinking water, rest places, creche shall be provided by the Contractor.

### 5.4.9 Architectural and Finishing Requirements

Reference shall be made to **Clause 5.3.2** for specification/thickness of the various Architectural finishes indicated below:

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**Floor Finishes**

| | | |
|---|---|---|
| Ground Floor (of all plant buildings) Switchgear rooms, Operating floors | - | Indian Patent Stone (IPS) with non-metallic hardener topping |
| Control room | - | Polished vitrified ceramic tiles- 600x600x10 thk |
| Battery room | - | Acid resistance tile flooring, dado and ceiling |
| Offices | - | Polished vitrified tiles of 600x600x10 thk |
| Toilet | - | Ceramic Tiles and skirting with 400x200x6 mm thk |
| Oil, Acid & Alkali- spillage areas | - | Acid / Alkali & Resistant tiles |
| General circulation areas like lift, Entrance area, office areas and | - | Heavy duty vitrified ceramic tiles- 600x600x10 thk |
| Laboratories | | |
| RCC staircases | - | Granite-20 mm thick black colour premium quality |
| Non-Plant Buildings : | | |
| Passages and lobby | - | Heavy duty vitrified ceramic tiles- 600x600x10 thk |
| Other Areas | - | Heavy duty vitrified ceramic tiles- 600x600x10 thk |
| All Pump houses, DG and compressor house | - | IPS with metallic floor hardener |

**False Ceiling**

| | | |
|---|---|---|
| Control room and other office areas | - | LUXALON |

**Roof finishes**

| | | |
|---|---|---|
| All Buildings | - | Polymeric membrane based waterproofing |

**Joinery**

**- Windows**

| | | |
|---|---|---|
| Turbine / Generator bay | - | Glazed, openable windows with aluminium frame |
| Control room | - | Glazed, fixed windows with aluminium frame with double glazing for outer windows and windows facing turbine bay and with single glazing for internal windows / partition |
| Switchgear room | - | Glazed, fixed windows with Aluminium frame |
| Offices | - | Glazed, openable windows with Aluminium frame |

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| | | |
|---|---|---|
| Other buildings | - | Glazed openable / fixed windows with Aluminium frame |
| **- Doors** | | |
| Control room | - | Fully glazed doors with aluminium frame |
| Offices | - | Fully glazed doors with aluminium frame |
| Toilets | - | Timber panelled doors with Teakwood frame and marine board panel with laminated plastic sheet on the inside face. |
| All other doors in Plant Buildings | - | Double plated steel doors |
| Fire barrier doors | - | Specially designed double plated steel doors with insulation having 2 hours fire rating. |
| Non plant buildings | - | Timber flush doors with teak wood frame or Fully glazed doors with Aluminium frame. |
| **- Painting** | | |
| Structural steel | - | Primer coat- Epoxy resin based zinc phosphate of DFT 100 microns thickness |
| | - | Intermediate coat- Epoxy resin based paint pigmented with Titanium dioxide of DFT 100 microns thickness |
| | - | Top coat-epoxy paint suitably pigmented of approved color and shade with glossy finish of 75 microns thick with finishing coat of polyurethane of 25 microns thick |
| All steel doors/windows/ventilators | - | Epoxy based paint of 250 mm microns thickness |
| Timber Joinery | - | Synthetic enamel paint |
| All Ceiling | - | Oil bound distemper (office rooms without false ceiling) |
| | | Acid resistant resin based Epoxy coating over two coats of DECKURDS-S manufactured by FOSROC or equivalent (Battery rooms) |
| | | White washing (all other areas) |
| Internal wall surfaces : | | |
| All areas (except following areas) | - | Epoxy based paint of 250 microns thickness |
| Control room/office/A/C areas | - | Acrylic Emulsion |
| External faces of walls | - | Apex Ultima/Exterior weather shield from ICI or equivalent |

| | | |
|---|---|---|
| Walls of battery room and other acid/alkali spillage areas | - | Chlorinated rubber paint an exposed walls above Dado. |
| | - | 2100 mm high Dado of Acid / Alkali resistant tiling |

**Metal Cladding**

| | | |
|---|---|---|
| STG & GTG Building insulated metal cladding system | - | Double skin permanent colour coated sandwiched |
| Other buildings (Where metal claddings is Specified) | - | Single skin permanent colour coated (non-insulated) metal cladding system |

A standard colour scheme for the different buildings/structures shall be prepared by the Contractor and the approval of the Owner/Owner's representative shall be obtained, before commencement of work.

### 5.4.10 Gas Turbine Generator (GTG) / Steam Turbine Generator (STG) Building

GTG / STG building shall be steel framed building with rigid jointed portal frames in the transverse direction and pin jointed braced frames in the longitudinal direction. TG bay shall have double skin colour coated sandwiched insulated cladding for roof and walls.

The building shall have double skin colour coated sandwiched insulated cladding for roof and walls. Walls have 230 thick brick cladding upto 1.0 metres from floor level and double skin insulated metal cladding above.

One row of continuous windows shall be provided at ground level and above crane girder. The ground floor slab shall be designed to withstand heavy vehicle movement. Suitable floor drainage arrangement with drain pits and buried pipes shall be provided and the same shall be connected to only water system.

### 5.4.11 Gas Turbine Foundation Steam Turbine Foundation and Other Equipment Foundations

**STG Foundation**

The Contractor shall choose between the following two types of foundation systems based on techno- economic considerations. The type of foundation offered shall be indicated in the bid document.

a) Conventional framed foundation in RCC, isolated from other structures of Power House.

b) Spring mounted foundation with inertia block supported on RCC structure isolated from the building frame.

Block type foundation may be adopted depending on the type of machine offered by the Contractor.

**GTG Foundation**

The Gas Turbine Generator foundation shall be a rigid mat foundation.

The Contractor shall furnish detailed calculations containing loading data (static and dynamic), general arrangement drawings and detailed dynamic analysis (free and forced vibration analysis) for Owner/Owner's representative's approval. The model considered for analysis shall take into account pile/soil/structure interaction.

**Other Equipment Foundations**

Foundations for other major equipment such as HRSGs, Boiler feed pump etc. shall also be supported on piles to avoid differential settlement. Type of foundation for other equipment foundation shall be based on the recommendations of the final soil investigation report. Spring supported foundations shall be provided for low frequency machine foundations wherever the same are required from technical considerations. Dynamic analysis calculations shall be submitted for approval.

All the machine foundation structural components shall be tested for voids using Non destructive (NDT) methods as per the recommendations of IS: 13311/UPSV tests, as required by the Owner/Owner's representative.

### 5.4.12 Transformer Yard

Heavy Transformer foundations such as Generator Transformers, Unit auxiliary transformers / Station transformers / Inter Connecting Transformers shall be founded on piles/isolated spread footings depending on the final soil investigation report. Individual transformer foundations shall have its own pit which would cover the area of the transformer and cooler banks, so as to collect any spillage of oil or oil drainage in case of emergency. The oil pit shall be filled with granite stones of 40 mm size uniformly graded. The individual oil pits shall be connected to an oil collection pit which shall be sized to accommodate oil volume of the largest transformer connected to it, without backflow. The oil pit shall be connected to oily water drainage system. Dimensions of the discharge pipe shall consider rainfall intensity also. The water shall be discharged into the nearest drain by gravity flow or pumping.

Provision of fire protection walls shall be provided in between transformer unit for safety point of view.

Local rail track shall be provided from the nearest road for movement of the generator transformers to the foundation location. Rail track foundation shall incorporate jacking pad foundation at intersections of rail racks. Pulling hooks shall be provided at suitable locations for pulling the transformer over the rails.

The area around the transformer shall be provided with RCC grade slab with nominal reinforcement and galvanised chain link fence with fence posts and gates shall be provided. The portion of the fence covering the rail track shall be made of removable type for movement of transformer during erection /removal. Alternatively, gate with provision for locking shall be provided. For small transformers of width not exceeding 5 metres, a gate shall be provided for access of transformer. In addition a small gate, 1.2 m wide shall be provided for man entry. The gates shall have provision for locking.

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### 5.4.13 Local Electrical/Control Rooms

The dimensions of the buildings shall be decided by the Contractor from Equipment Layout considerations.

Local Electrical / Control rooms for DM Plant and CW pump etc. shall be of RCC construction with plastered brick cladding. Windows and doors shall be of fully glazed type with aluminium box frames. Control rooms will be air conditioned and shall have false floor (where no cable cellar is provided) and false ceiling. In electrical rooms, rolling shutters shall be provided for equipment entry. Electrical rooms and control rooms in upper floors shall have provision for lifting of panels and the equipment access door shall be suitably sized to accommodate the largest transportation module of panels. Cable trenches shall be of RCC construction and with pre-cast RCC covers, where no panels are located. Where panels are located, chequered plate cover shall be provided over the balance width not occupied by panels. Sufficient slope shall be provided in the base slab of cable trenches to drain out seepage water/floor wash water. A sump shall be provided in the deepest stretch of trench and the drains shall be sloped towards the sump. The sump shall be connected to the nearest drain by gravity flow (if possible) or by pumping. Wherever the cable trenches inside the building join with or are continuous with external yard trenches a barrier RCC wall shall be provided at the periphery of the building and pipe sleeves shall be provided in the wall for cable entry. The annular space between the pipe sleeve and the cables shall be sealed after erection of cables.

Sufficient office space and toilet facilities shall be provided for operating personnel.

### 5.4.14 Chimney

A single flue self supporting Steel chimney shall be provided for one HRSG. The details & heights given are tentative and contractor shall submit calculation to satisfy that provision of Pollution Control Board are met.

External ladders with safety cage for the entire height with landings at every 15m shall be provided. All exposed structural steel items shall be galvanised/painted.

The roofing panels of the platforms and risers of the staircase shall be of gratings construction 25TH. Handrails for platforms and staircase shall be of tubular construction with 40 NB medium tubes.

Painting of steel surfaces shall be carried out as per specification

Necessary aviation day warning shall be provided by way of orange & white bands as per requirement of aviation authorities.

Galvanised mild steel discrete strakes shall be provided at the top (usually 1/3rd height) if found necessary from design requirements.

The superstructure shall be supported on a foundation system with piles.

### 5.4.15 Water Treatment Plant

All the facilities required for the Water treatment plant like Filtration plant, DM plant shall be housed in a common facility with foundation arrangements for miscellaneous tanks, pumps etc. which are the part of the Water treatment plant. The entire area shall be suitably paved.

Acid/Alkali storage shall be separated with a kerb and the flooring shall be lined with acid / alkali resistant tiles. The drains from the exchangers and vessels discharging into the neutralisation pit

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shall be lined with acid/alkali resisting tiles. Neutralisation pit shall be designed as a water retaining structure with external polymeric membrane based water proofing and internal lining with acid / alkali resistant brick lining. The discharge from the neutralisation pit shall be pumped to Guard pond.

DM Water tanks located outside shall be supported on sand pads with ring wall. The foundation system chosen shall limit the differential settlements.

Suitable maintenance area shall be provided for the water treatment plant.

All the drains in the water treatment plant area shall be provided with FRP grating material.

### 5.4.16 GIS control Room

GIS Control room shall be of RCC construction with plastered brick cladding. Windows and doors shall be of fully glazed type with aluminium box frames. Control rooms will be air conditioned. In electrical rooms, rolling shutters shall be provided for equipment entry. Electrical rooms and control rooms in upper floors shall have provision for lifting of panels and the equipment access door shall be suitably sized to accommodate the largest transportation module of panels. Cable trenches shall be of RCC construction and with pre-cast RCC covers, where no panels are located. Where panels are located, chequered plate cover shall be provided over the balance width not occupied by panels. Sufficient slope shall be provided in the base slab of cable trenches to drain out seepage water/floor wash water. A sump shall be provided in the deepest stretch of trench and the drains shall be sloped towards the sump. The sump shall be connected to the nearest drain by gravity flow (if possible) or by pumping. Wherever the cable trenches inside the building join with or are continuous with external yard trenches a barrier RCC wall shall be provided at the periphery of the building and pipe sleeves shall be provided in the wall for cable entry. The annular space between the pipe sleeve and the cables shall be sealed after erection of cables.

Sufficient office space and toilet facilities shall be provided for operating personnel.

### 5.4.17 Pipe/Cable Racks & Trenches

Pipe / Cable Rack shall be of Steel Construction and shall be single / multi-tiered as required. The cable tray supports shall be provided above the topmost pipe tier. Minimum clearance to the lowest tier of pipe rack shall be 3.0 m in general and 9.0 m under road crossings. In between pipes below pipes shall be finished with concrete flooring.

Pipe / Cable trenches shall be of RCC Construction with precast RCC cover slabs. The trenches shall have cross slope and longitudinal slope and shall be connected to drain pits at maximum 100 metre intervals. The drain pits shall have provision for fixing mobile submersible pumps.

### 5.4.18 CW System

CW Pump houses shall house the cooling water pumps as well as ACW pump for GTG and STG auxiliaries. Necessary forebay and sump accommodating the coarse screen, stop-logs including the handling arrangements shall also be provided in the CW Pump house. Super structure of pump house shall be of Structural steel truss resting on RCC column. No side cladding for CW pump house.

The Mechanical Induced draft cooling tower shall be of RCC framed structure with outside protection of concrete shall be done by use of concrete penetrating silane/siloxane water repelling primer and compatible epoxy top coat with crack bridging ability. DFT of epoxy coating shall be 300 microns. Alternatively, polyurethane based paint system may be adopted with the approval of the Owner/Owner's representative.

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CW channel shall be covered with RC slabs. Precast slabs shall be given at regular intervals for purpose of inspection and maintenance.

Protection of concrete and reinforcement steel against corrosion shall be provided. This shall include use of dense and durable concrete with plasticizer cum water proofing agent, use of sulphate resistant cement, corrosion resistant steel reinforcement, etc.

### 5.4.19 Black start cum Emergency DG Shed

DG shed shall be of Structural steel shed supporting on RCC column with plastered brick cladding all round. Windows and doors shall be of fully glazed type with aluminium box frames. Rolling shutters shall be provided for equipment entry.

### 5.4.20 Compressor House cum workshop

The dimensions of the buildings shall be decided by the Contractor from Equipment Layout considerations.

Compressor house cum workshop shall be of Structural steel shed with side sheeting all round.

Rolling shutters shall be provided for equipment entry. Compressor house shall have provision for lifting of panels and the equipment access door shall be suitably sized to accommodate the largest transportation module. Cable trenches shall be of RCC construction and with pre-cast RCC covers, where no panels are located. Where panels are located, chequered plate cover shall be provided over the balance width not occupied by panels. Sufficient slope shall be provided in the base slab of cable trenches to drain out seepage water/floor wash water. A sump shall be provided in the deepest stretch of trench and the drains shall be sloped towards the sump. The sump shall be connected to the nearest drain by gravity flow (if possible) or by pumping. Wherever the cable trenches inside the building join with or are continuous with external trenches a barrier RCC wall shall be provided at the periphery of the building and pipe sleeves shall be provided in the wall for cable entry. The annular space between the pipe sleeve and the cables shall be sealed after erection of cables.

### 5.4.21 Misc. Plant Buildings

All miscellaneous plant buildings shall be of RCC construction with brick cladding. Glazed steel windows and steel plated doors shall be provided.

## 5.5.0 Standard Technical Specification for Construction

### 5.5.1 Soil Investigation

**Scope**

This specification describes the methods and procedures for soil boring, field and laboratory testing of soil samples. It also outlines the contents of the soil report.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the contract, shall govern in respect of design, workmanship and methods & procedures of testing. Some of the relevant available codes are listed here under.

| | |
|---|---|
| IS: 446 | Presentation of drilling information and core description in foundation investigation. |
| IS:1498 | Classification and identification of soils for general engineering purposes |
| IS: 1888 | Method of load tests on soils |
| IS: 1892 | Code of practice for sub-surface investigation for foundations |
| IS: 2131 | Method of standard penetration test for soils |
| IS: 2132 | Code of practice for thin-walled tube sampling of soils |
| IS: 2720 | Methods of test for soils (ALL PARTS) |
| IS: 2809 | Glossary of terms and symbols relating to soil engineering |
| IS: 2810 | Glossary of terms and symbols relating to soil dynamics |
| IS: 4078 | Indexing and storing of drill cores. |
| IS: 4968 | Method of sub-surface sounding for (ALL PARTS) soils |
| IS: 5249 | Method of test for determination of in-situ dynamic properties of soils |
| IS: 5529 | Code of practice for in-situ permeability tests |
| IS: 9214 | Method of determination of modules of subgrade reaction (k-value) of soils in field |
| IS: 10060 | Code of practice for subsurface investigation for power house sites |

In the event of any conflict between the requirements in the specification and the above referred codes, the former shall govern.

**Equipment and Personnel**

The Contractor shall ensure that all machinery, equipment, instruments, etc., mobilized by him at site are in proper working order and accurately calibrated. If necessary, the Contractor shall obtain from independent and approved testing laboratories such reports/ certification as the Owner/Owner's representative may require to satisfy himself about the reliability of the Contractor's machinery, equipment, instruments, etc. The Contractor shall ensure that the field investigation and laboratory work are performed by competent technical personnel and labour who are specifically qualified and experienced in soil investigation work.

Interpretation and recommendation shall be the direct responsibility of the experienced senior technical personnel in the Contractor's organisation.

**Setting Out**

The Contractor shall be responsible to perform the necessary survey work to locate the bore holes/test locations on ground and obtain the ground levels at these locations with respect to the grids and bench mark provided by the Owner/Owner's representative.

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**Boring through Soil**

The method and diameter of boring shall be approved by Owner/Owner's representative. Minimum diameter of bore hole shall be 150 mm. Uncased holes are permitted only up to a depth where the side can stand unsupported. In case of side fall is noticed, the holes shall be stabilized immediately by using bentonite slurry or providing casing pipes as directed by the Owner/Owner's representative.

Water shall not be added while boring above water table level. Mud circulation/bentonite slurry shall not be used in the bore holes from which water sample is to be collected for analysis.

Casing pipes, where used, shall be stopped 150 mm short of the bottom of the bore at any stage of boring, particularly before collection of undisturbed samples or before conducting Standard Penetration Tests.

Bore holes shall generally be sunk up to the hard stratum or to a depth of 25 m below the ground level whichever is earlier, unless otherwise instructed by the Owner/Owner's representative. Drilling must be continued into rock or hard stratum having SPT value more than 75 for at least two bore holes. If rock/hard stratum having SPT value more than 75 is met with at a shallower depth, it shall be ensured that it is really the rock/hard stratum by continuing the boring into the stratum by 3m. Drilling in rock shall be carried out by rotary core drilling described under Rock Drilling.

The Contractor shall send copies of daily boring records to Owner/Owner's representative at the end of each day. These records shall include the field observations with regard to visual description of soil strata, level of ground water table, drilling fluid consumption, presence of lime, mica, etc. Bore holes shall be backfilled with bentonite/mud cement grout after all samples and other information are obtained from the bore holes.

**Rock Drilling**

During boring operation, once the rock strata is encountered, the normal method of boring operation as described earlier shall have to be stopped and drilling operation shall be resorted to for determining depth and nature of rock strata, in a manner as described below.

Rotary core drilling technique with continuous core recovery should be adopted for drilling through rock. The behaviour of rock mass is governed more significantly by the nature of fractures in the rock than by the type and hardness of the material composing the rock itself. Hence, good drilling technique should be adopted to obtain an intact sample truly representative of the in-situ material and for achieving highest percentage of recovery possible.

Variations in the speed of rotation, the downward pressure on the core barrel, the pressure at which the drilling fluid is introduced into the hole and the length of hole drilled (run length) prior to removal of the core are major items which must be controlled by the driller. In general, coring should be initiated with short runs because the upper portions of rock masses are commonly highly fractured and also because the elevations of any core losses can be more accurately determined. If conditions indicate that it is possible, the length of the runs may be determined by the length of the core barrel.

In zones which are highly fractured or where the barrel continuously becomes blocked, it is essential that short runs be used even though this means removal of the entire string of drilling tools every 300 mm. or less. Reduced bit pressure should be resorted to when rod vibration or chatter occurs. The pressure under which the drilling fluid should be introduced into the hole shall be the minimum to be consistent with adequate removal of cuttings from the hole and proper cooling of the bit. To minimize the erosive action of the drilling fluid on the core and thereby to improve core recovery, double tube core barrels should be used. The casing and core barrel to be used shall be of designation BX or NX.

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During the drilling operation for each bore hole the Contractor shall record the rate of sinking of drill rods, ground water table elevations, if any, nature, type and sequence of rock drilled. From the recovered cores, the Contractor shall determine nature of fractures and degree of weathering of the rock for each bore hole. The Contractor shall also note and record any appreciable loss of drilling fluid throughout the entire drilling operations for each bore hole. The Contractor shall also determine the percentage recovery ratio and rock quality designation from the recovered cores for each stage of core advance and for all the bore holes.

The Contractor shall furnish all the information mentioned above fully verified and signed by the Owner/Owner's representative at site and submit them in triplicate to the Owner/Owner's representative.

The drilling operation shall be terminated either 3 metres in hard rock or 95% of core recovery whichever is later.

In addition to the above mentioned points, the Contractor shall also take into consideration the provisions of the latest revisions of the relevant BIS Codes of Practice along with Amendments, if any.

**Collection of Samples**

**Sampling Depths**

Soil samples shall be taken generally at intervals of 1.5m and each change of strata in bore holes. Disturbed and undisturbed samples, wherever possible shall be collected. All samples collected shall be suitably and uniquely labelled.

**Undisturbed Soil Samples**

Soil samplers shall conform to relevant Indian standards. Undisturbed samples shall be 90 mm in diameter and 450 mm long. The type of sampler shall be appropriate for the soil to be collected. The undisturbed samples need not be collected when the SPT value is greater than 50.

All care shall be exercised by the Contractor not to disturb the soil during sampling operation. The sampler shall be forced in one continuous motion, not driven, into the ground below the casing. The sample shall be shipped to the laboratory in such a manner as not to cause any disturbances to or loss of moisture from the sample. The soil sample shall not be removed from the sampler tube and the ends shall be filled with paraffin and sealed with metal/ plastic caps. The Contractor shall have, at site, adequate number of samplers at all times.

**Disturbed Soil Samples**

Disturbed soil samples shall be collected from thin walled samplers or split spoon samplers of SPT. The samples shall be collected in air tight jars.

**Ground Water Sample**

Ground water sample shall be collected from any three of the bore holes. Care shall be taken to ensure that no other extraneous water, slurry or storm water, etc., gets mixed with natural ground water in the bore hole before collection. One litre of ground water shall be collected in clean and air tight container to be sent to the laboratory for immediate testing.

**Trial Pits**

Trial pits shall be of minimum 3 m. x 3 m. size at base so as to permit easy access for a visual examination of the walls of the pit and to facilitate sampling and in-situ testing operating. Precautions shall be taken to ensure the stability of pit wall, if necessary even by the provision of shoring. Arrangements shall be made for dewatering if the pit is extended below water table. In-situ tests shall be conducted and undisturbed samples obtained immediately on reaching the specified depths, so as to avoid substantial moisture changes in the subsoil.

After completion of tests and examination, the pits shall be suitably backfilled as directed by the Owner/Owner's representative. Unless specified otherwise, the excavated soil shall be used for this purpose.

**Standard Penetration Test (SPT)**

The equipment and procedure for Standard Penetration Test shall conform to IS: 2131. The bottom of bore hole shall be cleaned of mud slurry before conducting the Standard Penetration Test (SPT). The SPT shall be conducted generally at 1.5 m intervals and at changes of soil strata, as per IS: 2131. The blow count shall be recorded. If the blow count exceeds 75 or if the penetration is less than 25 mm per 50 blows, the test shall be stopped.

**Static Cone Penetration Test**

The test equipment and procedure shall meet the requirements of IS: 4968 (Part III). This test shall not be carried out on gravelly soils and for soils having SPT value greater than 50. The capacity of the equipment to be used for test shall not be less than 3.0 tonnes but preferably 10.0 tonnes. The cone resistance and cone & friction resistance shall be measured at pre-determined intervals. The rate of pushing shall be 1 cm per second. Unless otherwise specified it shall be conducted up to a depth of 25 m. If the penetration is found to be difficult at a shallower depth due to occurrence of fragment of rock or boulder the test shall be terminated and be executed at adjacent location as directed by the Owner/Owner's representative.

The results shall be prescribed in graphical form as well as in tabular form as given in Appendix-A of IS: 4968 (Part III).

The Contractor shall carefully interpret the results of boring and sounding.

**Dynamic Cone Penetration Test**

The test equipment and procedure shall meet the requirement of IS: 4968 (Part II). The driving shall not be done for more than 30 cm at a time after which it shall be stopped for a minute or two. Pumping shall, however, be continued. The tests shall be terminated when the blow counts exceed 35 for 100 mm. penetration when the cone is dry and 20 for 100 mm. penetration when the cone is penetrated by circulating slurry.

The results shall be reported in a suitable tabular form giving below counts for every 30 cm. penetration supplemented by a graphical plot of blow count versus depth.

**Plate Load Test**

Plate load tests shall be conducted at the specified founding depth by making test pit of sufficient size as per IS: 1888. Side protection, if required, shall also be provided by the Contractor at no extra cost. The Contractor shall provide suitable access to the bottom of the pit. The load shall be applied to the plate by hydraulic jack of suitable capacity jacking against a fixed platform loaded with sand bags or heavy truss anchored in the ground. The increment of each loading shall be such that the

ultimate load is reached in not less than ten increments. The water table level shall be noted in the nearest bore hole at the time of testing. If water table is within test zone to a depth of 3 times the width of plate, it is advisable to conduct the test at higher level.

The pit shall be backfilled with excavated earth in layers not exceeding 300 mm and well compacted.

**Cyclic Plate Load Tests**

The equipment and set up for cyclic plate test shall be similar to plate load test described above. The testing procedure shall be as per IS: 5249. The duration of each loading and unloading cycle shall be decided based on the type of soil under investigation. The initial loading and unloading cycles up to the safe bearing capacity of soil should be with smaller increments in load. The magnitude of load increment should be such that the ultimate load is reached in five to six increments. Based on the above test, the Contractor shall recommend the coefficient of sub- grade reaction, coefficient of elastic uniform compression.

**Vane Shear Test**

The test shall be conducted in soft to firm clays and sensitive clays. The test shall also be conducted in case of stiff fissured clays where samples cannot be taken. Tests may also be conducted by direct penetration from ground surface. The equipment used for vane shear tests shall be as per IS: 4434.

Straightness of vane shall be checked while the entire assembly of vane connected with the rod is being lowered to the bottom of bore holes. Samples shall be collected from the levels at which the tests have been conducted.

The results shall be reported in a suitable tabular form.

**In-Situ Permeability**

In-situ permeability test shall be performed in the bore holes specified or as directed by the Owner/Owner's representative for the determination of the permeability coefficient of the soil. The tests shall be conducted as per IS : 5529 (Part I) using pumping out method with piezometer installations.

**Menard Pressure Meter Test**

This test shall be carried out as per IS : 1892 to the full depth of bore holes, to assess the coefficient of earth pressure at rest and the stress-strain modules of soil. The tests shall be carried out at every 3.0 m. intervals.

The Contractor shall submit, for approval of the Owner/Owner's representative, detailed arrangement drawings for the tests including the detail of the equipment proposed.

**Block Vibration Test**

In-situ dynamic properties of the soil shall be determined by performing Block vibration tests in accordance with IS: 5249 at the location and depth indicated. A plain concrete block in concrete grade M 15 and of size 1500 x 750 x 700 mm shall be cast, at the specified founding depth for machine foundations. The test pit should be of suitable size having sufficient clearance for conducting the test. Forced vibration and free vibration tests shall be conducted. The wave propagation test for determination of shear modules shall also be conducted by exciting the block to the steady state vibrations in the vertical direction. The block shall have suitable provisions to fix the oscillator in different modes and at different frequencies. By suitable and adequate instrumentation,

the soil responses to the excitation are measured and various dynamic properties are computed. Based on these tests, the Contractor shall recommend design values to be adopted in design. Before backfilling the pit, the concrete block shall be dismantled and disintegrated and all rubbish shall be disposed off as directed by the Owner/Owner's representative.

**Electrical Resistivity**

Electrical Resistivity of subsurface layers shall be determined by vertical electrical soundings by Wenners method as indicated in IS: 1892. The spacing between the electrodes is initially kept as 0.5 metres and then gradually increased in steps of 0.5 metres up to 5.0 metres depth. Graphical representation of resistivity versus depth shall be plotted.

**Laboratory Tests**

All laboratory tests to assess the engineering properties of soil/rock shall be conducted by the Contractor in an approved laboratory. It is not the intent nor is it practical to specify all technical details and requirements of soil testing in the laboratory that would enable the proper evaluation of the soil parameters used in the detailed engineering stage. The Owner/Owner's representative reserves the right to direct the Contractor to perform any particular test during the course of the investigation. The Contractor shall keep furnishing preliminary copies of all test results to the Owner/Owner's representative for their review.

**Soil Report**

The soil report shall include but not limited to the following.

- A detailed write up on the procedures adopted in all phases of the soil investigation.
- A plan of bore hole and field test locations.
- Individual bore logs indicating various soil strata encountered their thicknesses and classifications, sampling locations, ground level, laboratory test results, SPT blow counts, ground water level and pertinent data.
- Cross section of soil profile in two perpendicular and diagonal directions and all load test curves & consolidation test curves.
- Detailed test results, laboratory observations both in tabular and graphical form and necessary extracts from technical literature used in calculation, evaluation & recommendations.
- Recommendation for type, depth, ultimate and safe bearing pressure and settlement of foundations for various structures.
- A summary of all design parameters.

The Contractor's recommendations shall include specific and definitive information on the following, supported by detailed calculations.

a. Founding depths for various foundations as given below and corresponding safe soil bearing capacities evaluated from both strength and settlement considerations. Values obtained from field tests and laboratory tests shall be compared and suitable interpretation shall be furnished.

   i) Heavy foundations for powerhouse building columns, boilers.
   ii) Heavy machine foundations such Turbo generator foundation, FD fans etc.
   iii) Foundations for smaller and larger circular storage tanks.

iv) Light foundations for non-plant buildings, sheds, compound wall, small pumps etc.

b. Consolidation and settlement characteristics.

c. Coefficient of sub grade reaction.

d. Dynamic properties of soil.

e. Type and capacity (vertical and lateral) of piles, if necessary, and data/ information on related aspects.

f. Anticipated problems during foundation construction and recommended solutions.

g. Roads, paving and grade slabs.

h. Harmful chemical contents in soil and ground water, if any, and recommendations to protect underground structures from their harmful effects.

i. Coefficient of earth pressure to be adopted for design of retaining structure.

j. Specification for soil to be used for backfilling.

k. Swelling characteristic of soil clearly indicating all swelling pressure etc.

### 5.5.2 Earthwork in Site Grading & Embankment

**Scope**

This specification covers the requirement in respect of materials, workmanship and quality for clearing, grubbing, grading, forming embankments and compacting of the areas in all kinds of soil.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

| | |
|---|---|
| IS:2720 | Method of test for soils - grain size (Part 4) analysis |
| IS:2720 | Method of test for soils - Determination (Part 5) of limit & plastic limit |
| IS:2720 | Method of test for soils - Determination (Part VII) of water content - dry density relation using light compaction. |
| IS:10379 | Code of practice for field control of moisture and compaction of soils for embankment and sub grade. |

**Materials**

Earth used for filling shall be selected earth as approved by the Owner/Owner's representative and free from organic and other objectionable matter. As far as possible excavated earth from excavation for foundations within the project area shall be used for filling. All clods of earth shall be broken or removed. Expansive soil shall not be used. The Contractor shall indicate in his offer the location of borrow areas and type of soil that he proposes to use.

Soil having plasticity index less than 20 and maximum proctor laboratory dry density more than 1.5 gm/cc shall only be used.

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Adequate dewatering facilities like dewatering pumps, pipes etc. shall also be provided by the Contractor for this work including for excavation in borrow areas at his own cost.

**Initial Levels**

The Contractor shall carry out the survey of the site before starting any work by taking accurate cross-section of the areas perpendicular to established grid / reference lines at 10 m interval or other intervals chosen by the Owner/Owner's representative based on the ground profile. For embankments initial levels shall be taken along the line of embankment and at right angles to the proposed alignment. These shall be checked by the Owner/Owner's representative and thereafter properly recorded.

**Clearing**

The area to be graded shall be cleared of plants, logs, stumps, bush vegetation, rubbish slush etc. If any roots of stumps of trees are met they shall also be removed. The material so removed shall be disposed of as directed by the Owner/Owner's representative, including burning if necessary. Trees to be cut shall be marked and the Owner/Owner's representative's approval taken before felling them. After the tree is cut and roots taken out the pot holes formed shall be filled with good earth in 250 mm layers and compacted. The tree shall be cut in suitable pieces as instructed by the Owner/Owner's representative,stacked and delivered to the Owner/Owner's representative. After the area is cleared of plants, logs, vegetation etc., the filling area shall be compacted with power roller of 8 - 10 tonne capacity to obtain 90% of maximum proctor laboratory dry density of top soil as per IS:2720 part VII, Initial level shall be taken again as described in the above clause. These initial levels shall be considered for calculation of compacted volume of fill subsequently.

**Grading**

The grading shall be carried out so as to obtain the levels indicated in the drawing after compaction. Generally such grading includes cutting and filling. The Contractor may employ any suitable means, mechanical, manual or a combination of both. The filled up area shall normally be filled with selected earth in layers of 250 mm (in loose condition uncompacted thickness) and compacted using rollers so as to obtain a density desired by the Owner/Owner's representative, normally minimum of 95 % of Proctor dry density for cohesive soils and 85% of Relative Density for non-cohesive soils.

When a layer of loose earth over an area has been removed during grading, the area shall be prepared by ploughing to loosen the earth before addition of soil to make up the lost earth. After the addition of soil over the ploughed area, it shall be compacted to the desired density.

**Embankments**

The finished formation width, side slopes and grade of the embankment shall be true to the line and level as shown on the drawings.

The embankment shall be made up in layers not exceeding 250 mm thickness (uncompacted thickness), over the whole width between the surface of the side slopes and shall be slightly concave in section so as to retain the water for water subsidence. All large clods shall be broken up.

When the embankments are on side-long ground the whole area of the embankment on slope shall be benched out or stepped so as to prevent the material from slipping.

In construction of embankment over the culverts or pipe drains care shall be taken to bring the embankment up, equally on both sides and over the top of the structure. Earth embankment shall be compacted as specified under Grading. In rock embankments, the rock filling shall be. carefully packed to the depths as shown on the drawing.

If embankments are made from borrow pits, the Contractor shall excavate the earth from borrow pits at the locations indicated on the drawings. They shall be regular in width and shape and shall be properly graded, drained and finished with neatly trimmed slopes.

**Testing and Acceptance Criteria**

The degree of compaction shall be as specified above or as decided by the Owner/Owner's representative as per site conditions. The actual method for measuring the compaction will be decided by the Owner/Owner's representative. The Contractor shall carry out at his own cost the required tests to prove that the soil has been compacted to the desired dry density. These tests shall be carried out at different stages of filling and also after entire fill height has been completed. Since the degree of compaction largely depends on moisture content of soil, a close watch shall be kept on it and corrections done to optimise the moisture content. Generally the moisture content shall be brought to within plus or minus 2% of optimum moisture content prior to rolling. The quality control operations shall include but not limited to the following items of work.

i) Lines, levels and grades

   a) Periodic surveys

   b) Establishment of markers, boards etc.

ii) Grading

   a) Checking the quality of fill material

   b) Checking moisture content of fill material

   c) Checking degree of compaction

The Contractor has to offer inspection request on each layer and Owner/Owner's representative may take the inspection on degree of compaction if desires. If a layer fails to meet the required density, it shall be reworked or the material shall be replaced and method of compaction/equipment altered as directed by the Owner/Owner's representative to obtain the desired density.

### 5.5.3 Concrete Piling

**Scope**

This specification covers the requirement in respect of materials, installation and testing of driven cast-in-situ, bored cast-in-situ, driven precast and bored precast concrete piles.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions (with all official amendments) as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the Contract, shall govern in respect of workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed hereunder:

IS:2131 Method of standard penetration for soils

IS:2911 Code of practice for design and construction of pile foundation.

**Materials**

The materials, cement, aggregates, steel used in the work shall be as specified hereunder:

Cement Portland slag cement conforming to IS-455 with minimum 50% slag or Portland pozzolana cement conforming to IS:1489 shall be used for construction, however if detailed final Soil Investigation Report recommends for more severe cement, the same shall be used without any extra cost to Owner/Owner's representative.

Aggregate Machine crushed blue granite conforming to IS:383.

Steel TMT/High Yield Strength Deformed steel bars of grade Fe-500 bars conforming to IS-1786. painted with fusion bonded epoxy coating as per IS:13620 shall be used for reinforcement.

Water used for mixing shall be potable water conforming to IS:456.

**Requirements for Precast Piles**

Precast piles shall be of octagonal shape, unless otherwise specified or approved by the Owner/Owner's representative.

The casting yard shall be so arranged that piles can be lifted directly from their beds and transported to the installation point with a minimum of handling.

Piles shall be cast in one operation. The form boxes shall be robust and clean using horizontal steel shutters of suitable length. The concrete shall be vibrated with the aid of shutter/immersion vibrators. Care shall be exercised that no cement slurry is lost. All faces of the piles shall be worked to be as smooth and dense as possible, including the exposed face at the top.

The cross-sectional dimensions of the pile as cast shall not be less than the specified dimensions and shall not exceed them by more than 6 mm. Further, any face of the pile shall not deviate by more than 6 mm from a straight edge 3 m long, laid on the face. The centroid of any cross-section of the pile shall not deviate by more than 12 mm from the straight line connecting the centroids of the end faces (head and tip) of the pile, or 1/500 of pile length, whichever is the least.

Side shutters shall not be struck till after 24 hours from the time of casting or later if so instructed by the Owner/Owner's representative.

Piles shall not be moved from the beds on which they were cast until the concrete has sufficiently hardened. This period shall be a minimum of 10 days for ordinary Portland cement/Sulphate resistant Cement concrete and 7 days for rapid hardening Portland cement concrete from the time of casting. Care shall be exercised by the Contractor during such movement that the pile does not crack or chip.

Piles shall be kept continuously wet for ten days from the time of casting, but longer curing shall be done, as directed by Owner/Owner's representative, when hard driving is expected.

When piles are stacked between the period of wet curing and driving/installing, they shall be protected from rapid drying by sheltering them from the wind and direct sunlight by covering the stacks.

All care shall be taken at all stages of transporting, lifting and handling of the piles to ensure that they are not damaged or cracked. During transport, the piles shall be supported at the appropriate lifting hooks provided for the purpose. If the piles are put down temporarily after being lifted, they shall be placed on trestles or blocks located at the lifting points.

Piles shall be provided with a coaxial cast iron or steel shoe for protecting the tip of the pile during driving, as indicated on drawing. The area of the tip of the shoe shall be such that the stress in the concrete in this part of the pile is within the safe limits.

For precast piles to be installed in pre-bored holes, a grouting pipe of appropriate diameter shall be embedded along the centre line of the pile for the entire length.

**Requirements for Driven Piles**

Standard helmet of cast-steel or structural steel shall be fitted on the pile head, unless a follower is required, to ensure axial alignment of the hammer and pile at instant of impact. Short hardwood dolly in one piece not thicker than the width of the pile with grains parallel to the pile axis shall be used with the helmet and shall be closely fitted inside the recess on top of the helmet. A steel band is to be pressed over the top of the dolly to prevent it from splitting. A steel plate of 25 mm minimum thickness shall be used on top of the dolly to distribute the hammer blows. The use of wood chips, small wood blocks or such other materials is prohibited. The Contractor shall note on the driving log when fresh cap block material is placed under the hammer and shall discount the measured resistance to driving immediately thereafter.

It is desirable that double acting diesel/ compressed air/steam operated hammers are used for driving the pile. Single acting hammers may be used only if permitted by the Owner/Owner's representative. The Bidder shall submit with his Bid, the details of driving equipment to be specifically deployed on this job. It shall be the responsibility of the Contractor to use the right equipment for driving. The Contractor shall satisfy the Owner/Owner's representative regarding suitability, efficiency and energy of driving equipment. The hammer blows shall always be in line with the pile axis. Drop of each and every blow shall be controlled and monitored.

The heaviest practical hammer with drop or stroke limited to the minimum shall be employed so as not to damage the pile. In any case, the weight of the hammer shall exceed 10 times the weight of 1.0 M length of the pile. Long continued driving after the pile has almost ceased to penetrate, shall be avoided. Care shall be taken not to damage the piles by overdriving. Any sudden change in the rate of penetration, which cannot be ascribed to the nature of the ground, shall be noted and its cause ascertained, if possible, before driving is continued/pile is accepted.

The Contractor under the supervision of the Owner/Owner's representative shall take temporary compression or rebound set curves on the piles during driving, as described in IS-2911. These shall be taken at a few pile penetration depths and at the final set, on the first few piles of each size and/or length. The values of (C1 + C2 + C3) thus obtained shall be used to recheck and modify if necessary the required "Set" for the safe load bearing capacity specified for the pile.

The final set of each pile shall be recorded as the penetration in millimetres per 10 blows.

Set criterion shall be mutually agreed upon on the basis of set recorded for piles for initial pile load tests, the Contractor's pile driving equipment, etc. In case of any conflict or disagreement, decision of the Owner/Owner's representative shall be binding.

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**Installation of Piles**

**General**

- **Location of Piles**

A plan in triplicate showing clearly the designation of piles to be installed by an identifying system shall be submitted to the Owner/Owner's representative before the installation of piling is started.

- **Trial bore holes**

To ascertain the founding strata, especially for precast driven piles, trial bore holes shall be carried out.

- **Record of Piles**

The record shall be kept by the Contractor in an approved form of the total penetration of every pile and the behaviour of each pile during driving / boring. Type of soil encountered, depth of boring/driving, depth of water table, cut-off level working level, time taken for concreting, consumption of cement, density of bentonite slurry and all other important observation shall be indicated in the standard record format. Any deviation from the designated location, alignment or load carrying capacity or any upheaval noticed only any pile during installation shall be immediately reported to the Owner/Owner's representative and adequate corrective measures taken as decided by the Owner/Owner's representative. On the completion of pile installation, pile driving / boring records together with the records of such changes or other sub-surface information that were obtained during the installation of piles shall also be submitted by the Contractor with the Owner/Owner's representative in triplicate.

**Sequence of Installation**

The Owner/Owner's representative shall decide the sequence of the group of piles that the Contractor should undertake for installation and Contractor shall proceed from those in the centre of the group towards those on the periphery or from one side to other.

**Installation**

- **General**

Piles shall be installed with due consideration for safety of adjacent structures, working equipment etc by a method which leaves their strength unimpaired & which develops and retains the required load bearing capacity.

- **Driven cast-in-situ piles**

Steel casings, shall be straight and shall have sufficient wall thickness and strength to withstand without damage, distortion etc., the handling stresses and driving stresses set up in obtaining the specified depth and set and to resist harmful distortion or buckling due to soil pressures developed during installation of pile or adjacent piles. Joints shall be welded or lock seamed. Casings and their joints shall be sufficiently tight to exclude water.

Casings shall be of such diameter as to give the specified nominal diameter of the pile. Casing lengths shall be the maximum consistent with standard practice, transport, handling and driving facilities.

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Detachable shoes shall be of cast iron or mild steel and of requisite strength of the standard sizes used with the respective steel casings and the shoe shall be coaxial with the steel casing.

In case of piles close to the existing plant & structures, the Owner/Owner's representative if necessary, may specify the fall of smaller than the standard and working hours for the rig & no extra claim shall be entertained due to these restrictions. The equipment and methods for installing piles shall be such that the loss of energy is limited to a suitable minimum.

Casings distorted from true and uniform shape, whether caused by driving or earth and water pressure, resulting in a reduction of the cross-sectional area of the pile in excess of 10% shall not be used on the work.

If there is a major variation between the depths at which adjacent foundation piles in a group meet refusal, a boring shall be made nearby to ascertain the cause of this difference. If the boring shows that the soil contains pockets of highly compressible material below the level of shorter pile, the pile shall be taken below the bottom of such layer.

Provisions of IS: 2911 (Part 1/Sec.1) shall be adopted for requirements not covered above.

- **Bored cast-in-situ piles**

Bored cast-in-situ piles shall be installed by suitable choice of techniques covering the manner of soil-stabilisation i.e. the use of casing and / or use of drilling mud, manner of concreting i.e. direct pouring and placing or by use of tremie and choice of boring tools in order to permit a satisfactory installation of pile. Preferably Direct Mud Circulation method shall be adopted for installation. The bentonite and bentonite slurry shall meet the requirement specified in IS. A minimum length of 1 meter of temporary casing shall be inserted in each bored pile. In case of collapsible soil strata, the full depth of boring shall be provided with temporary casing. If piles are founded on rocky strata, the casing shall be keyed for a minimum depth of 150 mm. After the borehole has been drilled to its final depth, fresh bentonite slurry shall be pumped through the chisel resting at the base of hole, to remove completely all cuttings and other loose materials from the base of pile. During this flushing the speed of pump shall be increased to maintain additional high pressure for 10 - 15 minutes. After the hole has been thoroughly flushed, the chisel and API rods shall be removed for the concrete. When installing piles in a group, sufficient time shall be allowed for freshly poured concrete in the adjacent pile to set.

Provisions of IS: 2911 (Part 1/Sec.2) shall be adopted for requirements not covered above.

- **Driven Precast Piles**

A minimum period of 28 days shall be allowed for curing from the time of casting the pile, before selecting the pile for driving. This period may be relaxed by the Owner/Owner's representative if he is satisfied that the pile has achieved adequate strength to take up driving stresses without suffering distress. In such case the Contractor shall obtain expressed permission of the Owner/Owner's representative in writing.

Driving shall be performed with fixed leads or leaders capable of holding the pile firmly in position, with the hammer and the pile in axial alignment. Care shall be taken during driving to prevent and correct any tendency of the pile to twist or rotate. Pile drivers shall have firmly supported leads extending down to the lowest point the hammer must reach.

Where cut off levels are below grade level, the Contractor shall be required to use followers to drive the pile further below ground level when the head of the pile is near ground level.

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In general, driving sequence of piles and clusters of piles shall, unless otherwise specified by the Owner/Owner's representative, proceed from the centre of the pile groups and progress outward from the centre, towards any two opposing sides of the perimeter.

Piles shall be driven in a continuous manner, without interruption, until the pile has been driven to final elevation of specified resistance, or a combination of both as shown on the drawings or as directed by the Owner/Owner's representative. Where, in exceptional cases driving is interrupted before final penetration is reached, the set per blow immediately upon retrieving shall be disregarded and such pile shall be driven to the final elevation to which the adjacent piles, which were not interrupted, have been driven.

Piles shall be driven in such manner that previously driven piles are not damaged/affected including partly set concrete of lengthened piles.

Piles shall not be abandoned partially driven at the end of the shift.

When a pile head is damaged during driving, the head shall be cut-off square at sound-concrete level, and all loose particles shall be removed by wire brushing, followed by washing with water. If pile is subjected to further driving, the head shall be replaced by concrete of an approved grade. Such piles shall not be driven until appended concrete has reached the specified strength.

If the driving of the pile has been accepted but sound concrete of the pile is below the cut off level, the pile shall be made good to the cut-off level with concrete of a grade not inferior to that of the concrete of the pile. While lengthening the pile, joints in the reinforcement shall be such that the full strength of the bar is effective across the joint. Welded joints shall be made in accordance with IS: 816 and/or IS: 1323 and the main longitudinal reinforcing bars in the head of the pile shall be exposed for at least 300 mm below the weld. For lap or splice joints sufficient link bars shall be provided to resist eccentric forces.

Provisions of IS:2911 (Part 1/Sec.3) shall be adopted for requirements not covered above.

**- Bored Precast Piles (Precast Pile Installed in Prebored Hole)**

Boring shall be similar to that for bored cast-in-situ piles.

Where indicated by site conditions, precast piles in prebored holes shall be socketed into competent stratum as indicated on the drawing or as directed by the Owner/Owner's representative.

In order to determine the competency of the stratum including rock for socketing as well as supporting the pile, standard penetration tests (SPT) shall be conducted during the progress of boring/chiselling into the stratum including rock.

The precast pile shall be brought near the borehole and lifted in vertical position. The pile shall be suspended over the borehole. The flush water shall be switched on through the central grout passage in the pile as the pile tip approaches the founding strata. On reaching the founding strata, water flush shall be continued for 10-15 minutes. Flushing shall be done under adequate pressure in order to ensure the cleaning of borehole bottom of any soft/cohesive material.

After cleaning the bottom of borehole, cement/sand grout (1 cement: 2 sand) with W/C ratio of 0.55 shall be pumped through the grouting pipe in the pile so as to grout the base and fill up the annular space around the pile. The grouting pressure shall be adequate to grout the full length of the pile. The minimum thickness of the grout mantle shall be 40 mm.

Temporary liners/casings if provided shall be extracted progressively as the grout level inside the borehole rises.

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Provisions of IS: 2911 (Part 1/Sec.4) shall be adopted for requirements not covered above.

**Jetting of Piles**

Jetting of piles by means of water shall not be permitted.

**Reinforcement**

All reinforcement for use in pile shaft shall be assembled and joints in longitudinal bars, if unavoidable, shall be made by lapping and the lap shall be tack-welded to prevent distortion of the reinforcing cage. The projecting length of the longitudinal bars beyond the pile cut-off level shall be equal to 50 times bar diameter. Minimum cover shall be 50 mm; however in aggressive soil cover shall be increased to 60 mm.

The helical reinforcement shall fit tight against the longitudinal bars and be fixed to them by soft annealed 16 gauge block iron wire, the free ends of which shall be turned into the interior of the pile.

In addition, lateral circular templates with 8 mm dia bar shall be provided at spacing specified by the Owner/Owner's representative and longitudinal bars shall be welded to templates. Care shall be taken to preserve the correct cover and alignment of reinforcement free from any twist, throughout the operation of placing the reinforcing cage into the borehole and concreting of pile.

**Concreting work in cast-in-situ piles**

The specifications laid down for concrete work shall also apply to the concrete work for piles, except as modified in this specification. The Contractor shall submit mix design as per IS method or ACI Code 211.1 and carry out adequate number of tests to ensure the minimum strength. The minimum cement content and the maximum water cement ratio considered in mix design shall be 400 kg/m3 and 0.45 respectively unless otherwise specified. The slump (130 - 180 mm flowing consistency for bored piles, 80-100 mm flowing consistency for driven piles) shall be selected by the Contractor based on the suitability of the chosen method of concreting for pile installation. If, during execution, workability is to be increased, higher cement content or admixtures shall be used with Owner/Owner's representative's approval.

The concrete shall be freshly mixed and of sufficient quantity in the casing (where used) to ensure that during the withdrawal of the casing, a sufficient head of concrete is maintained to prevent inflow of subsoil and ground water and to prevent formation of necking or wasting.

Exposed portions of piles be cured for ten (10) days.

When installing piles in a group, sufficient time shall be allowed for the freshly poured concrete in a pile to set before installing adjacent piles.

All care shall be taken to prevent formation of voids in the pile by pockets of air trapped within. Particular attention shall be paid to this during withdrawal of casing. The volume of concrete placed shall be checked against calculated volume of pile at the time of withdrawal of casing.

**Minimum Casting Levels**

Piles shall be cast at least 500 mm above the finished cut-off level so as to permit the removal of all latiance and weak concrete.

**Testing of Piles**

**General**

The Contractor shall cast/drive test piles for each kind of loading and carry out the load bearing tests before actually commencing the work unless otherwise specified, the number of test piles shall be based on the criteria specified in IS:2911(Part 4). The Contractor may be allowed to use quick setting cement or add the necessary admixtures to enable him to conduct the test within seven (7) days after installation for cast-in-situ piles or within 7 days of casting for precast piles.

The load tests shall be carried out by the Contractor as described herein. the load test on working pile however shall not normally be undertaken by the Contractor within 28 days after the installation of the pile in position for cast-in-situ piles or 28 days after casting precast piles. The vertical load test shall be carried out on single pile. The lateral load test shall be carried out between two piles. Before any load test is made the proposed arrangement for carrying out the load test including the preparation of the structure to receive the loads and the type of loading to be adopted shall be furnished by the Contractor and approved by the Owner/Owner's representative. The load tests shall be made under the supervision of the Owner/Owner's representative. The complete record of such loads shall be filed with the Owner/Owner's representative in triplicate. The responsibility for carrying out such load tests satisfactorily and safely and on proper lines rests with the Contractor.

The test shall be carried out at cut-off level wherever practicable, otherwise suitable allowance shall be made in the interpretation of the test results.

**Method of Testing**

The testing shall be conducted according to IS:2911, Part IV as described herein. If there is any discrepancy observed between the IS guidelines and the specification given here, the following guidelines shall be governing.

- Vertical load test (compression)

The test load to be applied on the loading platform supported on pile shall be

a) 2.5 times the proposed safe designed load in case of test pile.

b) 1.5 times the proposed safe designed load or upto a maximum settlement of 25 mm whichever occurs earlier in case of working pile.

The load increments shall be

a) 1/5, 2/5, 3/5, 4/5, 1, 1.25, 1.5, 1.75, 2, 2.25 and 2.5 times the safe designed load in case of test pile and

b) 1/5, 2/5, 3/5, 4/5, 1, 1.25 & 1.5 times the safe designed load in case of working pile.

Readings of settlements shall be recorded with minimum 2 dial guages of 0.01 mm sensitivity each positioned at equal distance around the pile and normally held by datum bars resting on immovable supports at a distance of 3D (subject to minimum of 1.5 m) from the edge of the pile where `D' is the stem diameter of circular piles or diameter of circumscribing circle in the case of square or non-circular piles.

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Taking of measurement or displacement of the pile top for each load increment is continued until the settlement is either 0.1 mm in first 30 minutes or 0.2 mm in first one hour or till 2 hours whichever occurs first.

The final test load shall be maintained for 48 hours. The safe load on single pile for the test pile shall be at least of the following:

Two thirds of the final load at which the total displacement attains a value of 12 mm.

50 percent of the final load at which the total displacement equal 10 % of the pile diameter in case of uniform diameter piles and 7.5 % of bulb diameter in case of under-reamed piles.

- **Lateral Load Test on Pile**

The safe lateral design load shall be the least of the following:

i) 5% of the safe axial load.

ii) Load corresponding to a maximum calculated deflection of 5 mm.

The test load shall be

a) 2.5 times the proposed safe lateral design load or 12 mm whichever occurs later in case of test piles.

b) 1.5 times the proposed safe lateral design load or 7.5 mm whichever occurs earlier in case of working pile.

The load increments shall be similar to the one given for the vertical load. The safe lateral load on a single pile shall be taken as the least of the following :

a) Fifty percent of the final load at which the total displacement increases to 12 mm.

b) Final load at which the total displacement corresponds to 5 mm.

- **Cyclic Load Test on Pile**

Alternate loading and unloading shall be carried out at each stage as given in relevant clause and each loading shall be maintained as given in relevant clause and each unloading stage shall be maintained for atleast 15 minutes and subsequent elastic rebound in the pile shall be measured accurately as specified in relevant clause. This test shall be continued upto 1.5 times the proposed safe design load. The skin friction and end bearing load of the pile shall be separated out either by graphical method or analytical method as described in IS.

- **Pull out Test**

Pullout test requirements shall be as per IS:2911 (Part 4).

**Acceptance Criteria**

The following are the general acceptance criteria.

The clauses pertaining to acceptance of concrete work as described for Plain and Reinforced Concrete work shall also be applicable to the work of piles.

**Positional Tolerance**

The permissible positional deviation of pile should not be more than 75 mm or D/4 whichever is less where 'D' is the diameter of pile (75 mm or D/10 whichever is more in case of piles having diameter more than 600 mm) at the working level. In the case of single pile under a column the positional deviation should not be more than 50 mm or D/4 whichever is less (100 mm in case of piles having diameter more than 600 mm). This will be measured after the driving of the pile and during the inspection of the tube prior to placing of reinforcement and concrete. Should the deviation be greater than that specified above, the Contractor shall remove the casing at his own cost & redrive the pile, if ordered so by the Owner/Owner's representative.

In the alternative, the Owner/Owner's representative may at his discretion order the driving of additional piles at the Contractor's cost which he considers necessary after checking up the design load on the pile group.

**Pile size & capacity**

The Contractor shall guarantee 90% of full cross sectional area of the pile and also guarantee against occurrence of necking of wasting, bulging, spalling of shaft concrete, exposure of reinforcement, porous concrete and similar defects which will impair the strength and durability of pile. The Owner/Owner's representative may direct the Contractor to completely exhume some or all test piles before or after load testing to examine the quality of the pile shaft. This shall be done either by excavating around the pile or by pulling out or by a combination of both methods. If the quality of the pile shaft does not satisfy the requirements of this specification and/or if the pile fails to attain workmanship or negligence on the part of the Contractor, all costs of mobilisation, installation and testing of test piles exhuming of test piles and any other work in connection with the test piles shall be to the cost of Contractor.

**Structural Soundness**

The concrete should have the minimum strength specified based on the cube test. The acceptance criteria mentioned in the specification for concrete works under Clause 4.5.0 shall be referred in this aspect. However the Owner/Owner's representative reserves the right of rejecting any pile which in his opinion is not structurally sound or is not in proper position and alignment. The Contractor shall be bound to pull the same out and re-install a new pile in its place or leave the defective pile and install at the Contractor's cost one or more additional piles to substitute the defective pile, as per directions of the Owner/Owner's representative.

### 5.5.4 Earthwork in Excavation & Backfilling

**Scope**

This specification covers the requirement of site clearing, excavation & backfilling in all types of soil for foundations, basements, trenches, drains, culverts etc.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

IS:1498 Classification and identification of soils for general engineering purposes.

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IS:3764 Safety code for excavation works

IS:4081 Safety code for blasting and related drilling operations

IS:9759 Guidelines for dewatering during construction

**Setting Out**

The work shall be set out to exact dimensions as shown on the drawings and shall be checked and approved by the Owner/Owner's representative before commencement of excavation.

In firm soil, the sides of excavation in foundations shall be kept vertical up to a depth of 1.5 m from the bottom and for greater depths the sides shall be widened by forming steps of 300 mm on either sides after every 1.5m from the bottom. Where soil is soft, loose or slushy, the width of steps shall be suitably increased or the side sloped or shored up, as directed by the Owner/Owner's representative. Working space shall be approved by the Owner/Owner's representative.

In case of excavation for pipes, the authorized width of excavation shall be 600 mm plus outer diameter of pipe or the width of bedding as shown in the drawing whichever is higher, upto a depth of 1.5 m. For higher depths, the width shall be widened by forming steps of 300 mm on either side after every 1.5 m from the bottom.

**Initial Levels**

Initial levels either in a definite grid pattern or as directed by the Owner/Owner's representative shall be taken by the Contractor jointly with the Owner/Owner's representative over the original ground prior to starting actual excavation work and after setting out.

**Clearing and Grubbing Etc.**

The area to be excavated shall be cleared out of trees, logs, stumps, bush, vegetation, rubbish, slush etc. and leveled up. Trees up to 300 mm girth shall be uprooted. Trees above 300 mm girth shall be cut up to 600 mm below ground level. Useful materials, saleable timber shall be the property of the Owner/Owner's representative and hence shall be handed over. All the spoils and unserviceable materials and rubbish shall be burnt or removed from site to approved disposal areas as may be specified.

**Excavation and Cutting**

The Contractor shall excavate to remove materials of any nature or description which may be encountered and excavate to depths, widths and inclinations as shown on the drawings and/ or as directed. The bed of the excavation shall be made level and firm by watering and ramming. The Contractor shall not remove any tree without permission.

While carrying out excavation for drain work, the sides and bottom shall be cut to the exact shape, slope and gradient as shown on the drawings. The surface shall be properly dressed. Excavated material shall not be placed within 1.5 m from the edge of any excavation or half of trench depth whichever is more.

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**Excavation in Rock**

Blasting where permitted shall be carried out as specified in IS:4081. Where blasting is prohibited, rock excavation shall be by chiseling, wedging or any other approved method. Depending on the exact location of rock excavation, decision to excavate by blasting or not will be taken by the Owner/Owner's representative.

**Variation in Excavation**

**Bad Soil**

Should the bottom of any excavation at design depth appear to be soft, unsound or unstable, the Contractor shall report the matter to the Owner/Owner's representative and if the Owner/Owner's representative so directs, shall excavate the same to indicated depths. The extra depth shall be filled up with concrete or such other materials as the Owner/Owner's representative shall direct. No extra compensation will be entertained in this account.

**Excavation Too Deep**

If the Contractor excavates to levels deeper than those shown on drawings for any reason other than those stated above, he shall fill it up at his own expense to the proper level with lean concrete 1:5:10 or sand filling as directed. No payment will be made for excavation taken down to depths more than those shown on the drawings or for the filling carried out as directed.

**Slips and Falls**

Every precaution shall be taken against slips and falls of earth, clay, sand or other materials in the excavations, but in the event of any such occurring; the Contractor shall at his own expense make good the space affected by slips or falls even if the affected area is outside the dimension of the work ordered.

The Owner/Owner's representative will determine in each case whether such affected area is to be filled up in whole or in part with concrete, brickwork or masonry of the quality used in the adjoining work or where only a part is to be so filled, the materials to be used for this remaining part.

If in the opinion of the Owner/Owner's representative there is a possibility of the newly constructed work having been damaged or disturbed by such collapse, the work shall be laid bare at the expense of the Contractor for inspection. Any damage caused shall be made good by the Contractor, at his own expense.

**Soil/Sub-soil Water Condition**

Boring and sub-surface data regarding the nature of soil, sub-soil water furnished to the Contractor shall be taken as guidance only and variation there from shall not affect the terms of Contract. The Contractor must satisfy himself regarding the character and volume of all work under this item and expected surface, and/or sub-soil water to be encountered.

**Keeping Works Site Free From Water**

The Contractor shall provide and operate pumps and all other equipment necessary to drain the sub-soil water, rain water etc. to the nearest sewer or drain through properly laid pipes or channels and keep excavation pits, trenches etc free from water at all times during excavation, backfilling and the continuance of the contract. Adequate care shall be taken to prevent movement of water through freshly laid concrete or masonry work. Sumps made for dewatering shall be kept clear of

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the foundation. Method of dewatering shall be approved by the Owner/Owner's representative but in no case the pumping arrangement shall be such that there is any movement of sub-soil or blowing-in due to differential head of water during pumping. If water table is high, well point dewatering has to be adopted for excavation beyond 1 metre below the water table. The dewatering shall be continued for a sufficient period so as not to affect the strength and other properties of the concrete. Guideline given in IS: 9759 shall also be followed.

**Protection of Work**

The Contractor shall support and maintain adjoining and abutting property and structures to render work safe to persons and property.

The Contractor shall provide necessary decking, guard, fencing, planking with red flags and red lights at night to maintain safe pedestrian and vehicular traffic near all open excavations.

**Shoring and Strutting**

Shoring and strutting shall be used as directed when excavation is to be carried out in soft or slushy soil which is likely to collapse during the excavation of the work. The shoring shall be either open or close boarded type depending on the nature of the soil and depth of excavation and the type adopted shall be as directed by the Owner/Owner's representative. While excavating in very unstable ground requiring support throughout the period of excavation, runners shall be used and shall be driven always in advance of the excavation. The size and spacing of different members to be used in shoring shall be as directed by the Owner/Owner's representative, depending on the site conditions. If however slips do occur, the same shall be removed by him and backfilled later by him at his own expense. The withdrawal of shoring & shoring material shall be done very carefully to prevent the collapse of pit or trench. No claim shall be entertained for any material which cannot be removed and is lost or buried.

**Disposal**

The excavated earth shall be disposed off in the following manner or as directed by the Owner/Owner's representative

i) By keeping separately the materials suitable for backfilling/area filling and material not suitable at areas to be designated by the Owner/Owner's representative.

ii) The excess material remaining after back-filling/area filling shall be spread evenly so as to allow natural flow of water in the area.

**Backfilling and Filling in Plinth**

Earth used for filling shall be free from organic and other objectionable matter. As far as possible, materials obtained from excavation in foundation shall be used. The earth shall be basically CNS soil (Cohesive Non-Swelling Soil). All clods of earth shall be broken or removed. Where excavated material is mostly rock, the boulders shall be broken into pieces not bigger than 150 mm in size and mixed with fine materials consisting of decomposed rock, moorum or earth and the mixture shall be used for filling. Expansive soils shall not be used for filling. Maximum thickness of filling (uncompacted) shall be 200mm and compacted to 95% of proctor density.

**Filling Around Foundation with Earth**

Filling shall be carried out in layers not exceeding 200 mm (un compacted thickness) in depth. Each layer shall be watered, rammed and properly compacted to 95% of proctor density or 85% of relative density depending on the soil type. For Turbine Foundation it shall not be less than 98%.

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**Sand filling in plinth**

Sand used for filling shall be free from dust, organic and other objectionable matter and shall not contain more than 10 percent of clay.

When filling has reached the appropriate level, the area shall be flooded with water for a minimum period of 24 hours to allow the fill to settle. The filling shall be allowed to dry and then compacted and dressed to the required level.

**Filling in trenches for pipes**

Filling in trenches for pipes shall be commenced as soon as the joints of pipes have been tested and passed. Filling of trenches shall be carried out simultaneously on both sides of pipes to avoid unequal pressure on the pipe. The earth shall be spread on the sides and top of the pipes in layers not exceeding 200 mm (un compacted thickness), watered, rammed and consolidated, taking care that no damage is caused to the pipe below. Maximum particle size for fill material around pipes shall be less than 20 mm.

**Testing and Acceptance Criteria**

**Excavation**

On completion of excavation, the dimensions of the pits will be checked as per drawings after the pits are completely dewatered, the work will be accepted after all under-cuts are set right, all over excavations are filled with lean concrete or compacted earth as directed and all necessary shoring & strutting done, all temporary approaches to the bottom of trenches provided, all to the satisfaction of the Owner/Owner's representative.

**Backfilling / Plinth Filling**

All filling shall be done to the compaction specified. The backfilling work will be accepted only after the Owner/Owner's representative is satisfied with the degree of compaction.

Level of each layer of backfilling shall be marked on the sides in order to exercise the control on the thickness of layer being laid.

### 5.5.5 Plain and Reinforced Concrete Work

**Scope**

This specification covers the requirement in respect of materials, workmanship and quality for Plain Cement Concrete (PCC) and Reinforced Cement Concrete (RCC) for all types of structures in foundation and superstructure.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed hereunder:

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**Cement**

| | |
|---|---|
| IS:269 | Ordinary and low heat Portland cement |
| IS:455 | Specification for Portland slag cement |
| IS:1489 | Specification for Portland pozzolana cement |
| IS:4032 | Method of chemical analysis of hydraulic cement |
| IS:6452 | High alumina cement for structural use |
| IS:8041 | Rapid hardening portland cement |
| IS:8112 | Specification for 43 grade ordinary Portland cement |
| IS:12330 | Sulphate resisting portland cement |

**Aggregate**

| | |
|---|---|
| IS:383 | Coarse and fine aggregates from natural sources for concrete |
| IS:2386 | Methods of test for aggregates for concrete |
| IS:2430 | Methods of sampling of aggregates for concrete |

**Concrete Plain and Reinforced**

| | |
|---|---|
| IS:456 | Code of practice for plain and reinforced concrete |
| IS:460 | Test sieves |
| IS:516 | Methods of test for strength of concrete |
| IS:1199 | Methods of sampling and analysis of concrete |
| IS:1607 | Methods for test sieving |
| IS:1834 | Hot applied sealing compounds for joints in concrete |
| IS:2645 | Integral cement water proofing compounds |
| IS:2750 | Steel scaffolding |
| IS:2974 | Code of practice for design and construction of machine foundations |
| IS:3370 | Code of practice for concrete structures for the storage of liquids |
| IS:9013 | Method of making, curing and determining compressive strength of accelerated-cured concrete test specimens |
| IS:9103 | Admixtures for concrete |
| IS:9893 | Precast concrete lintels and sills |

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IS:10262 Recommended guidelines for concrete mix design

IS:10297 Code of practice for design and construction of floors/roofs using pre-cast reinforced/pre-stressed concrete ribbed or cored slab units

IS:10566 Methods of tests for preformed fillers for expansion joints in concrete paving and structural construction

IS:10790 Methods of sampling of steel for prestressed and reinforced concrete

**Steel**

IS:432 Mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement

IS:1566 Hard-drawn steel wire fabric for concrete reinforcement

IS:1568 Wire cloth for general purposes

IS:1786 High strength deformed steel bars and wires for concrete reinforcement

IS:2502 Code of practice for bending and fixing of bars for concrete reinforcement

IS:2751 Code of practice for welding of mild steel plain and deformed bars used for reinforced concrete construction

**Materials**

All materials that shall be used for works covered under this specification shall conform to following standards / specification.

| | | |
|---|---|---|
| - | Aggregate | Machine crushed blue granite conforming to IS:383 |
| - | Cement | IS:269 - Ordinary Portland Cement |
| | | IS:455 - Specification for Portland slag cement |
| | | IS:8041 - Rapid Hardening Portland Cement |
| | | IS:8112 - High strength Ordinary Portland Cement |
| | | IS:12330- Sulphate Resisting Portland Cement |
| - | Reinforcement | IS:432/IS:1786/IS:1566 |
| - | Embedded plates | IS:2062 |
| - | Binding wire | PVC binding wires |
| - | Joint filler | Approved non extruding, resilient fillers |
| - | Sand | River or pit sand conforming to IS:2116 |
| - | Water stops | PVC/Rubber/Metallic - GI, Aluminium, copper |

- Admixtures IS:9103

- Water Clean, potable as specified in IS:456.

Source of coarse & fine aggregate shall be approved by the Owner/Owner's representative.

Test certificates for each consignment of cement procured have to be submitted by the Contractor to ensure conformity with relevant standards. The Owner/Owner's representative may reject such cements supplied in the event of unsatisfactory tests or in the event of deterioration due to age or bad storage etc. Decision of the Owner/Owner's representative shall be final in this regard.

Admixtures shall be used only after getting permission from the Owner/Owner's representative and as per the instruction of the manufacturer.

**Grades and Proportioning**

Any grades of concrete designated in latest revision of IS: 456 as shown on the drawings or as specified shall be used. Design mix concrete shall be adopted for all RCC works. Contractor, at his own cost shall get this Design Mix done by any premiere institute like approved by the Owner/Owner's representative. If the submitted results are not satisfactory to the Owner/Owner's representative, the Owner/Owner's representative has every right to reject the design mix. In case the Contractor fails to submit or comply with the design mix, he requires to follow Nominal Mix as per IS: 456 after obtaining the permission from Owner/Owner's representative. The mix shall be designed as per "Handbook on concrete mixes", SP:23. While designing the mix, the strength, durability, minimum cement content, maximum water cement ratio allowed and workability necessary for the job by most economical use of the various ingredients shall be considered by the Contractor. Contractor must use the same ingredients in the Design Mix which he uses in the works. The mix design shall be verified by carrying out preliminary test.

The water cement ratio, coarse aggregates and grading for each mix shall be predetermined from the results of cube tests of trial mixes. The mix proportions determined thus shall be followed at site and shall in no way relieve the Contractor of his responsibility as regards the prescribed strength mix. The mix proportions, however, shall be revised if the results of the cube tests during the construction show consistently lower than the prescribed one. No extra claim will be entertained due to such changes in mix designs, as the Contractor will be responsible to produce the concrete of required grade. The maximum size of aggregates used shall be as indicated in IS: 456 or specified elsewhere.

Nominal mix concrete in accordance with IS: 456 for grade M20 or lower may the used if shown on drawings or approved by the Owner/Owner's representative. In all cases the proportioning of ingredients and works control shall be in accordance with IS: 456 and shall be adopted for use after the Owner/Owner's representative is satisfied regarding its adequacy and after obtaining his approval in writing.

**Mixing**

Mixing should be carried out in mechanical mixers. No hand mixed concrete is permitted for RCC works. Hand mixing if permitted for PCC works shall be carried out on a clean, hard and water tight platform. Water cement ratio shall be rigidly controlled during mixing. Mixers shall be fitted with automatic devices to discharge measured quantity of water to the mixing pan. The water shall not be admitted to the drum until the cement and aggregate constituting the batch are thoroughly mixed. Mixing shall continue until the concrete is uniform in colour and not less than 2 minutes and forty (40) revolutions after all the material and water are in the drum. Regular checks on mixer efficiency shall be carried out as directed by the Owner/Owner's representative. Only those mixers whose efficiencies are within the tolerances specified in IS: 1791 will be allowed to be employed. Batching

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plant where used shall conform to IS: 4925. Concrete shall be prepared only by weigh batching the ingredients. Volume batching will not be permitted.

The entire content of the drum shall be discharged before the ingredients for next batch are fed into the drum. No partly set or remixed or excessively wet concrete shall be used. Such concrete shall be immediately removed from site. Each time the work stops the mixer shall be thoroughly cleaned and when the next mixing commences, the first batch shall have 10% additional cement at no extra cost to the Owner/Owner's representative to allow for loss in the drum.

**Placing**

Concrete shall be transported from the mixing plant to the forms, as rapidly as possible, by means which will prevent segregation, consolidation or drying out in hot weather. Concrete shall be placed within thirty (30) minutes after commencement of mixing. At the time of placing concrete in very hot weather, care shall be taken to see that the temperature of wet concrete does not exceed $38^0$C.

Before placing concrete, formwork, embedment's and reinforcement shall be checked for completeness, location and dimension. It should also be square and plumb. All chips and saw dust or other foul matter shall be removed from within the forms with the help of an air compressor. The base surface shall be well moistened and puddles wiped up. Earth foundation on which direct placement of concrete is allowed will be rammed and consolidated as directed by the Owner/Owner's representative such that it does not crumble and get mixed up with the water during or after placement, before it has sufficiently set and hardened. Concrete may be placed against moist surface but never on pools of water. In case the foundation cannot be dewatered completely, special procedure and pre-caution, as directed by the Owner/Owner's representative will have to be adopted. A layer of mortar of thickness between 12 mm to 25 mm as directed, of the same or less W/C ratio and the same proportion as that of concrete being placed and /or cement slurry will be spread thoroughly on the foundation or construction joint just prior to placement of concrete. Placing equipment and accessories shall be kept clean and free of partially set grout and concrete, and maintained in proper working order. Walking on reinforcement layers is not permissible. Walkways of wooden planks or similar can be placed with removable supports and should be independent of reinforcement.

In general, placing shall be direct, by transporting buckets. Where it is necessary to deposit the concrete at level differences of more than 1.5 m, short chutes shall be used. Short chutes and hoppers shall be so designed and installed that segregation will not take place. In cases where chutes are impracticable due to excessive drop to placing level, hoppers and sectional tubes (elephant trunks) shall be used.

After the concrete has been placed, it shall be spread, if necessary and thoroughly worked around reinforcement or other embedded fixtures into concrete form and shape. Vibrators shall not be used for pushing the concrete into the adjoining areas. Care must be taken to ensure that the inserts, fixtures, reinforcement and formwork are not displaced during or immediately after the placement and bring the concrete surface out of the alignment beyond tolerance limits, the Owner/Owner's representative may direct to remove the portion and reconstruct or repair the same at the Contractor's expense.

The rate of placement of concrete shall be such that no cold joint is formed and fresh concrete is placed always against green concrete which is still plastic and workable. No concrete shall be placed in open, while it rains. During rainy season, no placement in open is to be attempted unless sufficient tarpaulins or other similar protective arrangement for complete covering the still green concrete from rain is kept at the site of placement. If there has been any sign of washing of cement and sand, the entire affected concrete shall be removed immediately.

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**Compaction**

Concrete in general shall be consolidated by vibration using high frequency mechanically driven vibrators. Concrete shall be placed in layers at least 300 mm deep in walls and approximately 450 mm in mass pouring. Vibrators shall not penetrate more than 50 mm into the surface of previously placed layers but shall completely vibrate the working layer. Care shall be taken not to over-vibrate any concrete and especially those with higher slumps. Under no circumstances vibrators shall be attached to or allowed to touch reinforcement. Spare vibrators in good operating condition shall be on hand during placing operations.

**Construction Joints**

In general, construction joints shall be limited to those indicated on the drawings. In mass concrete, construction joints may not be indicated in the drawings but shall be made at breaks, offsets or other convenient levels as controlled by volume, plant capacity and time factors. Such construction joints shall be so located that they do not impair the strength of the structure. In walls and columns, height of each lift shall not generally exceed 1.5 m unless otherwise specified in the drawings or directed by the Owner/Owner's representative. Method of forming all construction joints shall conform to the provisions of IS:456.

All construction joints shall be cleaned with wire brush and water to remove all laitance and loose material to expose the aggregates. Immediately before placing fresh concrete, the surface of previously placed concrete shall be coated with a thin coat of cement mortar slurry of the same proportion as that of concrete.

Where locations of the joints are not specified, it will be in accordance with the following:

a. In a column, the joint shall be formed 75 mm below the soffit of the beam or the edge of the anchored bar of the beam framing into it whichever is lower. The Contractor shall refer to the beam reinforcement drawing before deciding on the location of the joint at column-beam junction.

b. Concrete in a beam shall preferably be placed without a joint, but if provision of a joint is unavoidable, the joint shall be vertical and at the middle one third of the span, clearing the cross beam location, if any.

c A joint in a suspended floor slabs shall be vertical and at the middle one third of the span and at right angles to the principal reinforcement.

d In general, construction joints shall be located preferably in a low shear stress zone and at right angles to the direction of the principal stress

Any deviation from the above shall be approved by the Owner/Owner's representative.

**Curing and Protecting**

As soon as the concrete has hardened sufficiently, it shall be covered either with Hessian, canvas or similar materials and kept continuously wet for at least seven (7) days after final setting. Curing by continuous sprinkling of water will be allowed if the Owner/Owner's representative is satisfied with the adequacy of arrangements made by the Contractor.

Curing of concrete with water shall comply with IS:456. Curing compound shall be used subject to approval by the Owner/Owner's representative. Finished floors shall be protected carefully until completely set. Protection of concrete against extreme weather conditions shall comply with the code.

**Finishing**

No touching-up will be permitted to the concrete after removal of formwork. Where damages, honey-combing or other unsatisfactory finishes have occurred to the concrete surfaces, they shall be rectified in a manner as directed by the Owner/Owner's representative, at no extra cost. If in the opinion of the Owner/Owner's representative the concreting is unsatisfactory, demolition of the entire concrete work and reconstruction of the same shall be carried out by the Contractor, as directed by the Owner/Owner's representative at his own cost.

**Formwork & Centering**

Form work in general shall conform to IS: 456.

For complicated work, the Contractor shall submit his proposal of formwork before starting the work for approval of the Owner/Owner's representative. The number of props, their sizes and dispositions shall be such as to be able to safely carry the full dead load and constructional loads. However, approval of the Owner/Owner's representative to this effect shall not relieve the Contractor of his responsibility for proper work and safety.

All forms of beams, slabs and members shall be so designed and erected that the sides can be removed without disturbing the soffit shutter and supports there to.

Beam soffit shall be provided with an upward, camber of 6mm for each 3 m of horizontal span or as directed by the Owner/Owner's representative. Vertical props shall be supported on wedges or sole plates or other measures where by the props can be gently lowered while commencing to remove the shuttering. Columns shuttering shall not be over 1.5 m in height a piece.

Before removal of the shuttering the concrete shall be examined and its removal order taken from the Owner/Owner's representative. In no circumstance shall forms be struck until the concrete reaches strength of at least twice the stress to which the concrete may be subjected at the time of striking.

Shuttering shall not be removed until the number of clear days specified in IS: 456 have elapsed since the last day of placing concrete in the member concerned. All formwork shall be removed without such shock or vibration as would damage the reinforced concrete. Before the soffits and struts are removed, the concrete surface shall be exposed, where necessary, in order to ascertain that the concrete has sufficiently hardened. The specified period may be extended if desired by the Owner/Owner's representative on account of delayed hardening caused by low atmospheric temperature.

**Reinforcement**

The reinforcement bending shall be carried out as per the approved bar bending schedule prepared based on design drawing.

Workmanship shall conform to IS: 2502. All reinforcement shall be free from loose mill scale, rust, oil, grease and paint. Reinforcement shall not be bent or straightened in a manner that will injure the materials and all bars shall preferably be bent cold. Hot bending shall not be permitted for bars whose strength have been increased by cold working.

Reinforcement bars shall be placed and maintained accurately in positions as shown in the drawings. The correct cover to the reinforcement shall be maintained by use of precast concrete blocks.

All intersections of longitudinal and transverse bars or stirrups and all laps shall be securely tied together with approved binding wire. The binding wire shall be so placed that it touches all the four corners of the intersection and the two ends shall be looped with pliers and the ends shall be turned into the body of the concrete.

Welded joints may be used but in all cases of important connections, tests shall be made to prove that the joints are of the full strength of bars connected. Welding shall be done in accordance with IS:2751 and IS:9417. Butt welding between the ends of a rod in line, whereby stress is transferred across the section may be adopted only for mild steel bars. In case of tack welding for fixing reinforcements in their position, no special precaution need be taken.

**Steel Embedment**

All embedment shall be accurately set, rigidly fastened and suitably anchored by welding lugs. Anchor bolts shall be set to template and firmly secured in vertical and horizontal line and required positions. The guidelines furnished by equipment supplier / vendor shall be taken in to account

Exposed surfaces of embedded materials are to be painted with one coat of red oxide zinc chrome and/ or bituminous paint. Correct location and alignment of all anchor bolts, anchor sleeves, inserts, hangers, conduit pipes and other embedded fixtures as per drawings/instruction shall be entirely the responsibility of the Contractor.

**Expansion & Isolation Joints**

**General**

Expansion and isolation joints in concrete structures shall be provided at specified places, as per details indicated on the drawings. The materials and types of joints shall be as specified hereinafter. In case of liquid retaining structures, additional precautions shall be taken to prevent leakage of liquids as may be specified on the drawings or as directed by the Owner/Owner's representative. All materials are to be procured from reliable manufacturers and must have the approval of the Owner/Owner's representative. Where it is the responsibility of the Contractor to supply the material, the Owner/Owner's representative may demand test certificates for the materials and/or instruct the Contractor to get them tested in an approved laboratory free of cost to the Owner/Owner's representative. Approved samples of the material to be incorporated in the works shall be with the Owner/Owner's representative. Joints shall be formed true to line, level, shape, dimension and quality as per drawings and specifications. Prior approval of the method of forming the joints should be obtained from the Owner/Owner's representative before starting the work.

**Bitumen Board**

Bitumen impregnated fiber board of approved manufacturer as per IS: 1838 may be used as fillers for expansion joints. It must be durable and water proof. It shall be compressible and possess a high degree of rebound. The dimensions of the board should be equal to that of the joint being formed. It should, preferably be manufactured in one piece, matching the dimension of the joint and not prepared by cutting to size smaller pieces from larger boards at site. At the exposed end, the joint shall be sealed with approved sealing compound to a depth of at least 25 mm after application of an approved primer. The sealing compound and the primer shall be applied as specified by the manufacturer.

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**Expanded Polystyrene Boards**

If required, commercial quality of expanded polystyrene products commonly used for thermal insulations may also be used as filler material in expansion joints. The thickness may vary from 12 mm to 50 mm. The material will have to be procured from reliable manufacturers as approved by the Owner/Owner's representative. The method of installations will be similar to that recommended by the manufacturers for fixing on cold storage walls. A coat of bitumen paint may have to be applied on the board against which concrete will be placed.

**Joint Filler**

The concrete surface shall be made clean, smooth and free from dirt or loose particles. When the surface is completely dry, a coat of hot blow bitumen conforming to IS: 702 of grade 85/25 shall be given with brush or spray. When the bitumen is still hot, the premoulded joint filler fibre board shall be pressed against the surface and held in position till the time it takes to adhere. When more than one layer of filler are specified each layer shall be made to adhere to the preceding layer with a few patches of bitumen between the two layers. After placing the filler in position, the surface of the filler against which further concreting is to be done is given a coat of bitumen.

**Joint sealing compound**

Sealing compound shall be of Grade A conforming to IS: 1834. Bitumen shall conform to IS: 3384.

Before application of the sealing compound the sides of the joint are sprayed or brushed with bitumen primer. The primer is then allowed to dry out thoroughly for at least 24 hours and then filled with a mix of 30 % fine sand and 70 % sealing compound by weight.

**Joint Sealing Strips/Water Stops**

Joint sealing strips may be provided at the construction, expansion and isolation joints as a continuous diaphragm to contain the filler material and/or to exclude passage of water or any other material into or out of the structure. The sealing strips will be either metallic like GI, Aluminium or non-metallic like PVC.

Sealing strips shall not have any longitudinal joint and shall be procured and installed in largest practicable lengths having a minimum number of transverse joints. The jointing procedure shall be as per the manufacturer's recommendations, revised if necessary, by the Owner/Owner's representative.

- **Metal Sealing Strips**

Metal sealing strips shall be either GI or Aluminium and formed straight, U shaped, Z shaped or any other shape and of thickness as indicated in the drawing and/ or as instructed by the Owner/Owner's representative.

The transverse joints will be gas welded using brass rods and approved flux and will be tested by an approved method to establish that it is leak proof. In case it is found that the joints cannot be made leak proof, longer lap length and different method of brazing which will render it leak proof, will be adopted by the Contractor. The edges shall be neatly crimped and bent to ensure proper bond with the concrete.

**GI Strips :** GI Strips shall be minimum 1.5 mm thick and 150 mm in width unless specified otherwise. The standard of Galvanising shall be as per relevant Indian Standards for heavy duty work. The strips shall be strong, durable, without any rust or crease. At the joints, the over-lapping should be for a minimum length of 50 mm.

**Aluminium Strips** : Aluminium strips shall be minimum 18 swg. thick and 300 mm wide unless specified other wise and shall conform to IS:737 of 19000 grade or 31000 grade (Designation as per IS:6051). A minimum lap of 50 mm length is required at the joints.

It should be cleaned thoroughly before use to expose fresh surface, without any reduction in gauge. A minimum lap of 50 mm is length is required at the joints.

- **Water stops**

This shall be of P.V.C. having any combination of the following features :

a. Plain
b. Central bulb
c. Dumb-bell or flattened ends
d. Ribbed and Corrugated Wings
e. V-shaped

Transverse joints will be allowed only under unavoidable circumstances and with the specific approval of the Owner/Owner's representative. The method of forming these joints, laps etc. shall be specified by the Manufacturer and/or as approved by the Owner/Owner's representative, taking particular care to match the central bulbs and the edges accurately.

The minimum thickness of P.V.C water stops shall be 8 mm and the minimum width 150 mm. The actual size and shape will be as shown in drawings and/or as directed by the Owner/Owner's representative. The material should be of good quality Polyvinyl Chloride highly resistant to tearing, abrasion and corrosion as well as to chemicals likely to come in contact with during use. The physical properties will generally be as follows. The actual requirements, which will be directed by the Owner/Owner's representative, may vary slightly. PVC water stops used in water retaining structures shall be able to withstand the water pressure to which it will be subjected to.

**Bitumen Compound**

When directed, the gap in expansion joints shall be thoroughly cleaned and bitumen compound laid as per manufacturer's specifications. The compound to be used shall be of approved manufacturer and shall conform to the requirements of IS: 1834.

**Isolation Joints**

Strong and tough alkathene sheet or equivalent, about 1 mm in thickness and as approved by the Owner/Owner's representative shall be used in Isolation Joints. It shall be fixed by an approved adhesive compound on the cleaned surface on the already set concrete, to cover it fully. Fresh concrete shall be laid against the sheet, care being taken not to damage the sheet in any way.

**Rubber Pad**

Hard foundation quality rubber pads of required thickness and shapes shall be used below machine or other foundation for vibration isolation. The rubber shall have a unit weight of 930 Kg/$m^3$, shore hardness - 65 A to 70 A and be of best quality of approved manufacturer, durable, capable of absorbing vibration and must be chemically inert in contact with moist or dry earth or any other deleterious material expected under normal conditions.

**Precast Concrete**

All precast work shall be carried out in a yard for the purpose. This yard shall be dry, properly levelled and having a hard and even surface. If the ground is to be used as a soffit form for the units, it shall be paved with concrete or masonry and provided with a layer of cement plaster with smooth neat cement finish or a layer of M.S. sheeting. Where directed by the Owner/Owner's representative, casting will have to be done on suitable vibrating table. The yard, lifting equipment, curing tank, finished material storage space etc. shall be designed such that the units are not lifted from the mould before seven (7) days of curing and can be removed for erection after twenty eight (28) days of curing. The moulds shall preferably be of steel or of timber lined with G.I. sheet metal. The yard shall preferably be fenced.

Lifting hooks, where necessary or as directed by the Owner/Owner's representative, shall be embedded in correct position of the units to facilitate erection, even though they may not be shown on the drawings, and shall be removed and the hooks finished after erection if directed by the Owner/Owner's representative.

Precast concrete units, when ready, shall be transported to site by suitable means approved by the Owner/Owner's representative. Care shall be taken to ensure that no damage occurs during transportation. All adjustments, levelling and plumbing shall be done as per instructions of the Owner/Owner's representative. The Contractor shall render all help with instruments, materials and men to the Owner/Owner's representative for checking the proper erection of the precast units. Chipped or cracked or otherwise damaged pre-cast elements will be rejected.

After erection and alignment, the joints shall be filled with grout or concrete as directed by the Owner/Owner's representative. If centerings have to be used for supporting the precast units, they shall not be removed until the joints have attained sufficient strength and in no case before fourteen (14) days. The joint between precast roof planks shall be pointed with 1:2 cement : sand mortar unless otherwise shown in the drawings.

**Waterproofing of Concrete to Structures**

**General**

Waterproofing of concrete structures shall be done by suitable extraneous treatments like applying paints, fixing bitumen felts polymeric membrane, installing water bars at construction joints etc.

The design, material and workmanship shall conform to the relevant I.S. codes where applicable. The Owner/Owner's representative's approval of the materials shall be obtained by the Contractor before procurement. If desired by the Owner/Owner's representative, test certificates for the materials and samples shall be submitted by the Contractor. The materials shall be best quality available indigenously, and suitable for the duties called upon.

**Water Stop**

Water bearing structures and underground structures shall have PVC water stops installed at the joints. Installation will be as described under "Expansion & Isolation Joints".

**Waterproofing Admixtures**

- **In Concrete**

The admixture shall be procured from reliable and reputed manufacturers and approved by the Owner/Owner's representative. The method of application and other details shall conform to the manufacturer's specification and/or as instructed by the Owner/Owner's representative.

- **In Plaster**

The concrete surface, to be plastered, shall be hacked to Owner/Owner's representative's satisfaction, cleaned thoroughly and kept wetted for 24 hours. The plaster shall be in cement sand mortar mixed is proportion varying from 1:1 to 1:4 by volume along with the approved waterproofing admixture and laid in appropriate thickness and in layer not exceeding 15 mm or as per manufacturer's specification. The additive shall be of quality and type approved by the Owner/Owner's representative. On completion, the plastered surface shall be cured continuously for a minimum period of fourteen (14) days like concrete.

**Bituminous or Tar Coating**

The surface to be waterproofed shall be rendered absolutely dry, clean and dust free. The surface shall be sand papered, cleaned and completely coated with hot coal tar pitch of approved manufacture and quality as per IS:216 (not heated above $375^0$F) using not less than 2 kg./ Sq.m. or with hot asphalt i.e. bitumen according to IS:73 (not heated above $400^0$F) using not less than 1.5 kg per Sq.m. When the first coat has completely dried up and approved by the Owner/Owner's representative, the second coat shall be applied in the same manner using not less than 1.25 Kg. per Sq.m. in case of coal tar and 1 kg per sq m in case of asphalt. Immediately after application of the second coat and before it is dried up, sand shall be spread on the surface to cover it completely. Sufficient time shall be allowed after spreading of sand before backfilling is done in order to allow the final coat to dry up completely.

**Testing Concrete Structures for Leakage**

Hydro-static test for water tightness shall be done at full storage level or soffit of cover slab, as may be directed by Owner/Owner's representative, as described below (In compliance with IS: 3370):

- In case of structures whose external faces are exposed, such as elevated tanks, the requirements of the test shall be deemed to be satisfied if the external faces show no sign of leakage or sweating and remain completely dry during the period of observation of seven days after allowing a seven day period for absorption after filling with water.

- In the case of structures whose external faces are submerged and are not accessible for inspection, such as underground tanks, the structures shall be filled with water and after the expiry of seven days after the filling, the level of the surface of the water shall be recorded. The level of water shall be recorded again at subsequent intervals of 24 hrs. over a period of seven days. Backfilling shall be withheld till the tanks are tested. The total drop in surface level over a period for seven days shall be taken as an indication of the water tightness of the structure. The Owner/Owner's representative shall decide on the actual permissible nature of this drop in the surface level, taking into account whether the structures are open or closed and the corresponding effect it has on evaporation losses. Unless specified otherwise, a structure whose top is covered shall be deemed to be water tight if the total drop in the surface level over a period of seven days does not exceed 40 mm. For open type, it shall be 60mm.

- Each compartment/segment of the structure shall be tested individually and then all together.

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For structures such as pipes, tunnels etc. the hydrostatic test shall be carried out by filling with water, after curing as specified, and subjecting to the specified test pressure for specified period. If during this period the loss of water does not exceed the equivalent of the specified rate, the structure shall be considered to have successfully passed the test.

Any leakage that may occur during the hydro-test or subsequently during the defects liability period or the period for which the structure is guaranteed shall be effectively stopped either by cement/epoxy pressure grouting, guniting or such other methods as may be approved by the Owner/Owner's representative. All such rectification shall be done by the Contractor at his own cost to the entire satisfaction of the Owner/Owner's representative.

Testing of Materials

**Cement**

The Contractor shall submit to the Owner/Owner's representative the manufacturer's certificate for each consignment of cement procured by him. If required by the Owner/Owner's representative's, representative samples shall taken from each consignment and tests for fineness (by hand sieving), setting time and compressive strengths as per IS:269 shall be carried out, free of charge by the Contractor.

**Aggregates**

Coarse and fine aggregate and the grading shall be as per IS:383. It shall be free from organic or clay coatings and other impurities, flaky particles, and any other material liable to affect the strength, durability or appearance of concrete. Washing of aggregates by approved means shall be carried out, if desired by the Owner/Owner's representative.

The Contractor shall carry out all the tests on aggregates as may be required by the Owner/Owner's representative in accordance with IS: 2386. The records of these shall be maintained and made available by the Contractor for the checking of Owner/Owner's representative. The acceptance criteria of samples tested shall be in accordance with the requirements of relevant Indian Standards.

**Admixture**

- **Air Entraining Agents**

Initially, before starting to use Air Entraining Agents, relationship between percentage of air entrained and the cylinder cube crushing strength vis-à-vis quantity of Air Entraining Agents used for all types of concrete will be established by the Contractor free of charge by carrying out sufficiently large number of tests. After that, at regular intervals and whenever directed by the Owner/Owner's representative, the Contractor will check up free of charge, the actual percentage of air entrained and corresponding curing strengths to correlate with the earlier test results.

- **Other Admixture**

Tests for establishing the various properties of any other admixtures which may be required to be added shall be carried out by the Contractor free of charge to the Owner/Owner's representative.

Usage of admixtures shall be purely subjected to the approval of Owner/Owner's representative.

**Concrete**

Sampling, curing and testing of specimen will comply with IS: 1199 and IS: 516. Sampling procedure shall generally conform to IS: 456. Sampling frequency for each grade of concrete M20 and above shall be as per relevant IS codes.

In case, the stripping time for shuttering needs to be reduced or early age strength is required to be known in specific cases, the Contractor shall carry out at short notice testing of cubes at one (1) day and three (3) days after accelerated curing as per IS:9013. The required number of additional samples for the same shall also be taken.

To control the consistency of concrete from every mixing plant/machine, slump tests and/or compacting factor tests as per IS:1199 shall be carried out by the Contractor every two hours or as directed by the Owner/Owner's representative in addition to the slump measured when making test cubes.

**Acceptance Criteria**

**Structural Criteria**

Acceptance criteria of concrete shall be generally in accordance with IS: 456. Immediately after stripping the formwork, all concrete shall be carefully inspected and any defective work or small defects either removed or made good before the concrete has thoroughly hardened.

The acceptance criteria of concrete shall be in accordance with IS: 456. Concrete work found unsuitable for acceptance shall have to be dismantled and replacement is to be done as per specification by the Contractor. In the course of dismantling, if any damage is done to the embedded items or adjacent structures, the same shall be made good, free of charge by the Contractor, to the satisfaction of the Owner/Owner's representative.

**Dimensional Criteria**

The permissible variation from dimension, lines given in the drawing shall be within tolerances specified below. Wherever tolerances are not specified below the same shall be in accordance with the relevant IS codes/other applicable national/international standards or as indicated by the Owner/Owner's representative.

- **Tolerances for R.C. Buildings** :

i) Variation from the plumb

- In the lines and surfaces of columns, piers, walls and in arises. : 5 mm per 2.5 m or 25 mm, whichever is less

- For exposed corner columns and other conspicuous lines

  In any bay or 5 m max. : 5 mm
  In 10 m or more : 10 mm

ii) Variation from the level or from the grades indicated on the drawings

- In slab soffits, ceilings, beam soffit, and in arises

  In 2.5 m : 5 mm
  In any bay or 5 m max. : 8 mm
  In 10 m or more : 15 mm

- For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines

| | | |
|---|---|---|
| In any bay or 5 m max. | : | 5 mm |
| In 10 m or more | : | 10 mm |

iii) Variation of the linear building lines from established position in plan and related position of columns, walls and partitions.

| | | |
|---|---|---|
| In any bay or 5 m max. | : | 10 mm |
| In 10 m or more | : | 20 mm |

iv) Variation in the size and locations of sleeves, - 5 mm except openings in walls and floors in the case of and for anchor bolts

v) Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls

| | | |
|---|---|---|
| Minus (-) | : | 5 mm |
| Plus (+) | : | 10 mm |

vi) Footings

- Variation in dimension in plan

| | | |
|---|---|---|
| Minus (-) | : | 5 mm |
| Plus (+) | : | 50 mm |

- Misplacement or eccentricity : 2% of footing width not more than 50 mm of misplacement but in the direction

- Variation in thickness

| | | |
|---|---|---|
| Minus (-) | : | 5% of specified thickness subject to a max. of 50mm |
| Plus (+) | : | 100 mm |

vii) Variation in steps

- In a flight of stairs

| | | |
|---|---|---|
| Riser | : | 3 mm |
| Tread | : | 5 mm |

- Inconsecutive steps

| | | |
|---|---|---|
| Riser | : | 1.5 mm |
| Tread | : | 3.5 mm |

- Tolerances in other Concrete Structures

i) All structures other than those covered in ii) below.

- Variation of the constructed linear outline from established position in plan

| | | |
|---|---|---|
| In 5 m | : | 10 mm |
| In 10 m or more | : | 15 mm |

- Variations of dimensions to individual structure features from established positions

| | | |
|---|---|---|
| In 20 m or more | : | 25 mm |
| In buried construction | : | 50 mm |

- Variation from plumb, from specified batter or from curved surfaces of all structures

| | | |
|---|---|---|
| In 2.5 m | : | 10 mm |
| In 5 m | : | 15 mm |
| In 10 m or more | : | 25 mm |
| In buried-construction | : | Twice the above amounts |

- Variation from level or grade indicated on drawings in slab, beams, soffits, horizontal grooves and visible arises

| | | |
|---|---|---|
| In 2.5 m | : | 5 mm |
| In 7.5 m or more | : | 10 mm |
| In buried construction | : | Twice the above amounts |

- Variation in cross-sectional dimensions of columns beams, buttresses, piers and similar members

| | | |
|---|---|---|
| Minus (-) | : | 5 mm |
| Plus (+) | : | 10 mm |

- Variation in thickness of slabs, walls, arch sections and similar members

| | | |
|---|---|---|
| Minus (-) | : | 5 mm |
| Plus (+) | : | 10 mm |

ii) Footing for columns, piers, walls, buttresses and similar members

- Variation of dimension in plan

| | | |
|---|---|---|
| Minus (-) | : | 5 mm |
| Plus (+) | : | 10 mm |

- Misplacement or eccentricity
  2% of footing width in the direction of misplacement but not more than 50 mm

- Reduction in thickness
  5% of specified thickness subject to a max. of 50 mm

Tolerances in other types of structures not covered above shall generally conform to those given in Recommended Practice for Concrete Formwork (ACI 347)

Tolerances in fixing anchor bolts and embedded parts shall be as follows :

| | | |
|---|---|---|
| - Anchor bolts without sleeves | : | (± )1.5 mm in plan |
| - Anchor bolts with sleeves | : | (±)5.0 mm in elevation |
| - For bolts upto and including 28 mm dia | : | (±) 5 mm in all directions |
| - For bolts 32 mm dia and above | : | (±) 3 mm in all directions |
| - Embedded parts | : | (± )5 mm in all directions |

- Tolerances in precast members

i) Length

| | | |
|---|---|---|
| Upto 3 m | : | (±) 6 mm |
| 3 m to 4.5 m | : | (±) 9 mm |
| 4.5 mm to 6 m | : | (±) 12 mm |
| Additional for every subsequent 6 m | : | (±) 6 mm |

ii) Cross Section (Each direction)

| | | |
|---|---|---|
| Upto 50 cm | : | (±) 6 mm |
| 50 cm to 75 cm | : | (±) 9 mm |
| Additional for every subsequent 25 cm | : | (±) 3 mm |

iii) Straightness or bow (Deviation from intended line)

| | | |
|---|---|---|
| Upto 3 m | : | 6 mm |
| 3 m to 6 m | : | 9 mm |
| 6 m to 12 m | : | 12 mm |
| Additional for every subsequent 6 m | : | 6 mm |

iv) Squareness

When considering the squareness of a corner, the longer of the two adjacent sides being checked should be taken as the base line. The shorter side should not vary in its distance from a perpendicular so that the difference between the greatest and shortest dimensions does not exceed the following limits.

| | | |
|---|---|---|
| Length of shorter sides up to and including 1.2 m | : | 6 mm |
| Over 1.2 m but less than 2 m | : | 9 mm |
| 2 m and over | : | 12 mm |

For the purpose of this requirement, any error due to lack of straightness should be ignored; squareness should be measured with respect to the straight lines which are most nearly parallel with the features being checked.

v) Flatness

The maximum deviations from a 1.5 m straight edge placed in any position on nominally plane surface should not exceed 6 mm.

**STORAGE AND HANDLING OF MATERIALS**

**Cement**

Cement shall be stored in easily countable stacks with consignment identification mark above ground level in perfectly dry and watertight sheds. Bulk cement shall be stored in air tight containers. Cement shall be stored in a manner so as to facilitate removal of first-in first-out basis. Any cement considered defective by the shall not be used by the Contractor and shall be removed from the site immediately. Cement that has been in store for three months or more shall be tested for quality. Should at any time the Owner/Owner's representative has reasons to consider that any cement is defective, then irrespective of its origin, date of manufacture and manufacturer's test certificate,

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such cement shall be tested immediately at the Contractor's cost at an approved laboratory and until the test results are found satisfactory, the cement shall not be used on any work. The Contractor is not entitled to any claim of any nature on this account.

**Coarse and fine aggregate**

Aggregates shall be stored in easily measurable stacks on brick soling or an equivalent platform so that they do not come in contact with dirt, clay, grass or any other injurious substances at any stage. Aggregate of different size shall be kept in different stacks. If so desired by the Owner/Owner's representative, aggregate from different sources shall be stacked separately with proper care to prevent intermixing.

Any aggregate delivered at site in a wet condition or becoming wet at site due to rain or any other means shall be kept in storage for at least twenty four (24) hours to obtain adequate drainage before it is used for concreting or the water content of the mix must be suitably adjusted as directed by the Owner/Owner's representative.

**Reinforcement**

Reinforcement bars shall be stored off the ground under all circumstances and under cover, if so desired by the Owner/Owner's representative. If necessary, a coat of cement wash shall be given to bars to guard against rusting. Reinforcing steel shall be stored consignment wise and diameter wise.

### 5.5.6 Turbo Generator Foundations

**Scope**

This specification covers specific requirements in regard to formwork, staging and placing of concrete for the construction of turbo-generator foundation and pedestal. The requirements specified below shall be in addition to the general requirements as specified in Clause 5.5.5 for Plain & Reinforced Concrete Works". Although the specification covers the requirements for STG foundation, the same is applicable for GTG foundation also.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed hereunder:

| | |
|---|---|
| IS: 456 | Code of practice for plain and reinforced concrete |
| IS: 2974(Part 3) | Code of practice for design and construction of machine foundation - Foundation for rotary type machines (Medium and high frequency). |

**Formwork**

**Design of Formwork**

The design of Form work shall take into account all vertical and lateral loads that the forms will carry or be subjected to, during the construction process. Besides weight and pressure of reinforced concrete and weight of the forms themselves, the design shall consider loadings due to unsymmetrical placement of concrete; impact from dumping of concrete; concentrated loads produced by storing materials on the freshly placed concrete; movement of men and construction equipment; wind action and any other imposed load during construction. Contractor shall assess the magnitude of vertical live load to be taken for design of formwork duly considering his method, sequence and rate of pour of concrete. However, minimum design vertical live load to be considered shall be 750 Kg/m² excluding weight of concrete.

Staging for the deck slab shall be supported directly from the TG raft independent of the TG pedestal columns already cast.

Side shuttering shall be designed to cater for concrete pressures, duly considering rate of pour, temperature of concrete, slump and rate of vibration. The column shuttering shall be designed for a rate of vertical pour not less than 4 metres per hour. For shuttering of deck slab of pedestal, the design rate shall not be less than 1.5 metres per hour. Concrete temperature for design purpose shall be taken to be 21°C (or 70°F) or less. Lateral pressures for design of forms shall be based on ACI Committee 622 Pressure Formula or CERA Research Report No.1 Pressure Design Chart. Following Table, based on ACI Committee 622 Pressure Formula, is given as guidance for assessing maximum lateral pressure for design of forms. Pressure in excess of 2400 Kg/m3 x height of fresh concrete in metres shall not be considered.

| Rate of Concrete placement in metre per hour | Maximum lateral pressure in Kg/cm² for temperature indicated | | |
|---|---|---|---|
| | 21° C (70°F) | 15°C (60°F) | 10°C (50°F) |
| 1.5 | 3870 | 4395 | 5125 |
| 1.8 | 4500 | 5125 | 6005 |
| 2.1 | 5130 | 5860 | 6885 |
| 2.4 | 5750 | 6590 | 7765 |
| 3.0 | 7010 | 8055 | 9520 |
| 3.6 | 8265 | 9520 | 11280 |
| 4.2 | 9520 | 10985 | 13035 |

**Materials for Formwork**

Scaffolding, props, struts and bracings for the shuttering of TG pedestal shall be of structural steel. Plywood faced shuttering shall be used for achieving smooth exposed concrete finish.

**Wall ties/through bolts**

Through bolts, when used as wall ties, shall be in one single piece for the full length.

Through bolt diameter and spacing should be designed to cater for entire lateral concrete pressure on the shuttering. In addition, side stays shall be provided to take atleast 50% of the specified design pressure.

Where use of through bolts is not feasible, the entire pressure shall be taken by side stays/props.

Welding of through bolts to reinforcement shall not be permitted.

**Platforms/Windows**

Suitable and adequate working platforms shall be provided at TG deck slab level, all round the TG pedestal for easy access for construction and inspection.

Adequate windows at maximum 2 m vertical spacings shall be provided in column shuttering for concreting, inspection and introducing vibrators. Arrangements should be made for closing tightly the windows to prevent loss of water and fine material from concrete, as the pour level overtakes the window level.

**Inserts/Embedment**

Inserts/embedment shall not be supported on or tied to reinforcement, but independently on shuttering. If the embedments are to be welded, separate rebars have to be provided for the purpose. Suitable arrangements shall be made to locate and fix them to shuttering. Stools shall be provided where required.

Main equipment foundation bolts, pipe sleeves and block-outs for pockets shall be placed and maintained in position at the top by means of an adequately braced steel template. While planning the template, care should be taken to ensure that it does not block the top of beam and that adequate free space is left to pour concrete from the top.

**Placing of Concrete**

Contractor shall furnish to Owner/Owner's representative together with formwork design, his proposed scheme for concreting the TG base raft and pedestal. The scheme shall indicate types of equipment, mobilisation of men and materials, standby arrangements and method, sequence and rate of pouring concrete. Work shall proceed only after Owner/Owner's representative's approval.

Concrete for TG raft and TG deck slab be cooled to a temperature of 23°C and adequate arrangements shall be made to ensure this. Concrete for columns shall be cooled if the least dimensions of column is more than 1.4m.

The base raft shall be cast in not more than two pours or as shown on the drawing. Full raft thickness shall be achieved in each continuous pour. Extent of each pour and sequence of pours shall be as directed by Owner/Owner's representative or as shown in drawing released for construction.

TG pedestal columns from top of base raft to bottom of TG deck etc., shall be cast in one single continuous pour, unless otherwise directed by Owner/Owner's representative or as shown in drawings released for construction.

TG deck slab shall be cast in a single pour without construction joints/cold joints. Successive layers shall be placed before initial set of previous layer or within one hour, whichever is earlier. For proper placement and vibration, the layers shall not be less than 500 mm thick.

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Chutes/tremie pipes of adequate dia (225 mm) shall be used to place concrete if the beams are more than 2 m deep and for this purpose, some top bars will have to be displaced temporarily to allow inserting of the same.

In areas where second stage grouting is to be done after the TG set is erected and aligned, the concrete shall be laid 50 mm higher than the actual level required and chipped back to exact required level. The concrete surface under equipment sole plates shall be ground to ensure a minimum contact area of 85%.

**Tolerances in TG Foundation**

Concreting of TG foundation (raft & pedestal) shall be to following tolerances in horizontal and vertical directions:

| | | | |
|---|---|---|---|
| - | Foundation dimensions | : | ± 10 mm |
| - | Location of embedded anchor bolts | : | ± 5 mm |
| - | Location of sleeves for piping and through holes for anchor bolt | : | ± 10 mm |
| - | Others | : | As specified in Clause 4.5.0<br><br>Technical Specifications for "Plain & Reinforced Concrete Work" |

**5.5.7 Prestressed Concrete**

**Scope**

This specification covers the requirements in respect design, workmanship and quality of pre-stressed concrete structures. It is supplementary to and has to be read in conjunction with the specification of plain and reinforced concrete work in Clause 5.5.0.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the contract, shall govern in respect of design, workmanship and methods & procedures of testing. Some of the relevant available codes are listed hereunder.

| | |
|---|---|
| IS : 1343 | Code of practice for the prestressed concrete. |
| IS : 1785 | Specification for plain hard drawn steel wire for prestressed concrete. |
| IS : 6003 | Specification for intended wire for prestressed concrete |
| IS : 2090 | Specification for high tensile bars for prestressed concrete. |
| IS : 6006 | Specification for uncoated stress relieved strand for prestressed concrete. |

**Materials**

**Prestressing Steel**

Prestressing steel shall conform to IS: 1785, IS: 2090, IS: 6003 and IS: 6006.

Non-tensioned Reinforcement

Non-tensioned reinforcement may be mild steel bars conforming to IS: 432 or high yield strength deformed bars conforming to IS: 1786.

For other materials refer specification for plain and reinforced concrete work.

**Grades and Proportioning**

For prestressed concrete construction, only controlled concrete shall be used. The design of the concrete mix shall conform to the requirements laid down for controlled concrete under relevant clauses of IS: 456, and the workmanship shall conform to specification for cement concrete subject to the following further conditions :

i) The minimum cube strength of concrete at 28 days where ordinary portland cement is used, and at 7 days where rapid hardening portland cement is used on 15 cm cubes, shall not be less than 45 N/mm² for pre-tensioned system and 35 N/mm² for post-tensioned systems.

ii) The mix shall contain not less than 380 kg of cement per $m^3$ of concrete for pre-tensioned work. The corresponding value of the post-tensioned work shall be 360 kg/m³ of concrete. The cement in the mix shall not normally exceed 530 kg/m³ of concrete.

iii) The mix shall contain as low a water content as consistent with adequate workability.

iv) The concrete shall be compacted thoroughly by vibration, pressure, shock, spinning or other means and shall have a density of not less than 24 KN/m³.

**Workmanship**

Workmanship and method of execution shall conform to the requirements of IS: 1343.

The type of jack, like hydraulic jack, etc. used for prestressing shall be standard type and of approved manufacture. The method of anchorage shall be also of approved type so as not to allow more than nominal slip in the wires. The anchorage shall be safe and secure against both dynamic and static loads as well as against impact.

**Testing and Acceptance Criteria**

Sampling, strength test and acceptance of precast prestressed members shall be in accordance with the provisions of IS:456 & IS:1343. The Contractor shall conduct load test on one random piece per batch or 1000 units precast. Load test on more than one piece per batch may have to be done if required by the Owner/Owner's representative. The Contractor shall inform the Owner/Owner's representative the number of units that would be cast in a single operation based on which the number of units to be tested will be decided. If a piece/unit fails in a load test the entire batch will be rejected.

### 5.5.8 Structural Steelwork

**Scope**

This specification covers the requirements in respect of materials, workmanship and quality for preparation of fabrication drawings, supply, fabrication, inspection, testing, painting and erection of structural steelwork including tubular steel work for buildings and structures.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed here under:

| | |
|---|---|
| IS:800 | Code of Practice for use of structural steel in general building construction. |
| IS:801 | Code of Practice for use of cold formed light gauge steel structural members in general building construction. |
| IS:806 | Code of Practice for use of steel tubes in general building construction. |
| IS:808 | Dimensions of hot rolled steel sections. |
| IS:813 | Scheme of symbols for welding. |
| IS:814 | Covered electrodes for metal are welding of structural steel. |
| IS:815 | Classification and coding of covered electrodes for metal are welding of mild steel. |
| IS:816 | Code of Practice for use of metal are welding for general construction in mild steel. |
| IS:817 | Code of Practice for training and testing metal are welders. |
| IS:818 | Code of Practice for Safety and Health requirements in electric and gas welding and cutting operations. |
| IS:822 | Code of Practice for inspection of welds. |
| IS:919 | Recommendations for limits and fits for engineering. |
| IS:961 | Structural Steel (High Tensile). |
| IS:1148 | Hot-rolled rivet bars for structural purposes. |
| IS:1149 | High tensile rivet bars for structural purposes. |
| IS:1161 | Steel tubes for structural purposes. |
| IS:1200 | Method of measurement of steel work and Part VIII iron work. |
| IS:1239 | Mild steel tubes, tubular and other wrought steel fittings. |
| IS:1363 | Hexagon head bolts, screws and nuts of product grade C. |

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| | |
|---|---|
| IS:1364 | Hexagon head bolts, screws and nuts of product grade A and B. |
| IS:1367 | Technical supply conditions for threaded steel fasteners. |
| IS:1442 | Covered electrodes for metal arc welding of high tensile structural steel. |
| IS:1608 | Method for tensile testing of steel products. |
| IS:1730 | Dimensions for steel plate, sheet and strip for structural and general engineering purposes. |
| IS:1731 | Dimensions for steel flats for structural and general engineering purposes. |
| IS:1852 | Rolling and cutting tolerances for hot-rolled steel products. |
| IS:1977 | Structural steel (ordinary quality) St-42-0. |
| IS:2062 | Weldable structural steel. |
| IS:2074 | Ready mixed paint, air drying, red oxide zinc-chrome, priming. |
| IS:2633 | Methods of testing uniformity of coating on zinc coated articles. |
| IS:3757 | High strength structural bolts. |
| IS:4000 | High strength bolts in steel structures - Code of Practice. |
| IS:5369 | General Requirements for Plain Washers and Lock Washers |
| IS:5372 | Taper washers for channels (ISMC) |
| IS:5374 | Taper washers for I-beams (ISMB) |
| IS:6610 | Specification for Heavy Washers for Steel Structures |
| IS:6649 | Specification for Hardened and Tempered Washers for High Strength Structural Bolts and Nuts |
| IS:6623 | Specification for High Strength Structural Nuts |
| IS:7205 | Safety code for erection of structural steelwork. |
| IS:7215 | Tolerances for fabrication of steel structures. |
| IS:9595 | Recommendations of metal arc welding of carbon and carbon manganese steels. |
| AISC | American Institute of Steel Construction Specification for the Design, Fabrication and Erection of Structural Steel for Buildings. |
| SP6(4) | Hand book for use of high strength friction grip bolts. |

**Materials**

**Structural steel**

All structural steel shall be of tested quality and shall conform to IS:2062. High tensile steel, when supplied, shall conform to IS:961.

**Bolts and nuts**

Bearing bolts and nuts shall conform to IS:1363 and IS:1364 and unless shown or specified otherwise shall be hexagonal. All nuts shall fit tight. Mechanical properties shall conform to IS:1367. High strength friction bolts shall conform to IS:3757 and nuts to IS:6623.

**Washers**

Washers shall conform to IS:5369, IS:5372, IS:5374, IS:6610 and IS:6649 as applicable.

Plain washers shall be made of mild steel, unless otherwise specified. Spring washers shall be provided for those parts which carry dynamic loads and where black bolts for connection are permitted.

**Electrodes**

Mild steel electrodes shall conform to IS:814 and high tensile steel electrodes to IS:1442. The manufactures shall have ISO certification. The Contractor shall furnish to the Owner/Owner's representative a certificate issued by the manufacturer to the effect that the electrodes supplied are in accordance with the above specifications. For welding in any particular position, the electrodes used shall be those recommended by the manufacturer for use in that position.

**Paints**

Paints to be used for shop coat of fabricated steel shall be compatible with the finish coat specified.

**Other Materials**

Other materials used in association with steel work shall comply with the appropriate Indian Standard specifications.

**General requirements regarding supply of materials by Contractor**

Before ordering bought out items, special accessories, equipment etc. and materials of any description, the Contractor shall submit, for the approval of the Owner/Owner's representative, the names of the proposed manufacturers or suppliers together with the specification of the materials and shall, thereafter, send to the Owner/Owner's representative copies of the orders.

When a supplier or sub-Contractor orders materials for the execution of his sub-contract, he shall also comply with the aforesaid requirements, by the submission through the Contractor, for the approval of the Owner/Owner's representative, of the names of the manufacturers proposed and by sending to the Owner/Owner's representative of copies of the orders.

The Contractor shall furnish to the Owner/Owner's representative the following certificates, if required, before commencement of fabrication:

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i) A certificate stating the process of manufacture and chemical composition of the steel supplied.

ii) Test certificates by the manufacturer giving the results of each of the specified mechanical tests applied to the structural steel, bolts, nuts and washers and the chemical composition of the same.

**Drawings and Lists**

Unless otherwise stated, the Contractor shall be responsible for the preparation of the detailed fabrication/working drawings, erection and marking plans and all necessary lists such as indents, rivet and bolt lists, material lists, Despatch lists and lists for all bought out items. The fabrication drawings shall indicate the size of each component and length and sequence of all welds & bolted connections.

Fabrication work shall not be taken in hand until the relevant shop drawings have been approved by the Owner/Owner's representative. Although these drawings receive the approval of the Owner/Owner's representative, the Contractor shall be wholly responsible for their being correct and complete. The drawings shall be supplied at least two weeks in advance to enable the Owner/Owner's representative to study the drawings. One copy of the approved drawings will be returned to the Contractor and the work shall be carried out according to the approved drawings.

**Fabrication**

**General**

- **Workmanship**

All workmanship shall be equal to the best practice in modern structural shops. Greatest accuracy shall be observed in the manufacture of every part of the work and all similar parts shall be strictly interchangeable.

- **Templates**

Templates used throughout the work shall be all steel, steel bushed in such cases as the Owner/Owner's representative may consider necessary. In cases where actual materials have been used as templates for drilling similar pieces, the Owner/Owner's representative shall decide whether they are fit to be used as parts of the finished structure.

- **Straightening**

All materials shall be straight and if necessary before being worked shall be straightened and/or flattened by pressure unless required to be of curvilinear form and shall be free from twists.

- **Clearance**

The erection clearances for cleated ends of members connecting steel to steel should preferably be not greater than 2.0 mm at each end. The erection clearance at ends of beams without web cleats should be not more than 3 mm at each end, but where for practical reasons greater clearance is necessary suitably designed seatings should be provided.

- **Shearing, flame cutting and planning**

Shearing or flame cutting may be used at the Contractor's option provided that a mechanically controlled cutting torch shall be used for the flame cutting and that the resulting edge shall be reasonably clean and straight. Sheared members shall be free from distortion at sheared edges.

The edges and ends of all flange plates and web plates of plate girders and built-up columns of plates, forming chords or web members of lattice girders and all cover plates, the ends of all angles, tees, channels and other sections forming the flanges of plate girders and columns and chords and web members of lattice girders shall be planed.

The ends of all stiffeners shall be planed or ground to fit tightly between the main angles or flanges. Care shall be taken to ensure a full bearing of the stiffeners at the supports and at other points where concentrated load is applied. The ends shall not be drawn or caulked.

The butting surfaces at all joints of girders or columns shall be planed so as to butt in close contact throughout the finished joint.

The ends of all built-up girders and of all columns shall be faced in a machine. The bearing surfaces of all slabs and plates for caps and bases of columns and for seatings for heavy girders shall be machined.

Unless clean, square and true to shape, all flame-cut edges shall be planed.

Cold sawn ends if reasonably clean and flame cut ends of sections not inferior to sawn ends in appearance need not be planed except for butting ends.

- **Holing**

Holes for black bolts shall be not more than 1.5 mm larger than the nominal diameter of the bolt, unless specified otherwise. All holes, except as stated here under shall be drilled to the required size or sub-punched 3 mm less in diameter and reamed thereafter to the required size. All matching holes for black bolts shall register so that a gauge 1.5 mm less diameter than the hole can pass freely through the members assembled for bolting. All holes for turned and fitted bolts shall be drilled and reamed, if necessary, to a tolerance of only plus 0.13 mm unless specified otherwise. When the number of thicknesses to be riveted exceeds three or the total thickness is 90 mm or more, the holes shall be drilled or reamed in position after assembly, except when steel-bushed jigs are used. The parts shall be firmly bolted together during such block drilling and taken apart for removal of burrs after drilling.

Holes in purlins, side sheeting, runners, packing plates and lacing bars may be punched full size.

All punching and sub-punching shall be clean and accurate and all drilling free from burrs.

No holes shall be made by gas cutting process.

- **Assembly**

All parts assembled for bolting shall be in close contact over the whole surface and all bearing stiffeners shall bear tightly at both top and bottom without being drawn or caulked.

The component parts shall be so assembled that they are neither twisted nor otherwise damaged and specified cambers, if any, shall be provided.

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- **Bolting**

Bolted construction shall be permitted only in the case of field connections, if called for on the drawings and is subject to the limitation of particular connections as may be specified. In special cases, however shop bolt connections may be allowed if directed by the Owner/Owner's representative. Unless otherwise specified, faces of heads and nuts bearing on steel work shall be machined. All such bolts shall be provided with washers having a hole of 1.6 mm larger in diameter than the barrel of bolt and thickness not less than 6.5 mm so that the nut, when tightened, shall not bear on the unthreaded body of the bolt. In all cases, where the full bearing area of the bolt is to be developed, the threaded portion of the bolt should not be within the thickness of the parts bolted together. The threaded portion of each bolt shall project through the nut by at least one thread. Tapered washers shall be provided for all heads and nuts bearing on beveled surface.

- **High Strength Friction Grip Bolting**

Installation of high strength friction grip bolts in joints shall comply with IS:4000 and/or BS:3294. The diameter of the bolt holes must not be more than 2.0 mm larger than the nominal diameter of the bolt. All contact surfaces in a connection including those associated with the bolt heads, nuts and washers, shall be free of scale, burrs, dirt and other foreign matter tending to inhibit uniform sealing of the joint components. However, tight mill scale and the light residual oil coating on bolts, nuts and washers need not be removed.

All fasteners in a joint shall be tightened to a tension equal to or greater than the tension specified in Table 3 of IS: 4000.

Tightening may be achieved by use of Direct tension Indication or part twin method. A hardened washer shall be placed under the element being turned. Bolts shall be tightened at the most rigid portion of the joint, proceeding towards the free edges. Procedure given in IS:4000 shall be followed.

Inspection of friction grip bolting shall ensure that the selected tensioning procedure has been correctly applied and all bolts are fully tensioned. The methods suggested in IS:4000 shall be used to check that all bolts are fully tensioned.

**Welding**

- **General**

The welding and the welded work shall conform to IS: 816 unless otherwise specified. The permissible stresses for welding shall be taken as 75 per cent of those specified in IS:816, where welds are not tested by either radiographic or ultrasonic methods. All butt welds in critical structures such as crane girders, heavy columns, bunkers, etc. shall be tested by either radiographic or ultrasonic methods. As much work as possible shall be welded in shops and the layout and sequence of the operations shall be so arranged as to eliminate distortion and shrinkage stresses to the satisfaction of the Owner/Owner's representative.

- **Plant and equipment**

The plant used shall be of sufficient capacity to suit the welding procedure laid down and be capable of depositing the particular type or types of electrodes to be used under the conditions of current and voltage specified by the electrode manufacturer. The number of welding sets, both automatic and hand operated proposed to be used in the work shop for fabrication of the structural steel work for the contract shall be given by the Bidder along with his tender. Efficient means shall be provided for the accurate indication of the current and in addition, a pair of tong testers shall be supplied by the Contractor and be available to the Owner/Owner's representative.

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All equipment, accessories and connections shall be maintained in proper working order.

- **Electrodes**

All electrodes shall be kept under dry conditions. Any electrode damaged by moisture shall not be used unless it is stated by the manufacturer that when it is properly dried, there will be no detrimental effect. Any electrode which has part of its flux coating broken away or is otherwise damaged, shall be discarded. Any electrode older than 6 months from the date of manufacture shall not be used. Low hydrogen electrodes shall be used for joints in material above 20 mm thick and all important connections.

- **Preparation of Material**

Surface to be welded shall be free from loose scale, slag, rust, grease, paint and any other foreign material except that mill scale which withstands vigorous wire brushing may remain. Joint surfaces shall, be free from fins and tears. Preparation of edges by gas-cutting shall, wherever practicable, be done by a mechanically guided torch.

- **Welding procedure**

Before commencement of work the Contractor shall submit to the Owner/Owner's representative for his approval, the procedure proposed to be adopted. The welding procedure shall be arranged to suit the details of the joints as indicated on the drawings and the position at which welding has to be carried out. Welding procedure shall cover the following:

i) Type and size of electrodes

ii) Current and (for automatic welding) arc voltage

iii) Length of run per electrodes, or (for automatic welding) speed of travel

iv) Number and arrangement of runs in multi-run welds

When necessary the procedure shall also cover the following:

v) Position of welding

vi) Preparation and set up of parts

vii) Welding sequence

viii) Pre or post heating

ix) Any other relevant information

- The welding procedure shall be so arranged that the distortion and shrinkage stresses are reduced to a minimum and that the welds meet the requirement of quality specified here under.

- The Contractor shall record the approved welding procedure and shall provide each operator with all relevant details. Alternative approved procedure may be furnished in such cases when it is desirable to make the fullest use of available plant. The welding procedure then laid down shall be strictly followed and no variation shall be permitted without the approval of the Owner/Owner's representative.

- Preening of the welds involving deformation of the weld surface either during deslagging operation or thereafter, shall not be allowed.

**Fusion faces and surrounding surfaces:**

- Fusion faces and the surrounding surfaces within 50 mm of welds shall be free from all mill scale and free from oil, paint, or any substance which might affect the quality of the weld or impede the progress of welding. They shall be free from irregularities such as would interfere with the deposition of the specified size of weld or be the cause of defects.

- All mill scale within 50 mm of welds shall be removed prior to welding either by pickling at works followed by thorough power wire brushing or by other approved methods.

- If preparation or cutting of the fusion faces is necessary the same shall be carried out by shearing, chipping, gas-cutting or flame-gouging.

- Where hand gas cutting or hand-gouging is employed, the blow pipe or gouging blow pipe shall be properly guided.

- **Assembly for welding:**

Parts to be welded shall be properly assembled and held firmly in position by means of jigs and clamps prior to and during welding.

The fit of joints at contact surfaces which are not completely sealed by welds, shall be close enough to exclude water after painting. Abutting parts to be butt-welded shall be carefully aligned. Misalignments greater than 3 mm or 25% of the thickness of thinner plate whichever is smaller shall be corrected and in making the correction the parts shall not be drawn into a sharper slope than two degrees (2 deg).

The work shall be positioned for flat welding whenever practicable.

- **Welding Sequence**

In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as will avoid needless distortion and minimise shrinkage stresses. Where it is impossible to avoid high residual stresses in the closing welds of a rigid assembly, such closing welds shall be made in compression elements.

In the fabrication of cover-plated beams and built-up members, all shop splices in each component part shall be made before such component part is welded to other parts of the member. Long girders or girder sections may be made by shop splicing not more than three sub-sections, each made in accordance with this paragraph.

When required by the Owner/Owner's representative, welded assemblies shall be stress relieved by heat treating in accordance with the provisions of the relevant Indian Standard or any other Standard approved by the Owner/Owner's representative.

- **Welding technique**

All complete penetration groove welds made by manual welding, except when produced with the aid of backing material not more than 8 mm thick with root opening not less than one-half the thickness of the thinner part joined, shall have the root of the initial layer gouged out on the back side before welding is started from that side, and shall be so welded as to secure sound metal and compact fusion throughout the entire cross-section. Groove welds made with the use of a backing of the same material as the base metal shall have the weld metal thoroughly fused with the backing

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material. Backing strips need not be removed. If required, they may be removed by gouging or gas cutting after welding is completed, provided no injury is done to the base metal and weld metal and the weld metal surface is left flush or slightly convex with full throat thickness.

Groove welds shall be terminated at the ends of a joint in a manner that will ensure their soundness. Where possible, this should be done by use of extension bars or run-off plates. Extension bars or run-off plates need not be removed upon completion of the weld unless otherwise specified elsewhere in the specifications.

The effective area of fillet welds shall be considered as the effective length times the effective throat thickness. The effective length of fillet welds except fillet welds in holes and slots shall be the overall length of full size fillet, including returns.

The effective throat thickness of a fillet weld shall be the shortest distance from the root to the face of the diagrammatic weld.

The minimum size of weld is determined by the thicker of the two parts joined except that the weld size need not exceed the thickness of the thinner part joined unless a larger size is required by calculated stress. For this exception, particular care shall be taken to provide sufficient preheat for soundness of the weld. The minimum size of fillet welds are as follows.

| Material thickness of thicker part joined | Minimum size of fillet weld | Minimum effective throat thickness of partial penetration groove welds |
|---|---|---|
| Upto 6 mm | 3 mm | 3 mm |
| 6mm to 12 mm | 5 mm | 5 mm |
| 12 mm to 19 mm | 6 mm | 6 mm |
| 19 mm to 38 mm | 8 mm | 8 mm |
| 38 mm to 57 mm | 8 mm | 10 mm |
| 57 mm to 152 mm | 8 mm | 13 mm |
| Over 152 mm | 8 mm | 16 mm |

The minimum effective length of a fillet weld designed on the basis of strength shall not be less than 4 times the nominal size (of weld) or else the size of the weld shall be considered not to exceed 1/4 of the effective length.

In intermittent welds the effective length of any segment of intermittent fillet welding shall be not less than 4 times the weld size with a minimum of 40 mm.

The minimum amount of lap on lap joints shall be 5 times the thickness of the thinner part joined but not less than 25 mm.

Side or end fillet welds terminating at ends or sides respectively of parts or members shall wherever practicable, be returned continuously around the corner for a distance not less than 2 times the nominal size of weld.

To get the best and consistent quality of welding, automatic submerged arc process shall be preferred. The technique of welding employed, the appearance and quality of welds made, and the methods of correcting defective work shall all conform to the relevant Indian Standards.

Preheating techniques combined with the use of low hydrogen electrodes shall be used for

i. Certain joint configurations as specified in the drawings and as directed by the Owner/Owner's representative.

ii. Welding involving plates over 20 mm thickness conforming to IS:2062.

- Temperature

No welding shall normally be done on parent material at a temperature below (-) 5 deg C. However, if welding is to be undertaken at low temperatures, adequate precautions as recommended in relevant Indian Standard shall be taken. When the parent material is less than 40 mm thick and the temperature is between (-) 5 deg C and 0 deg C, the surface around the joint to a distance of 100 mm or 4 times the thickness of the material, whichever is greater, shall be pre-heated till it is handwarm. When the parent material is more than 40 mm thick, the temperature of the area mentioned above shall in no case be less than 20 deg C. All requirements regarding preheating of the parent material shall be in accordance with the relevant Indian Standard.

The table below may be used as a guideline for preheat and interpass temperature to be maintained within 75 mm on either side of the point of welding.

| Thickness of the thickest part at the point of welding | Minimum preheat & Interpass temperature | |
|---|---|---|
| | other than low hydrogen welding electrodes | Low hydrogen welding electrodes |
| Upto 20 mm | None | None |
| 20 mm to 40 mm | 65°C | 20°C |
| 40 mm to 63 mm | 110°C | 65°C |
| Over 63 mm | 150°C | 110°C |

- **Accuracy of fit up**:

Parts to be fillet welded shall be brought into as close contact as practicable and the gap due to faulty workmanship or incorrect fit up shall not exceed 1.5 mm. If greater separation occurs at any position, the size of fillet weld shall be increased at such positions by the amount of the gap.

- **Jigs and manipulators:**

Jigs and manipulators shall be used where practicable and shall be designed to facilitate welding and to ensure that all welds are easily accessible to the operators.

- **End of butt welded joints**:

The ends of butt joints shall be welded so as to provide the full throat thickness. This may be done by the use of extension pieces, cross-runs or other means approved by the Owner/Owner's representative.

- **Weld face and reinforcement of butt welds**:

The weld face shall at all places be deposited proud of the surface of the parent metal. Where a flush surface is required the surplus metal shall be dressed off.

- **Minimum leg length and throat thickness in fillet welds**:

The minimum leg length of a fillet weld as deposited shall be not less than specified size. In no cases shall a concave weld be deposited without specific permission of the Owner/Owner's representative. Where permitted, the leg length shall be increased above that specified, so that the resultant throat thickness is as great as would have been obtained by the deposition of a flat-faced weld of the specified leg length.

- **Deslagging:**

After making each run of welding all slag shall be thoroughly removed.

- **Quality of welds**:

The weld metal, as deposited (including tack welds if to be incorporated) shall be free from cracks, slag inclusions, gross porosity, cavities and other deposition faults. The weld metal shall be properly fused with the parent metal without serious undercutting or overlapping at the toes of the weld. The surface of the weld shall have a uniform consistent contour and regular appearance.

- **Working conditions:**

Welding shall not be done under weather or other conditions which might adversely affect the efficiency of the welding and where necessary effective protection or other safeguard shall be provided.

- **Qualification and testing of welders:**

The Contractor shall satisfy the Owner/Owner's representative that the welding operators are suitable for the work upon which they will be employed and shall produce evidence to the effect that welders have satisfactorily completed appropriate tests as described in IS:817. The Owner/Owner's representative may at his discretion order periodic tests of the welders and/ or of the welds produced by them. Such tests shall be at the expense of the Contractor.

- **Supervision:**

The Contractor shall employ a competent welding supervisor or charge-hand to ensure that the standard of workmanship and the quality of the materials comply with the requirements laid down in this specification.

**Machining of butts, caps and bases**

Column splices and butt joints of struts and compression members depending on contact for stress transmission shall be accurately machined and close butted over the whole section with a clearance not exceeding 0.2 mm locally. In column caps and bases, the ends of shafts together with the attached gussets, angles, channels etc. after rivetting, bolting and/ or welding together as the case may be, should be accurately machined so that the parts connected butt over the entire surfaces of contact. Care should be taken that those connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by machining by more than 2.0 mm.

Where sufficient gussets and bolts or welds are provided to transmit the entire loading or where connection is by full penetration butt welds, the column ends need not be machined.

Slab bases and caps, if applicable, shall be in one solid piece, and except when cut from material with surfaces, and shall be accurately machined over the bearing surfaces and shall be in effective contact over the whole area of the machined end of the stanchion. A bearing face need not be

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machined if it is to be grouted directly to a foundation provided it is true and parallel to the machined face. To facilitate grouting, holes shall be provided where necessary in stanchion bases for escape of air.

**Shop painting**

The whole of steel work with the exception of bolts and nuts and machined surfaces after being thoroughly cleaned to remove rust, loose scale, grease, dust etc. shall be given one shop coat of primer compatible with the finish paint. For epoxy based paints, surface preparation shall be by sand blasting. All rivets, bolts, nuts and washers etc. shall be thoroughly cleaned and dipped in boiled linseed oil. All machined surfaces shall be well coated with a mixture of white lead and tallow. Surfaces which are to be held in contact by bolting shall be painted before assembly, and the parts brought together while still wet. Unless specified otherwise, all surfaces inaccessible after bolting or intermittent welding shall be given two coats of approved paint before assembly. In the case of surfaces to be welded, the steel shall not be painted or metal coated within a suitable distance of any edges to be welded if the paint specified or the metal coating would be harmful to welders or impair the quality of the welds. Welds and adjacent parent metal shall not be painted prior to deslagging, inspection and approval. Parts which are to be encased in concrete shall not be painted or oiled.

**Marking, packing and despatching**

Each piece shall be distinctly marked before delivery, in accordance with an approved marking diagram and shall bear such other marks as will facilitate erection. For easy identification at site, a small distinguishing mark for each building shall be painted on each end of every member before despatch from fabrication shop. The fabricated steel work shall be despatched in such portions as may be found convenient for erection or as ordered by the Owner/Owner's representative.

All projecting plates or bars and all ends of members at joints shall be stiffened, all straight bars and plates shall be bundled, all screwed ends and machined surfaces shall be suitably packed and all rivets, bolts, nuts, washers and small loose parts shall be packed separately in cases so as to prevent damage or distortion during transit.

**Erection**

**General**

The material shall be verified with marking on the marking plan or shipping lists which shall be supplied by the Contractor.
Any material found damaged or defective shall be stacked separately and the damaged or defective portions be painted in distinct colour. Such material is to be dealt with under the orders of the Owner/Owner's representative without delay.

The field assembling of the component parts of a structure shall involve the use of method and appliances not likely to produce injury by twisting, bending or otherwise deforming the metal. No member slightly bent or twisted shall be put in place until the defects are corrected and members seriously damaged in handling shall be rejected.

All small bends or twists received by members shall be rectified before such members are put in place; any serious bends or damage shall be reported at once to the Owner/Owner's representative by the Contractor for instructions. The straightening of bent edges of plates, angles and other shapes shall be done by methods not likely to produce fracture or other injury.

Following the completion of the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of incipient or other fractures.

**Setting Out**

The Contractor shall assume full responsibility for the correct setting out of all steel work and erecting it correctly as per alignment and levels shown on the drawings and plumbing of vertical members. Datum points will be fixed by the Owner/Owner's representative near the work site. Notwithstanding any assistance rendered to the Contractor by the Owner/Owner's representative, if at any time during the progress of the work any error should appear to arise therein, on being required to do so, the Contractor at his own cost shall remove and amend the work to the satisfaction of the Owner/Owner's representative.

**Field connections**

All field connections in the trusses, columns, girders, framework etc. shall be welded, unless otherwise specified. Connection of purlins, girts and other unimportant members only may be bolted with black bolts, except where welded connections are required.

Use of "high strength friction grip" bolts in place of welding may be permitted for field connections at the discretion of the Owner/Owner's representative.

**Field bolting**

All relevant portions in respect of bolted construction of the Specification for Fabrication of Structural Steel work shall also be applicable for field bolting in addition to the following.

Bolts shall be inserted in such a way so that they may remain in position under gravity even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled, all joint surfaces, including those adjacent to the washers, shall be free of scales except tight mill scales. They shall be free of dirt, loose scales, burns, and other defects that would prevent solid seating of the parts. Contact surfaces within friction-type joints shall be free of oil, paint, lacquer, or galvanising.

All high tensile bolts shall be tightened to provide, when all fasteners in the joint are tight, the required minimum tension by any of the following methods.

**Turn-of-nut method**

When the turn-of-nut method is used to provide the bolt tension, there shall first be enough bolts brought to a "snug tight" condition to ensure that the parts of the joint are brought into good contact with each other. "Snug tight" is defined as the tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench: Following this initial operation, bolts shall be placed in remaining holes in the connection and brought to snug tightness. All bolts in the joint shall then be tightened additionally by the applicable amount of nut rotation specified in Table I with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation, there shall be no rotation of the part not turned by the wrench.

TABLE-I

| Bolt length exceeding 8 times diameter or 200 mm | Remark |
|---|---|
| 2/3 turn | Nut rotation is relative to bolt regardless of the element (nut or bolt) being turned. Tolerance on rotation- 30° over or under |

Bolts may be installed without hardened washers when tightening is done by the turn-of-nut method.

Bolts-tightened by the turn-of-nut method may have the outer face of the nut match-marked with the protruding bolt point before final tightening, thus affording the inspector visual means of noting the actual nut rotation. Such marks can be made by the wrench operator by suitable means after the bolts have been brought up snug tight.

**Torque wrench tightening**

When torque wrenches are used to provide the bolt tensions, the bolts shall be tightened to the torques specified in Table-II. Nuts shall be in tightening motion when torque is measured. When using torque wrenches to install several bolts in a single joint, the wrench shall be returned to "touch up" bolts previously tightened, which may have been loosened by the tightening of subsequent bolts, until all are tightened to the required tension.

**TABLE-II**

| Nominal Bolt Diameter (mm) | Torque to be applied (Kg.M) for Bolt class 8.8 of IS:1367 |
|---|---|
| 20 | 56.93 |
| 22 | 81.63 |
| 24 | 103.73 |

In either case of the above two methods if required, because of bolt entering and wrench operation clearances, tightening may be done by turning the bolt while the nut is prevented from rotating.

Impact wrenches, if used, shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately ten seconds.

Holes for turned bolts to be inserted in the field shall be reamed in the field. All drilling and reaming for turned bolts shall be done only after the parts to be connected are assembled.

Tolerances applicable in the fit of the bolts shall be in accordance with relevant Indian Standard Specifications. All other requirements regarding assembly and bolt tightening shall be in accordance with this Sub-Clause.

**Field welding**

All field assembly and welding shall be executed in accordance with the requirements for shop fabrication, excepting such as manifestly apply to shop conditions only. Where the steel has been delivered painted, the paint shall be removed before field welding, for a distance of at least 50 mm on either side of the joints.

**Bedding and grouting**

Bedding shall be carried out with cement grout or mortar having a compressive strength of 250 kg per sq. cm at 28 days for main column bases and 200 kg per sq. cm at 28 days for secondary column bases. For the main column the Contractor shall provide screed bars of mild steel flats and fix them in mortar. The Owner/Owner's representative will be the sole authority in deciding "main"

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and "secondary" columns and his decision in this matter will be binding on the Contractor within the terms of this contract.

The bedding shall not be carried out until a sufficient number of columns has been properly aligned, levelled and plumbed and sufficient girders, beams, trusses and bracings are in position to the satisfaction of the Owner/Owner's representative.
Immediately before grouting, the space under the base plate and around bolts shall be thoroughly cleaned and made free from excessive moisture.

The grout or mortar shall be mixed as thick as possible consistent with fluidity and shall be poured under pressure with pressure grouting machine, until the space has been filled with mortar. Admixtures, if directed to be added will be measured and paid separately. If desired, ready mix high strength non-shrink grout of specified strength shall be used.

**Painting after erection**

Before painting of steel which is delivered unpainted is commenced, all surfaces to be painted shall be dry and thoroughly cleaned of all loose scale, rust, dust, grease, etc.

The specified protective treatment shall be completed after erection. All rivet and bolt heads and the site welds after deslagging shall be cleaned. Damaged or deteriorated paint surfaces shall be made good first with the same type of paint as the shop coat. Where specified, surfaces which will be in contact after site assembly shall receive a coat of paint (in addition to any shop priming) and shall be brought together while the paint is still wet.

Surface which will be inaccessible after site assembly shall receive the full specified protective treatment before assembly.

Site painting should not be done in frosty or foggy weather or when humidity is such as to cause condensation on the surface to be painted.

Two or more final coats of approved paint as specified shall be applied to the steel work after erection.
Correction of misfits

Correction of minor misfits, a reasonable amount of reaming and cutting of excess-stock from rivets will be considered a legitimate part of the erection.

Any error in shop work which prevents the proper assembling and fitting up of parts by the moderate use of drift pins or a moderate use of reaming and slight chipping or cutting shall immediately be reported to the Owner/Owner's representative and his approval of the method of correction obtained.

**Testing and Acceptance Criteria**

**General**

The Owner/Owner's representative shall have free access at all reasonable times to those parts of the manufacturer's works which are concerned with fabrication of the steel work and shall be afforded all reasonable facilities for satisfying himself that the fabrication is being undertaken in accordance with the provisions of this specification.

Unless specified otherwise, inspection shall be made at the place of manufacture prior to despatch and shall be conducted so as not to interfere unnecessarily with the operation of the work.

Tolerance for fabricated structures shall be as per IS:7215.

Should any structure or part of a structure be found not to comply with any of the provisions of this specification, it shall be liable to rejection. No structure or part of the structure, once rejected shall be resubmitted for test, except in cases where the Owner/Owner's representative considers the defect as rectifiable.

Defects which may appear during fabrication shall be made good with the consent of and according to the procedure laid down by the Owner/Owner's representative.

All gauges and templates necessary to satisfy the Owner/Owner's representative shall be supplied by the manufacturer.
The Owner/Owner's representative may, at his discretion, check the test results obtained at the manufacturer's works by independent tests at the Government Test House or elsewhere.

When all tests to be performed in the Contractor's shop under the terms of this Contract have been successfully carried out, the steel work will be accepted forthwith and the Owner/Owner's representative will issue an acceptance certificate, upon receipt of which, the items will be shop painted, packed and despatched. No item is to be delivered unless an acceptance certificate for the same has been issued. The satisfactory completion of these tests or the issue of the certificates shall not bind the Owner/Owner's representative to accept the work, should it, on further tests before or after erection, be found not in compliance with the Contract.

**Tolerances**

- **Fabrication**

Tolerances for fabrication of structures shall be generally as per IS:7215.

In particular the acceptable fabrication tolerances for various parameters are given below:

| | | | |
|---|---|---|---|
| - | **Length** | | |
| - | Length of strut finished for tight bearing contact | : | (±) 1 mm |
| - | Length of any other member upto and including 12 m | : | (+) 0, (-)3.0 mm |
| - | Length of any other member over 12 m | : | (+) 0, (-)0.00025 L subject to a max. of (-)5.0 mm |
| - | **Width** | | |
| - | Width of built-up girders (plate girders) | : | (±) 3 mm |
| - | Deviation in the width of members required to be inserted in other member | : | (+ )0, (-)2 mm |
| - | **Depth** | | |
| - | Depth of girders (measured at centreline of web) for depths upto 4 m | : | (+) 3, (-)2 mm |
| - | -do- for depths over 4 m | : | (+) 4, (-)3 mm |
| - | **Sweep, Camber** | | |
| - | Deviation from straightness in plan (Sweep) | : | 0.001 L subject to max. of 10 mm |

- Deviation in elevation convexity (Camber) : (+ )5 mm, (-)0

- Deviation of centreline of web from centreline of flanges in built-up members at contact surfaces : 3 mm

- Deviation from flatness of plate webs of built-up members in a length equal to the depth of the member : 0.005 d subject to max. of 10 mm

**Tilt of flange of plate girders**

  - at splices & stiffeners, at supports, at the top flanges of crane girders, at bearings : 0.005 b subject to max. of 2 m

  - at other places : 0.015 b subject to max. of 4 mm

  - Deviation from squareness of flange to web of box columns and box girders : (±) 3 mm

  - Deviation from squareness of fixed base plates to axis of column. This dimension shall be measured parallel to the longitudinal axis of the column at points where the outer surfaces of the column sections make contact with the base plate

- Deviation from squareness of machined ends to axes of columns : 0.5 mm

- Deviation from squareness of machined ends to axes of beam or girder : 0.6 mm

In addition to the above tolerances, the fabrication of crane girders shall comply with the following:

- Top flanges shall be as flat as possible and the cross camber over the central width of 150 mm shall not exceed 0.6 mm with the convex surface upwards. Crane girder with a concave surface over the central width of 150 mm will not be accepted.

- Webs will be flat and straight and shall not vary from the intended line by more than 2 mm measured at the top flange.

- Gantry girders shall be straight with SWEEP not exceeding 3 mm in 12 m length of the girder. CAMBER shall not exceed 3 mm in 12 m length.

- The tolerance on the overall depth of crane girders without their bearings shall be (±) 2 mm.

**Acceptance**

Should any structure or part of a structure be found not to comply with any of the provisions of this specification, the same shall be liable to rejection. No structure or part of the structure, once rejected, shall be offered again for test, except in cases where the Owner/Owner's representative considers the defects rectifiable. The Owner/Owner's representative may, at his discretion, check the test results obtained at the Contractor's works by independent tests at an approved laboratory.

**Erection**

| | | | |
|---|---|---|---|
| - | Columns | | |
| - | Shifting of column axis at foundation with respect to building both in longitudinal & lateral direction | : | (± )3 mm |
| -. | Out of plumbness (verticality) of column axis from true vertical axis as measured at column top | | |
| - | For column upto 10 m height | : | (±) 5 mm |
| - | For column exceeding 10 m 10 m height | : | (±)1/2000 of column height but not more than 15 mm |
| - | Deviation in the level of bearing surface of columns at foundation top with respect to true level | : | (±) 3 mm |
| - | Deviation in bearing levels for beams, trusses . etc. with respect to true level | : | (±) 3 mm |
| - | Difference in bearing level between adjacent column both across and along the building | : | (±) 6 mm |
| - | Difference in erected position at adjacent pairs of columns along the length or across the width of building prior to connecting trusses/beams with respect to true distance | : | (±) 10 mm |
| - | Trusses/Beams | | |
| - | Deviation at Centre of span of upper chord from vertical plane running through of truss or of chord and perpendicular to plane at truss/beams | : | 1/250 of depth member 20 mm whichever is less |
| - | Lateral displacement of top chord at centre of span from vertical plane running through centre of supports | : | 1/1500 of the span or 10 mm whichever is less |
| - | Lateral shift in location from it true line of purlin/beam | : | (±) 5 mm |
| - | Crane Girders & Rails | | |
| - | Difference in levels of crane girder/crane rails measured between adjacent columns | : | 5 mm |
| - | Difference in levels of crane rails (across the building) | | |
| - | Over the supports | : | 10 mm |
| - | At the mid span of girders | : | 15 mm |

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| | | | |
|---|---|---|---|
| - | Difference in level of flange of successive girders at connection | : | 1 mm |
| - | Deviation in the crane rail level at any point from true level | : | (±) 5 mm |
| - | Difference in crane rail actual levels between any two points 2 m apart along the rail length | : | 2 mm |
| - | Relative shift of crane rail surfaces at a joint in plan and elevation | : | 2 mm subject to grinding of Surfaces for Smooth transition |
| - | Relative shift in the location of crane stops (end buffers) along the crane tracks | : | 1/1000 of track gauge to a max. of 20 mm |
| - | Deviations of crane rail axis from centerline of web | : | (±) 3.5 mm |
| - | Deviations in alignment of crane rail in plan measured between any two points 2 m apart | : | 1 mm |
| - | Deviation in crane rail gauge | : | 5 mm |

### 5.5.9 Brickwork & Plastering

**Scope**

This specification covers the requirements in respect of materials, workmanship and quality for brickwork and plastering.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Indian Standards Institution and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

**Brick work**

| | |
|---|---|
| IS:1077 | Common burnt clay building bricks |
| IS:1542 | Sand for plaster |
| IS:1661 | Code of practice for application of cement and cement-lime plaster finishes |
| IS:2166 | Sand for masonry mortars |
| IS:2212 | Code of practice for brickwork |
| IS:2250 | Code of practice for preparation and use of masonry mortars |
| IS:2691 | Burnt clay facing bricks |

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IS:3495 Methods of tests of burnt clay building bricks

IS:3696 Safety code for scaffolds and ladders

IS:5454 Methods of sampling of clay building bricks

**Materials**

**Cement**

Cement used shall conform to IS:269, IS:455 or IS:1489

**Sand**

The sand shall be approved river or pit sand and it shall conform to IS:2116 for masonry mortar and to IS:1542 for plaster mortar.

**Bricks**

The bricks used shall be at least chamber burnt second class (class B) bricks conforming to IS:1077 having a minimum compressive strength of 35 kg/cm2. Bricks are to be whole, uniform texture, sound, well burnt, free from cracks, square and well shaped, uniform in size, uniform red cherry or copper colour and shall emit a clear ringing sound when struck. Slight distortion or rounded edges are permitted provided no difficulty arises during laying of uniform course.

Water absorption after 24 hours immersion shall not exceed 20% by weight. Dimensional tolerance shall not exceed 8%. Laboratory test has to be conducted to ascertain the same. Representative samples shall be submitted and approved samples shall be retained by the Owner/Owner's representative for future comparison.

**Storage and Handling**

Bricks shall not be dumped at site. These shall be stacked in regular tiers on firm ground, even as these are unloaded, to minimize breakage and defacement of bricks. Bricks selected from different situation of use in the work shall be stacked separately. The broken bricks shall not be used in the masonry and shall be separated from the lot being used for masonry works.

**Workmanship**

**Brick work**

The whole of the brickwork shall be carried out by the Contractor in a uniform manner.

All the bricks shall be kept under water till they are completely soaked and used on the works on their becoming skin dry.

The Contractor shall set out and build all brickwork to the dimension, thickness and heights shown on the drawings. The Contractor shall build all brickwork in English bond and half brick walls and casing to pipe, chases etc in stretcher bond. Brickbats shall not be used except where required for bond.

The Contractor shall lay bricks in full mortar beds with shoved joints. The joints are not to exceed 10 mm in thickness and are to be full of mortar, close, well finished and neatly struck. The vertical joints in any course shall not be nearer than quarter of a brick length from those in the course below. All joints shall be of same width except for small variations to maintain bond. The brickwork

shall be laid plumb and trim to line and level. No portion of brickwork shall be raised more than 1 metre above another at one time. If the mortar in any course has begun to set, the joints shall be raked out before another course is laid. The top course of brickwork in reinforced concrete framed structure shall be wedged against reinforced concrete surface and joint well filled with mortar.

The Contractor shall flush up thoroughly with mortar all joints as the work proceeds. Where brickwork is to receive plaster, the joints shall be raked to a depth of 12 mm to provide proper bond.

The brickwork as it progresses shall be thoroughly watered on its faces and top. New work shall be properly bonded with the old work. The surface of unfinished work shall be cleaned and thoroughly wetted before joining new work to it.

Any work in which the mortar perishes shall be dismantled and rebuilt by the Contractor at his own expense.

The Contractor shall carry out work in as clean a manner as possible and shall remove excess material and mortar droppings daily.

Where brick walls, are to receive plaster, excess materials and mortar droppings shall be removed and the surface shall be brushed clean.

During cleaning operations, adjacent work shall be protected and any damage resulting from improper protection shall be made good by the Contractor at his own cost.

Reinforcement if shown in the drawing shall be provided fully embedding in mortar after thoroughly cleaned. These shall be lapped with dowels if left in RC columns or welded to steel columns.

Encasing of structural steel shall be done by building masonry work round flanges, webs etc., and filling the gap between steel and masonry by minimum 12 mm thick mortar. Encased members shall be wrapped with chicken wire mesh when shown on drawings or instructed by the Owner/Owner's representative. The minimum lap in chicken wire mesh shall be 50 mm. Other steel embedment shall be generally embedded in mortar and masonry unit shall be cut as required.

**Plastering**

Unless otherwise specified, all plaster work shall be carried out according to IS:1661. The thickness and proportion of cement plaster shall be as specified in the drawing.

The surface to be plastered shall be cleaned of all extraneous matter and rubbish. In brickwork the joints shall be raked and concrete surface roughened by chipping or hacking. Any shuttering material adhering to the concrete shall be removed. The Contractor shall make plaster pads of the required thickness of plaster for correctness of plumb, line and level. The surface shall be thoroughly watered and soaked and aerated and all holes shall be closed before starting plastering operation.

Plaster, when more than 15 mm thick shall be applied in two coats - a base coat followed by the finishing coat. Thickness of under coat shall be of sufficient to fill up all unevenness in the surface, no single coat, however, shall exceed 15 mm in thickness.

For one coat plaster work, the plaster shall be laid slightly thicker than the specified thickness and the surface then levelled with flat wooden rule to the required thickness. The plaster shall be well pressed into the joints and the surface finished as specified.

For two coats of plaster work, the first coat shall be applied as described above except that the surface shall be left rough and keys formed for the application of second coat. The second coat shall be applied a day or two after the first coat has set, but the first coat shall not be allowed to dry.

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The second coat shall consist of mortar ground very fine and shall be laid on with a wooden rule to a specified thickness, rubbed smooth and levelled and the surface plastered completely the same day. The levelling shall be continued till the plaster is quite dry and all moisture which exudes from the plaster shall be wiped off with a fine cloth. The surface shall be kept dry until exudation of moisture ceases, during the process of rubbing.

**Finish**

- **Sand faced plaster**

The plaster shall be applied in two coats. The first coat or the scratch coat should be approximately 14 mm and shall be continuously carried out without breaks to the full length of wall or up to doors, windows etc. The scratch coat shall be dashed on the prepared surface with heavy pressure, brought to true and even surface and then lightly roughened by cross scratch lines to provide bond for finish coat. The scratch coat shall be cured for at least 7 days and then allowed to dry.

The second coat shall be 6 mm thick and it shall not be applied until at least 10 days have elapsed after the application at second coat. Before application of the second coat, the scratch coat shall be evenly damped. This coat shall be applied from top to bottom in one operation and without joints, finish shall be straight, true and even. Only approved river sand shall be used for the second coat and for finishing work. Sand for finish shall be of even coarse size and shall be dashed on the surface and sponged.

- **Plaster-of-Paris Punning**

Plastered surfaces, where specified, shall be finished with plaster-of-paris punning. The thickness of punning shall be 2 mm and shall be applied by skilled workman. The finish shall be smooth, even and free from undulation. Before bulk work is taken in hand, a sample of punning shall be done on roughly 1 sq.m area and approval of the Owner/Owner's representative taken. The work shall be taken then in hand as per per approved sample.

**Curing**

The brick shall be cured for a period of fourteen (14) days after laying and the plaster shall be cured for a period of seven (7) days.

**Expansion & Separation Joints**

Location and details of expansion joints shall be strictly as shown in the drawings. Expansion joint filler boards and sealing strips shall have minimum transverse joints. Transverse joints shall be approved by the Owner/Owner's representative.

Separation joints shall be with standard water proof paper or with alkathene sheets about 1 mm in thickness. Length and sealing of laps shall be to the satisfaction of the Owner/Owner's representative.

**Damp Proof Course**

The proportion of cement to aggregates shall be 1:2:4 using 6 mm down stone chips with a water proofing admixture. The percentage of waterproof admixture shall be as per manufacturer's specification but not less than 1% by weight of cement. The brick masonry surface shall be levelled, flushed up and prepared as directed to receive the damp-proof course. The thickness of damp proof course shall be 40 mm. In masonry walls of buildings it shall normally be placed above the external ground level. It shall be laid for the full width of the wall. The top surface shall be kept rough or ribbed for mortar for brickwork coming over it, for proper adhesion. All exposed surfaces of the damp-proof course shall be finished fair and smooth. It shall be cured for at least 7 days. After the

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surface has partially set, hot bitumen shall be applied in two coats at the rate of 1.7 kg / sq.m per coat and dry sand spread over it.

### 5.5.10 Sheeting Work in Roof and Siding

**Scope**

This specification covers the requirements in respect of materials, workmanship and quality for sheeting work in Roof and Siding of Buildings.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed hereunder:

| | |
|---|---|
| IS : 277 | Galvanised steel sheets. |
| IS : 730 | Hook bolts for corrugated sheet roofing. |
| IS : 2096 | Asbestos cement flat sheets. |
| IS : 5119 | Laying and finishing sloped roof coverings. |
| IS:1726 | Sheet metal rain water pipes. |
| IS : 8869 | Washers for corrugated sheet roofing. |
| IS :12866 | Fibre glass reinforced plastic sheets. |

**Materials**

Roof and Side sheeting shall generally be of the following types of materials.

a) Aluminium Sheet (AL)

b) Galvanised Iron (GI)/Galvanised Steel (GS)

c) Fibre Glass Reinforced Plastic (FRP)

d) Colour Coated steel sheets

**Aluminium Sheet (AL)**

Aluminium sheets and accessories shall be of INDAL (Indian Aluminium Company) brand or approved equivalent.

Aluminium roofing and siding shall be of the following types as indicated in the drawings.

a) Corrugated

b) Troughed

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Aluminium sheets shall be 0.71 mm and 0.56 mm thick for roof and side sheeting respectively unless otherwise specified.
Flashing ridge etc. shall be of plain aluminium sheets.

**Galvanized Iron/Steel Sheet (GI/GS)**

Galvanised sheets shall be zinc coated cold rolled sheets, confirming to class 3 of IS 277 and of the following types.

a) Corrugated
b) Plain

Galvanised sheets shall be of 1 mm (20G) corrugated sheets for roofing, 0.8 mm (22G) corrugated sheets for side sheeting, flashing etc and 1 mm(20G) plain sheets for ridges, flashing gutters etc unless otherwise specified.

**Fibre-glass reinforced plastic sheets (FRP)**

Fibre glass reinforced plastic sheets shall conform to IS: 12866 and shall be translucent or opaque as shown in drawing. These sheets shall be shatterproof and should not crack, chip or rot.

The sheets shall have uniform thickness, translucency (if specified) and strength. The sheets shall be of approved manufacture and shall match the roofing profiles.

Wherever necessary and as shown in the drawing, caulking shall be of non-hardening and non-staining type.

**Colour Coated Sheets**

- **Permanent colour coated sandwiched insulated metal cladding system**

Troughed zinc - aluminium alloy coated (both sides) MS sheet having 0.6 mm minimum thickness (or high tensile steel sheet of 0.5 mm minimum thickness) shall be used on external face (outer face) of cladding system. Weight of coating shall not be less than 150 gm /sq.m. The outer side (exposed face) shall be permanently colour coated with Polyfluro Vinyl Coating (PVF2) of Dry Film Thickness (DFT) 20 microns (min) over primer. Inner side of external sheet shall be provided with suitable pre-coating of minimum 7 microns.

Galvanized MS sheets of minimum 0.6 mm thickness shall be used as inner liner (internal face) of cladding system. The exposed face shall be permanently colour coated with silicon modified polyester paint of DFT 20 microns (min) over primer.

Inner face of external sheet shall be provided with suitable pre-coating of minimum 7 microns. The rate of galvanization shall not be less than 150 gm /sq .m.

The permanent colour coated sheet shall meet the general requirements of IS : 14246 and shall conform to class 3 for the durability.

Inner sheet shall fixed directly to side runners and Z spacers made of at least 2 mm thick galvanized steel sheet of grade 375 as per IS : 277. Inner sheet shall be fixed at the rate not more than 1.50 m center to center to hold the insulation and external sheeting.

The insulation shall be of bonded mineral wool of minimum thickness 50 mm conforming to IS : 8183, having a density of 32 kg / cu.m for glass wool & 48 kg /cu.m for rock wool.

- **Permanent colour coated (non-insulated) metal cladding system**

Troughed zinc aluminium alloy coated not less than 150 gm/sq.m M.S sheets having 0.6 mm minimum thickness (or High tensile steel sheet of 0.5 mm minimum thickness) shall be used for the cladding system. The outer side (exposed face) shall be permanently colour coated with PVF2 paint of minimum DFT 20 microns over primer and the inner side (internal face) shall be coated with same paint of minimum DFT 12 microns over primer. These shall be fixed directly to runners. The sheets shall meet the general requirement of IS : 14246 and shall conform to class 3 for the durability.

**General**

The Contractor shall also supply all necessary, special fittings, fasteners, flashings, caulking etc. required for installation of the sheets in strict accordance with manufacturer's instructions.

Roof & siding sheets shall be capable of withstanding 200 kg/sq.m wind loads. Wind tie of 40 mm x 6 mm GI flat shall be fixed at the two caves end of the roof slopes. Fixing shall be done with the same bolts which secure sheets to the purlins. Slot holes shall be cut in the wind ties to allow for temperature variations.

**Installation**

**Aluminium Sheets**

Aluminium sheets shall be fixed with aluminium fasteners along with aluminium curved/flat washers with bituminous felt, neoprene or rubber washers. Generally manufacturer recommendations shall be followed.

**Galvanised Sheets**

Galvanised sheets shall be fixed with minimum 150 mm and 100 mm end laps for roof and side sheets respectively, unless higher laps are specified by the manufacturer or in the drawings. Side laps shall be as per manufacturer's recommendations. Unless otherwise specified, 10 mm and 8 mm dia GI Hook/J Bolts shall be used for roof and side sheets respectively. 6 mm dia GI seam bolt and nut with GI round washer/limpet washer shall be used for stitching of roof sheets/fixtures and GI round washer/diamond washer for side sheets. There shall be at least three hook bolts at the ridges of corrugations in each sheet in every purlin and their spacing shall not exceed 300 mm. Seam bolts shall be placed zigzag on overlapping corrugations, with spacing not exceeding 600 mm in each staggered row. Ridge pieces shall be fabricated from 600 wide (girth) sheets with a radius of curvature of 50 mm unless specified. For fixing requirements not specified here, manufacturer's recommendations shall be adopted.

**Colour Coated Sheets**

Installation procedure and fixing details shall be generally in line with that for GI sheets. The sheets shall be fixed with J or L polymer coated bolts, polymer caps, seal washer and thrust washer. Spacing of bolts etc. shall be identical to GI sheets.

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Acceptance Criteria

The installation shall present a neat appearance and shall be checked for water-tightness. The following shall be checked.

- Side and end laps.
- Absence of holes or damages in sheet.
- Spacing of bolts.
- Provision of double washers.
- Proper installation of flashings, wind ties etc.

### 5.5.11 Floor and Floor Finishes

**Scope**

This specification covers requirements in respect of material, workmanship and quality for soling, concrete floor and floor finishes work.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest additions as published by Bureau of Indian Standards and all other such as may be directed published by them during currency of the contract, shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed here under:

| | |
|---|---|
| IS:777 | Specification for glazed earthenware wall tiles. |
| IS:2114 | Code of practice for laying in situ terrazo floor finish |
| IS:2571 | Codes of Practice for laying in-situ concrete flooring |
| IS:3461 | Specification for PVC Asbestos floor tiles. |
| IS:3462 | Specification for unbacked flexible PVC flooring. |
| IS:4457 | Ceramic unglazed vitreous acid-resistant tiles |
| IS:5318 | Code of practice for laying PVC flooring. |
| IS:5491 | Code of practice for laying in-situ granolithic concrete floor topping |

**Boulder Soling**

The boulders for soling shall be granite, basalt or similar hard stone approved by the Owner/Owner's representative and generally shall be 230 mm thick. The sub grade shall be dressed to correct level and shall be rammed or rolled to proper consolidation before laying the soling. Stones shall be placed close to each other. The specified thickness shall be made up in one or more layers depending on thickness. The voids between the stones shall be hard packed first with smaller pieces and hammered into place so as to completely fill up the void along with murum as binding material and the layer is watered and is compacted by roller/mechanical compactor. In case of building enclosing heavy machinery like Gas turbine/Steam turbine, the compaction shall be by roller of 8/10 MT capacity.

**Cement Concrete Flooring**

**Materials**

Requirements given in Section 5.5.5 shall be applicable.

**Workmanship**

The workmanship shall generally conform to the specification for Plain & Reinforced concrete (Section 5.5.5) and also to IS:2571. For ground floor slab or paving in open area, where the slab has to be laid over a consolidated ground, soling, a kraft paper shall be spread over the area and kept moist before concreting.

The floor shall be laid in alternate panels, of size not exceeding 4 m to reduce risk of cracking, intermediate panels being filled in after two or three days. For paving in open area, contraction joint and expansion joints shall be provided as per IS specification. The expansion joints shall be filled with bitumen impregnated boards 25 mm thick of approved manufacturer and top 25 mm shall be covered with approved mastic sealing compound.

**Floor Finishes**

**Indian Patent Stone (IPS) with ironite topping**

It shall consist of a under bed and a topping laid on an already laid and matured concrete base.

- **Thickness**

The total thickness of finish shall be 40 mm of which the topping shall be 12 mm. While the topping shall be uniform thickness the under bed may vary in thickness to provide necessary slopes.

- **Mix**

For underbed, it shall be 1:2:4 mix using 10 mm down graded stone chips.
For toppings of heavy duty, the proportion of metallic hardener shall be strictly as specified by the manufacturer. In absence of such direction, one (1) part of metallic hardener shall be mixed dry with 4 parts of cement by volume. To this mixture, 6 mm nominal size stone chips shall be added in portion of 1:3 (mixture of hardener & cement : stone chips) by volume. Minimum quantity of water to be added to make it workable.

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- **Laying**

The topping including the underbed shall be laid in alternate bays or in chequered board pattern. No panel shall be cast in contact with another already laid till the contraction of latter has already been taken place.

The maximum area of each panel shall be 3 sq.m of which no side shall be more than 2 m long.

A cement grout shall be applied and worked into the surface to receive the finish, the under bed then laid, compacted and levelled to proper grade with a screed or float. The topping shall be applied evenly on the underbed while it is not fully set, but firm enough and rolled and pressed to get full bond. The topping shall be troweled to a dense finish to the satisfaction of the Owner/Owner's representative. All trowel marks shall be mopped out with a cloth to give a clean smooth surface.

- **Curing**

After the surface is sufficiently set, the finished floor shall be kept moist for 7 days for curing.

**Indian Patent Stone (IPS) with non-metallic surface hardener finish**

It shall consist of an underbed and a topping on which the hardener shall be laid.

- **Thickness**

The total thickness of finish shall be 40 mm of which the topping shall be 12 mm including the hardener finish.

- **Mix**

Mix for underbed and topping shall be same as for IPS flooring.

- **Hardener**

Hardener shall be non-metallic abrasion resistant surface hardener NITOFLOR HARDTOP or equivalent.

- **Laying**

The topping and underbed shall be laid as for IPS flooring. While the topping is still green, the hardener shall be applied by dry shake-on system. Cleaning of surface, surface preparation, curing and trowel finish shall be as per manufacturer's specifications and recommendation. The surface hardener application rate shall be as follows:

| | | |
|---|---|---|
| Heavy duty | : | 7 kg/m² |
| Medium duty | : | 5 kg/m² |
| Light duty | : | 3 kg/m² |

**Precast Terrazo Tile Finish**

It shall consist of manufactured terrazo tiles and an underbed.

- **Thickness**

The total thickness of finish including underbed shall be minimum 40 mm for floors and 30 mm for skirting. The skirting shall project 6 mm out from the adjacent wall finish. The necessary cutting into the surface receiving tile finish shall also be done.

- **Tiles**

The tiles shall be hydraulically pressed under strict quality control in a shop. The size of tiles shall be 250 x 250 x 20 mm unless otherwise specified. The topping of tiles shall not be less than 10 mm. Maximum tolerance allowance in length & breadth shall be ± 1 mm and the thickness ± 3 mm. All angles of tiles shall be right angles, all arises sharp and true, colour and texture of wearing face uniform throughout, and face shall be plane, free from pin holes and other blemishes.

The topping of tiles shall be composed of cement, (grey or white or mixture of two) colour pigment, marble dust and marble chips (chips size 3 to 20 mm) in such a proportion so as to produce the desired colour, texture & pattern approved by the Owner/Owner's representative.

The backings shall be composed of 1 part of ordinary grey cement, 1 1/2 part of sand and 3 parts of 6 mm down graded stone chips mixed with water. First grinding shall be given to the tiles at the shop before delivery. Tiles shall be packed properly to prevent damage during transit and storage. The tiles must be stored carefully to prevent staining of damp, rust, oil and grease or other chemicals.

- **Underbed**

The underbed for floor shall consist of a mix of 1 part cement, 1 1/2 parts coarse sand and 3 parts machine crushed 10 mm down stone chips by volume. For skirting, the mix shall consist of 1 part cement and 3 parts coarse sand. Only sufficient water to be added to give workable consistency.

- **Laying**

The underbed mortar shall be evenly spread and brought to proper grade and consolidated. The surface shall be roughened for better bond. Before the underbed has time to set and while it is still fairly moist but firm, cement shall be hand dusted over it or a cement slurry applied and tiles shall immediately be placed upon and firmly pressed by wooden mallet onto the underbed until it achieves the desired level. The tiles shall be kept soaked for about 10 minutes just before laying. The joints between tiles shall be also as possible and not more than 1.5 mm wide.

When tiles are required to be cut to match the dimensions, these shall be sawn and edges rubbed smooth. The location of cut tiles shall be planned in advance and approval of the Owner/Owner's representative taken.

The floor tiles shall atleast enter 12 mm under the skirting tiles.

After fixing, the floor shall be kept moist and allowed to mature undisturbed for 14 days.

Aluminium or glass dividing strips shall be used for forming the panels.

- **Grinding and Polishing**

After sufficient curing, the surface shall be ground with fine grit blocks. It shall again be cleared with water, the slurry (mixture of cement & pigment) applied again to fill up any pinholes might have appeared and allowed to be cured again for five days. The surface is ground again with very fine grit blocks to get smooth surface without any pinhole. The grinding shall be done by a suitable machine. Where grinding machine cannot be used, hand grinding may be allowed. The choice of grit blocks at different stages of polishing shall be as per manufacturer's recommendations.

The surface shall be cleaned with water, dried and covered with oil free clean saw dust if directed by the Owner/Owner's representative. The final polishing shall be postponed till before handing over if so desired by the Owner/Owner's representative.

Just before handing over, the surface shall be dusted with oxalic acid at the rate of 0.33 gm per sq.m, water sprinkled on to it and finished by buffing with felt or hessian bobs. The floor shall be cleaned with soft moist rag and dried. If desired by the Owner/Owner's representative, wax polish shall be applied. However, all excess wax polish to be wiped off and surface to be left glossy but not slippery.

**Acid Resistant Tile Finish**

This shall include all varieties of special tiles used for specific chemical/acid resistance function and an underbed over already laid concrete or masonry.

- **Thickness**

The total thickness of finish shall be 50 mm of which the tile shall be 25 mm, acid proof mortar 6 mm, bitumen 3 mm and cement mortar underbed 15 mm.

- **Tiles**

The tiles shall be of best approved manufacture, conforming to IS:4457 and resistant to the chemical likely to come in contact. The tiles shall have straight edges, uniform thickness, plain surface, uniform non-fading colour and textures. The water absorption after 24 hours of soaking shall not be more than 2% by weight. The compressive strength of tiles shall not be less than 700 kg/cm2. The surface shall be abrasion resistant and durable.

- **Under bed**

The underbed shall be laid in three layers. The first layer shall be composed for 1 part cement and 3 parts river sand with just enough water to make the mix workable. This layer shall be trovelled level and curved with water for atleast 3 days prior to application of the second layer. The second layer consist of 3 mm thick hot blown bitumen conforming to IS:702 of grade 85/25 and shall be applied in three coats with brush or spray. The third layer of acid proof mortar as specified by manufacturer shall be applied. The acid proof mortar shall have chemical resistant properties equal to that of the floor tiles.

- **Laying**

The tiles shall be embedded in the acid proof mortar and the gap between the tiles shall be grouted to the full depth of tile. The setting and fixing shall be strictly as per the manufacturer's specification and shall be approved by the Owner/Owner's representative.

- **Curing**

The joints in the floor shall be cured with the solution of 25% proof hydrochloric acid or as specified by the manufacturer.

**In-Situ Terrazzo Finish**

It shall consist of an underbed and a topping laid over an already laid and matured concrete base.

- **Thickness**

Unless otherwise specified the total thickness of the finish shall be minimum 40 mm for horizontal and 25 mm for vertical surface of which the topping shall be not less than 15 mm. While the topping shall be of uniform thickness the underbed may vary in thickness to provide necessary slopes. The vertical surface shall project out 6 mm from the adjacent plaster or other finish. Necessary cutting into the surface receiving the finish shall be done to accommodate the specified thickness. All junctions of vertical with horizontal shall be rounded neatly to uniform radius of 25 mm.

- **Underbed**

The underbed for floors and similar horizontal surfaces shall consist of a mix of 1 part cement, 1-1/2 parts sand and 3 parts stone chips by volume or cement sand mixture 1:3. For vertical surfaces the mix shall consist of 1 part cement to 3 parts sand by volume. The sand shall be coarse. The stone chips shall be 10 mm down well graded. Only sufficient water to be added to give a workable consistency. Stone chips are machine crushed blue granite metal.

- **Topping**

The mix of the topping shall be composed of cement, colour pigment, marble dust and marble chips. Proportions of the ingredients shall be such as to produce the terrazzo of colour, texture and pattern approved by the Owner/Owner's representative. The cement shall be white or grey or a mixture of the two to which pigment shall be added to achieve the desired colour. To 3 parts of this mixture, 1 part marble powder by volume shall be added and thoroughly mixed dry. To 1 part of this mix 1 to 1-1/2 parts of marble chips by volume shall be added and thoroughly mixed dry again.

The pigment must be stable and nonfading. It must be very finely ground. The marble powder shall be from white marble and shall be finer than I.S. Sieve No. 30. The size of marble chips may be between 3 mm to 10 mm.

Sufficient quantity to cover all visible area shall be prepared in one lot to ensure uniform colour. Water to make it just workable shall be added to a quantity that can be used up immediately before it starts to set.

- **Laying**

The underbed shall be laid in panels. The panels shall not be more than 5 sq.m in area of which no side shall be more than 2.5 m long. For exposed locations the maximum area of a panel shall be 2.0 sq.m.

The panel shall be laid in alternate bays or chequered board pattern. No panel shall be cast in contact with another already laid until the latter has contracted to the full extent.

Dividing strips made of aluminium or glass shall be used for forming the panels. The strips shall exactly match the total depth of underbed plus topping. These strips shall be left in place.

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After laying, the underbed shall be levelled compacted and brought to proper grade with a screed or float. The topping shall be laid after about 24 hours while the underbed is still somewhat 'green' but firm enough to receive the topping. Slurry of the mixture of cement and pigment already made shall be spread evenly and brushed in just before laying the topping. The topping shall be rolled for horizontal areas and thrown and pressed for vertical areas to extract all superfluous cement and water and to achieve a compact dense mass fully bonded with the underbed. The surface of the topping shall be troweled over, pressed and brought to a smooth dense surface showing a minimum 75% area covered by marble chips in an even pattern of distribution.

- **Curing**

The surface shall be left for curing for about 12 to 18 hours and then cured by allowing water to stand on the surface or by covering with wet sack for four days.

- **Grinding and Polishing**

When the surface has sufficiently hardened it shall be watered and ground evenly with rapid cutting coarse grade (no.60) grit blocks, till the marble chips are exposed and the surface is smooth. Then the surface shall be thoroughly washed and cleaned. A grout with already prepared mixture of cement and pigment shall be applied to fill up all pinholes. This surface shall be cured for seven (7) days by keeping it moist and then ground with the fine grit blocks (no. 120). It shall again be cleared with water, the slurry applied again to fill up any pinholes that might have appeared and allowed to be cured again for five (5) days. Finally the surface is ground again third time with very fine grit blocks (no. 320) to get smooth surface without any pin hole. The grinding shall be done by a suitable machine. Where grinding machine cannot be used hand grinding may be allowed when the first rubbing shall be with carborundum stone of coarse grade (no.60), second rubbing with medium grade (no.120).

The surface shall be cleaned with water, dried and covered with oil free clean sawdust if directed by the Owner/Owner's representative. The final polishing shall be postponed till before handing over if desired by the Owner/Owner's representative.

Just before handing over the surface shall be dusted with oxalic acid at the rate of 0.33 gm per sq.m, water sprinkled on to it and finished by buffing with felt or hessian bobs. The floor shall be cleaned with soft moist rag and dried. If desired by the Owner/Owner's representative, wax polish shall be applied. However, all excess wax polish to be wiped off and the surface to be left glossy but not slippery. The choice of grit blocks at different stages of polishing shall be as per manufacturer's recommendations.

**Carborandum Tile Finish**

It shall consist of manufactured carborandum tile and an underbed.

- **Thickness**

The total average thickness including underbed shall be minimum 40 mm for floors, and 30 mm for skirting unless otherwise specified.

**- Tiles**

The tiles shall be heavy duty carborandum tile `STILAN or equivalent', machine made under quality control in a shop. The tiles shall be pressed hydraulically to a minimum of 140 kg/cm$^2$.

Each tile shall bear on its back, permanent and legible trade mark of the manufacturer. All angles of the tiles shall be right angles, all edges sharp and true, colour and texture of the wearing face uniform throughout. Maximum tolerance/allowance for length and breadth shall be ± 1 mm and the

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thickness + 3 mm along the wearing surface of the tile and the wearing surface shall be plane and free from pin-holes and other blemishes.

The tiles shall be composed of a backing and topping. The topping shall be of uniform thickness not less than 6 mm. The total thickness including the topping shall be as specified but not less than 20 mm in any case.

The backing shall be composed of 1 part ordinary grey cement, 2 parts and sand 4 parts of stone chips by volume and mixed with water.

The topping shall be carborandum grit (passing 1.18 mm mesh but retained on 0.6 mm mesh) and shall be sprinkled on the surface at the rate of 1.35 kg/m² and worked into the surface, to achieve a smooth and uniform surface.

The tile shall be cured at the shop for at least 14 days before delivery to the site. Tiles shall be packed properly to prevent damage during transit and storage. The tiles must be stored carefully to prevent staining by damp, rust, oil and grease, or other chemicals. Tiles made in each batch shall be kept and used separately so that the colour of each area of the floor may remain uniform.

The manufacturer shall supply along with the tiles the grout mix containing cement and pigment in exact proportions as used in topping of the tiles. The containers of the grout mix shall be suitably marked to relate it to the particular type and batch of tiles.

- **Underbed**

The underbed for floors and similar horizontal surfaces shall be 1 part cement, 1.5 parts coarse sand and 3 parts stone aggregate by volume mixed with sufficient water to form a stiff workable mass. For skirting and dado and all vertical surfaces it shall be about 10 mm thick and composed of 1 part cement and 3 parts coarse sand by volume.

- **Laying**

The underbed mortar shall be evenly spread and brought to proper grade and consolidated to a smooth surface. The face shall be roughened for better bond. Before the underbed has time to set and while it is still fairly moist but firm, cement shall be hand-dusted over it or a cement slurry applied and the tiles shall be immediately placed upon and firmly pressed by wooden mallet onto the underbed until it achieves the desired level. The tiles shall be kept soaked for about 10 minutes just before laying. The joints between tiles shall be as close as possible and not more than 1.5 mm wide.

Special care shall be taken to check the level of the surface and the lines of the joints frequently so that they are perfect.

When tiles are required to be cut to match dimension. These shall be sawn and the edges rubbed smooth. The location of cut tiles shall be planned in advance and approval of the Owner/Owner's representative taken.

At the junction of horizontal surface with vertical surface, the tiles on the former shall enter at least 12 mm under the latter.

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**PVC or Vinyl Asbestos Tile/Sheet Finish**

This shall include various types of tiles or sheets manufactured from PVC, set with a sticker on concrete or masonry or particle base. An underbed may be required to secure desirable surface and grade.

- **Thickness**

The thickness of the tiles/sheets shall be 2 mm for light duty and 3.02 mm for heavy-duty applications. The total average thickness including the underbed shall be 40 mm.

- **Tiles**

Unless otherwise specified, the tiles/sheets shall conform to the requirements of IS:3461 & IS:3462 and shall be of approved dimensions. The tolerance in dimensions shall be ± 1.5 mm.

The face of the tiles shall be free from porosity, blisters, cracks, embedded foreign matters or other physical defects which affect appearance or serviceability. All edges shall be cut true and square.

The colour shall be non-fading and uniform in appearance insoluble in water and resistant to alkalies, cleaning agents and usual floor polishes.

Each tile shall be marked on the back legibly and indelibly with manufacturer's trade mark, the thickness, sizes, batch number and date of manufacture.

Tiles/sheets shall be delivered securely packed and stored in a clean, dry, well ventilated place at a temperature near about to that the tiles/sheets shall be called upon to stand ultimately.

Adhesive to be used for sticking the tiles or sheets shall be neoprene based rubber adhesive of approved make and approved by the manufacturer of the tile. The adhesive shall have a short drying time and long life in addition to toughness.

- **Underbed**

The underbed where required to make-up the specified thickness or to give the required grade or to get the right type of surface shall be composed of 1 part cement : 2 parts of coarse sand : 4 parts stone aggregate 10 mm down size, mixed with just sufficient water to make it workable.

- **Laying**

The tiles or sheets shall be kept in the room to be tiled for at least 24 hours to bring them to the same temperature as the room. For air conditioned space, the air-conditioning shall be completed before tiling is taken-up.

The surface to receive this finish shall be firm, even textured, but not too smooth, without undulations and other deficiencies. If an underbed is laid, the same shall be cured for at least 7 days by keeping it moist and then fully dried.

The surface shall be thoroughly cleaned. All loose dust particles shall be removed. Oil and grease, if any, shall be completely cleaned by use of detergent.

The adhesive shall be applied to fully dry surface in desired thickness uniformly. The adhesive shall also be applied to the backs and edges of the tiles or sheets and allowed to surface dry. The tiles and sheets shall be placed neatly on the surface exactly to the approved pattern and set with a suitable tool. If the edges tend to curl up, weights shall be used to keep the edges down. Special

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care shall be taken to avoid formation of air pockets under the tiles or sheets. The joints shall be very fine. Any adhesive squeezed out through the joints shall be removed immediately.

- **Finishing**

If any adhesive mark is there on the surface, a soft cloth soaked in solvent shall be used to wipe it off. The surface shall be cleaned with soft water and soap, dried and polished with an approved type of polish just before handing over.

- **Epoxy Floor Coating**

Epoxy floor coating shall consist of a solvent based, two pack system with epoxy resins and amine curing agents, chosen to withstand high degrees of chemical and abrasive action.

- **Thickness**

Thickness of the epoxy coating including screeding shall be minimum 3 mm. Total thickness of finish including underbed shall be 40 mm when applied on floors of buildings. In pits and dyke areas, no underbed is required to be provided.

- **Materials**

The screed shall be solvent free combination of epoxy resin, modified amine hardeners filled with specially graded and selected chemically inert aggregates of high strength. The system shall include an epoxy resin primer and screed which are both supplied in pre-weighed units ready for on-site mixing and application.

An epoxy resin sealing coat of specified thickness shall form the topping coat.

- **Underbed**

Underbed shall be similar to that PVC floor finish.

- **Laying**

The surface shall be sound, clean and dry in order to achieve maximum adhesion with the primer coating.

The primer shall be applied by brush and shall be allowed to become tacky. The screed shall be prepared as per manufacturers specification and laid in specified thickness evenly over the base floor by trowel. The finished, cured screed shall have a sightly granular texture of uniform brown.

The epoxy resin topping shall be applied at least 24 hours after the laying of the screed. This topping shall be applied by brush or sprayed to a specified thickness in two coats with 3-5 hours interval between them. Care shall be taken to finish the topping perfectly smooth and devoid of any bubbles and unevenness. The newly laid floor shall be protected from dust or moisture and allowed to be used only after a minimum lapse of 48 hours.

**Ceramic Floor Tile/Glazed Wall Tile Finish**

This finish shall be composed of glazed earthen ware tiles with an underbed laid over a concrete or masonry base.

- **Thickness**

The total thickness shall be between 20 mm and 25 mm including the underbed.

The tile finish on vertical surface shall project out 6 mm uniformly from the adjacent plaster or other wall finishes. The necessary cutting into the surface receiving the finish, to accommodate the specified thickness shall be done.

- **Tiles**

The glazed tiles shall be of earthenware, covered with glaze, white or coloured, plain or with designs, of 100 mm x 100 mm nominal sizes and 5 mm thick, unless otherwise specified. Ceramic floor tiles shall be of matt finish, white or coloured, plain or with designs of 150 mm x 150 mm nominal size and 6 mm thick, unless otherwise specified. The tolerance shall be ± 1.5 mm for length and breadth and ± 0.5 mm for thickness.

Specials like internal and external angles, beads, coves, cornices, corner pieces etc. shall match. The top surface of the tiles shall be glazed with a gloss or matt unfading stable finish as desired by the Owner/Owner's representative. The tiles shall be flat and true to shape. The colour shall be uniform and fractured section shall be fine grained in textures, dense homogenous. The tiles shall be strong and free from flaws like cracks, chips, craze, specks, crawlings etc. and other imperfections. The edges and the underside of the tiles shall be completely free from glaze and the underside shall have ribs or indentations for better anchorage with the fixing mortar. The coloured tiles, when supplied, shall preferably come from one batch to avoid difference in colour.

- **Underbed**

The mix for the underbed shall consist of 1 part cement and 3 parts coarse sand by weight mixed with sufficient water or any other mix if specified.

- **Laying**

Procedure for laying shall be same as that for precast terrazo tiles.

- **Finishing**

The joints shall be cleaned and flush pointed with white cement and cured for seven (7) days by keeping it wet. The surface shall be cleaned with soap or suitable detergent, washed fully and wiped with soft cloth to prevent scratching before handing over.

### 5.5.12 Doors, Windows, Louvres, Rolling Shutters & Glazing

**Scope**

This specification covers the requirements in respect of materials, workmanship and quality for doors, windows louvres, Rolling Shutters and glazing work.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

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**Metal Doors & Windows**

IS:733 Wrought aluminium and aluminium alloy bars, rods and sections (for general engineering purposes)

IS:1038 Steel doors, windows and ventilators

IS:1361 Steel windows for industrial buildings

IS:1948 Aluminium doors, windows and ventilators

IS:1949 Aluminium windows for industrial buildings.

IS:4351 Steel door frames

**Timber Doors**

IS:4021 Timber door, window and ventilator frames

IS:1003 Timber paneled and glazed shutters.

IS:2191 Wooden flush door shutter (cellular and hollow core type)

IS:2202 Wooden flush door shutters (solid core type)

**Rolling Shutters**

IS:6248 Metal rolling shutters and rolling grills

Glazing

IS:1081 Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators

IS:2553 Safety Glass - Specifications

IS:2835 Flat transparent sheet glass

IS:3548 Code of practice for glazing in buildings

IS:5437 Figured rolled and wired glass

Builder's Hardware

IS:204 Tower bolts

IS:205 Non-ferrous metal butt hinges

IS:208 Door handles

IS:281 Mild steel sliding door bolts for use with padlocks

IS:363 Hasps and staples

IS:723 Steel counter sunk head wire nails

IS:1823 Floor door stoppers

IS:2209 Mortice locks (vertical type)

IS:2681 Non-ferrous metal sliding door bolts for use with padlocks

IS:3564 Door closers (hydraulically regulated)

IS:3847 Mortice night latches

IS:4992 Door handles for mortice locks (vertical types)

IS:6607 Rebated mortice locks (vertical type)

**Materials & Workmanship**

**Steel doors, Windows, Ventilators Etc.**

- **Door Frames**

Frames shall be rolled or pressed sections from 18 g sheet conforming to IS: 4351. They shall be mortised, reinforced, drilled and tapped for hinges and lock and bolt strikes where necessary, frames shall be reinforced for door closures. Welded construction with mitred corners shall be used. Rubber door silencers shall be furnished for the striking jamb. Loose 'T' masonry anchors shall be provided. Frames shall finish flush with floor and adjustable floor anchors shall be supplied. Frames shall be brought to site with floor ties/ weather bars installed in place.

- **Double Plate Flush Door Shutters**

Door shutters shall be 45 mm thick, completely flush design and shall comprise of two outer sheets of 18 g steel sheets, rigidly connected and reinforced inside with continuous vertical 20 g stiffeners, spot welded in position at no more than 150 mm on centres. Both edges of doors shall be joined and reinforced full height by steel channels placed immediately inside and welded to the door faces. Top and bottom of doors shall be reinforced horizontally by steel channels running full width of door. Doors shall not have more than 2.5 mm clearance at jambs and head, shall have proper bevel on lock stiles and rails to operate without binding, and shall be reinforced at corners to prevent sagging or twisting. Pairs or double doors shall have meeting-stile edges bevelled or rebated.

Doors shall be mortised, reinforced, drilled and tapped in shop for hinges, locks and bolts. They shall also be reinforced for closures, push-plates and other surface hardwares where necessary. Any drilling and tapping required for surface hardware shall be done at site. Where necessary, provision shall be made for fixing glazing, vision panels, louvres etc. glazing mouldings shall be of 18 g steel and suitable for fixing 6 mm glass. Louvre blades shall be V or Z shaped and made out of 16 g sheets.

- **Sliding Doors**

Sliding doors shall be double plate construction made out of 18 g steel sheets with adequate stiffness. The Contractor shall specify the weight of the door in his shop drawing and submit the manufacturer's catalogue of the sliding gear he proposes to use. Where shown on drawings, the Contractor shall make provisions for openings in the door for mono-rail beams. Doors shall close positively to exclude rain water from seeping in. Sliding doors shall withstand specified wind loads without buckling or jamming. The door shall slide freely under all ambient conditions.

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- **Steel Windows, Sashes, Ventilators, etc.**

These shall conform in all respects to IS: 1038 and IS:1361. The details as called for in the above codes shall be applicable for coupling mullions, transoms, weather bars, pivot arrangements for ventilators, etc.

All welds shall be dressed flush on all exposed and contact surfaces.

Where composite unit openings are provided the individual window units shall be joined together with requisite transoms and mullions. All windows shall be outside glazed, fixed with putty or metal glazing beads.

All welds at the corner of casement shall be done by flash butt welding process and dressed flush on all exposed and contact surfaces.

**Aluminium Doors, Windows and Frames**

Aluminium sections for fabricating doors, windows, partitions etc., shall be extruded sections conforming to IS:1948 & IS:1949 or as manufactured by Indian Aluminium Company Ltd or approved equivalent. The alloy used shall conform to IS designation HE 9-WP of IS:733.

Extruded sections shall have a minimum 2.5 mm wall thickness. All sections shall be approved by the Owner/Owner's representative before fabrication is taken up. Doors, frames, mullions, transoms etc. shall be anodized in a bath of sulphuric acid to provide a clear coating of minimum

0.06 mm thickness. The anodised materials shall then be sealed by immersing in boiling water for 15 minutes. A protective transparent coating shall be applied to the sections before shipment from the factory.

All work shall be fitted and shop assembled to a first class job, and ready for erection. Shop joints shall be made to hair lines and then welded or braced by such method as will produce a uniform colour throughout the work. Work on the above, other than described, shall be neatly finished with concealed fasteners. Glazing beads shall be snap fit type, without visible screws and shall be of sizes to accommodate 6 mm thick glazing.

**Timber Doors**

All timber shall be best quality well seasoned specified species free from large or loose knots cracks or other defects. Where specified, timber shall be treated with approved wood preservative before starting the joinery work, the Contractor shall have the rough timber approved by the Owner/Owner's representative.

Plywood shall be of commercial quality teak veneer or with decorative surface veneer as specified.

The core for solid core doors shall be of block board or wood particle board. Manufacturer's literature and test certificates shall be submitted for the approval of the Owner/Owner's representative. The Contractor shall give a guarantee that the adhesive used is phenol-formaldehyde confirming to IS:848.

Fixtures for doors, windows, furniture etc. shall be as shown on drawing. These shall be of heavy type, best quality and from approved manufacturer. The Contractor shall have to mention the name of the manufacturer for different types of joinery hardwares, fittings and fixtures. Samples of each type of fittings shall have to be submitted to the Owner/Owner's representative for obtaining approval before bulk supply.

The work shall be done by skilled carpenters as per details shown on drawing or instructed by the Owner/Owner's representative.

Framing timber and other work shall be close-fitting with proper wood joinery, accurately set to required lines or levels and rigidly secured in place. The surface of frames etc. which will come in contact with masonry after fixing shall be given two coats of approved paint before fixing. Mastic caulking shall be done after fixing external door and window frames. Special care shall be taken to match the grain of timber or plywood which will be subsequently polished. Screwing or nailing will not be permitted to the edge of plywood or chip-board sheets. All exposed plywood edges shall be finished with teakwood timber lipping unless otherwise shown on drawings.

All carpentry work after finishing shall be sand papered smooth. Prime coat paint shall be given after inspection of the Owner/Owner's representative to all surfaces other than those which shall be subsequently polished or covered with laminated plastic sheet.

When shown on drawings decorative ply or laminated plastic sheets shall be bonded under pressure to the surface to be finished. The adhesive used shall be of approved brand and bought to site in sealed containers. The rate of application and the length of time for which the pressure is to be applied shall be as per the manufacturer's instruction. The edge of sheets shall be protected by teakwood timber lipping. However, where available factory made ready for use material of reputed manufacturer shall be used.

All frames shall be square and flat at the time of delivery and shall be checked for dimensions and corner angles. After fixing they shall be on a fine vertical plane. All external door and window frames shall be caulked with mastic.

**PVC Doors & Windows**

PVC doors and windows shall be obtained from reputed manufacturers and shall be SINTEX or approved equivalent quality. The material used shall be unplasticised PVC having superior impact resistance. Density of the material shall be 1.4 grams/cm3 and tensile stress and bending stress of 480 and 770 kilopascal/cm$^2$. The outer section wall thickness shall be min. 1.7 mm.

The section shall be reinforced with steel sections concealed inside a cavity of PVC sections. Corners shall be welded, transom/mullions welded or mechanically joined. Weather sealing shall be by double sealing with elastomeric weather strip, the corners being glued.

Opening for PVC doors/windows shall be 10 mm more than the window/door size.

The doors shall be fixed to the wall by expandable fasteners or by brackets. Manufacturer's recommendation shall be followed for installation.

**Rolling shutter (Hand operated, Mechanical gear operated and Electrically operated).**

Rolling shutters shall be fabricated from 18 gauge steel and machine rolled with 75 mm rolling centres with effective bridge depth of 12 mm lath sections, interlocked with each other and ends locked with malleable cast iron clips to IS:2108 and shall be designed to withstand a wind load of 200 Kg/m2 without excessive deflection.

The guides shall be either rolled or pressed deep channel sections 75 mm and 25 mm wide fitted with necessary fitting and fixtures.

The suspension shaft shall be formed from heavy duty tubes conforming to IS:1161 and of sufficient diameter so as to resist deflection due to weight of the rolling shutter. The deflection shall not exceed 5 mm/ metre width. The shaft shall be provided with CI pulleys and helical springs for counter balancing the weight of the shutter adequately.

The springs shall be approved high tensile flat springs conforming to Grade 2 of IS:4454. These shall be fitted inside the fabricated housing of either ends which counter-balance the shutter curtain.

The ball bearings shall be double row self-aligning ball bearings fitted inside C.I. housing fixed on side brackets holding the suspension shaft at either end. The roller assembly shall be designed so as to be capable of producing sufficient torque to ensure easy operation of the rolling shutter in any position. The spring tension shall be adjustable by means of suitable adjustments holes drilled on the rims of the pulley.

The hood cover shall be made of 20 gauge galvanized sheets with necessary stiffeners and framework to prevent sag. The bottom lock plate shall be made of 5 mm thick M.S. plate and 95 mm wide reinforced with angle/T iron of suitable section with 6 mm dia M.S. rivets interlocked with last stride of curtain.

The locking arrangement shall consist of sliding bolts at both ends of the bottom plate fitted to engage with suitable receiving pockets at the bottom of guide channels.

Unless otherwise specified, for overall area of rolling, shutters up to 9 sq.m pull and push type hand-operated shutters shall be used; for area between 9 and 12 sq.m pull and push type shutters shall be provided with ball bearings; for area larger than 12 sq.m mechanical gear type or electrically operated shutters shall be supplied.

**Glazing**

Glass for glazing shall be of the following types:

- 4 mm thick transparent sheet glass conforming to IS:2835 generally used for openable shutters of windows.

- 6 mm thick wired glass conforming to IS:5437 generally used for fixed shutters of windows.

- 6.3 mm thick laminated safety glass conforming to IS:2553 generally used for fixed glazed partitions.

- 6 mm thick transparent sheet glass used for aluminium glazed doors.

All glass shall be cut according to the sizes required as per drawings. Glazing of metal doors, windows and ventilations shall conform to IS:1081 either with putty or metal clips. The Contractor shall thoroughly clean all glass and replace all putty or glass damaged during the work.

**Double Glazing**

Shall be as per approved manufacturer's specifications and relevant IS codes.

**Storage and Handling**

All metal doors, windows etc. shall be packed and crated properly before despatch and shall be stored under cover in a way to prevent damage or distortion. Special care shall be taken to prevent staining of aluminium products by rust or mortar etc. Glass shall be brought to site in manufacturer's original packing.

**Assembly and Erection**

The Contractor shall assemble and install all doors, windows, louvers, etc. including transoms mullions for composite units in respective places keeping proper lines and levels, and in approved workman like manner, to give trouble free and leak proof installations. The installations shall be done according to the instructions of the manufacturer and/or as approved by the Owner/Owner's representative. If required by the Owner/Owner's representative, the installation shall have to be carried out under the supervision of the manufacturer's staff.

After installation of steel doors, windows etc. all abrasions to shop-coat of paint shall be retouched and made good with the same quality of paint in shop coat. All coupling mullions, transoms, frames etc. in contact with adjacent steel and other members shall be well bedded in mastic. Door shutters, partitions, hardware fixtures shall be fixed only after major equipments have been installed in rooms.

**Hardware and Fixtures**

Hardware and fixtures shall be best quality from the approved manufacturers and shall conform to the relevant IS specification and able to withstand repeated use. The Contractor has to provide the required number / size of fixtures for trouble free operation and adequate strength. Door closers shall be suitable for shutter weight and shall be guaranteed against manufacturing defect for one year and any defect found within this period shall be rectified or the door closer replaced without extra cost to the Owner/Owner's representative.

The Contractor shall submit samples of each type of hardware to the Owner/Owner's representative and the approved samples shall be retained by the Owner/Owner's representative for comparison with bulk supply.

### 5.5.13 Painting, Colour Washing Etc.

**Scope**

This specification covers the requirements in respect of materials, workmanship and quality for finishing works, such as white washing, colour washing, distempering and painting to masonry, concrete, timber and metal surfaces of doors, windows, rolling shutters etc. Separate specification shall be referred for painting of structural steel work.

Codes and Standards

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Indian Standards Institution and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

**White washing, colour washing and distempering**

| | |
|---|---|
| IS:427 | Distemper, dry colour as required |
| IS:428 | Distemper, oil emulsion, colour as required |
| IS:6278 | Code of practice for white washing and colour washing |

**Painting**

| | |
|---|---|
| IS:5 | Colours for ready mixed paints and enamels |
| IS:102 | Ready mixed paint, brushing, red lead, non-setting, priming |
| IS:123 | Ready mixed paint, brushing, finishing, semigloss, for general purposes |
| IS:1477 | Code of practice for painting of ferrous metals in buildings |
| IS:2074 | Ready mixed paint, air drying, red oxide-zinc chrome, priming |
| IS:2338 | Code of practice for finishing of wood and wood based materials. |
| IS:2339 | Aluminium paint for general purposes in dual container |
| IS:2395 | Code of practice for painting concrete, masonry and plaster surface |
| IS:2932 | Enamel, synthetic, exterior, a) undercoating, b) finishing. |
| IS:2933 | Enamel, exterior, a) under coating, b) finishing. |
| IS:5410 | Specification for cement paint, colour as required |
| IS:5411 | Specification for plastic emulsion paint |

**Materials**

**Distemper**

Dry Distemper shall be made from suitable pigments, extenders lime proof tinters, water soluble binders confirming to IS:427. Oil bound washable distemper shall be of oil emulsion type containing suitable preservatives confirming to IS:428.

**Gum and blue pigment**

Gum and blue pigment for white wash shall be of best quality and of approved make.

**Water Proof Cement Paint**

Water proof cement paint shall be made from best quality white cement and lime resistant colours with accelerators, water proofing agents and fungicides. The paint shall confirm to IS: 5410.

**Paint**

The painting and finishing materials for use in the work shall conform to relevant Indian Standards specifications and shall be best brands of approved make produced for each kind of work. Aluminium paint shall be in two back containers and shall resist weathering.

The acrylic emulsion paint, after it is dried, shall be able to withstand washing with mild soap and water without any deterioration in colour or without showing flaking, blistering or peeling.

**Primer coat**

Unless otherwise specified, the primer coat for concrete, steel and iron work shall be as specified by the manufacturer.

**Weather Shield coating**

Shall be as per approved manufacturer's specifications and relevant IS codes.

**Acrylic Emulsion Paint**

Shall be as per approved manufacturer's specifications and relevant IS codes.

**Textured Paint**

Shall be as per approved manufacturer's specifications and relevant IS codes.

**Acid Resistant Paint**

Shall be as per approved manufacturer's specifications and relevant IS codes.

**Enamel**

Shall be as per approved manufacturer's specifications and relevant IS codes.

**White Washing, Colour Washing and Distempering**

**Mixing**

The slaked lime shall be screened to pass through a sieve of 49 meshes per sq.cm. and dissolved in a tub with sufficient quantity of water and shall be well mixed to give a thin creamy consistency. It shall then be strained through a clean coarse cloth and clean gum dissolved in hot water added to it at the rate of 2 kg for each cubic meter of lime and ultramarine blue added to the mixture in small proportion just sufficient to give a very light bluish tint.

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Colour wash shall be prepared in the same way as for white washing except that necessary amount of colouring matter shall be added to lime wash to obtain the colour specified. No blue shall be added in this case. The entire quantity shall be mixed strictly in accordance with the manufacturer's instructions unless these are varied by the Owner/Owner's representative.

Distemper shall not be mixed in a larger quantity than is actually required for a day's work and hot water shall be used in preparing the mixture.

**Preparation of Surface**

Before white wash is laid on new wall, the surface of wall shall be well cleaned and brushed and all patching must be scraped properly. After cleaning the surface, all holes, cracks and patches shall be made good with approved materials.

Masonry cracks shall be cleaned out and patch filled with mortar similar to the original surface and finished with cement wash. For all internal painting the surface shall be made smooth by application of approved paste fillers before applying primer.

The distemper shall not be applied on damp walls and shall be applied in dry weather. The surface to be distempered shall be thoroughly cleaned of dust, dirt, grease, oil marks, cement marks, loose scales etc. and rubbed with sand paper to give a uniform smooth surface.

**Workmanship**

White wash shall be applied with brush, each coat consisting of vertical stroke from top downwards followed by opposite stroke upwards over the first stroke and horizontal stroke from left to right followed by stroke right to left. Each coat must be allowed to dry before the next coat is applied. On completion, the surface when it becomes dry, shall present a uniform white appearance. When dry, no coat of white wash shall show any patches, haircracks or streaks nor shall it come off when rubbed with hands. White washing shall be done in 3 coats unless otherwise specified. Doors, windows, floors etc. must be protected from white wash splashes. Any splashes and droppings shall be removed and cleaned.

Colour wash shall be applied in the same manner as specified for white wash. During application, the solution shall be stirred continuously and wash shall be applied with care to avoid any cut shade or brush marks on the walls when the work is complete. For all new work, the surface to be colour washed shall first be treated with a priming coat of lime wash. Unless otherwise specified, two coats of white wash shall first be applied before colour wash is applied. The colour wash, whether applied inside or outside of a building shall be of uniform tint and shade.

The workmanship for distempering shall conform to IS:427 and IS:428 unless specified otherwise. Distempering shall be done with proper distemper brushes of approved quality. The finished surface shall be of absolutely uniform shade throughout and free from brush marks. On drying, the distemper shall not come off on touch and shall not crack. Distemper shall be applied in two coats over one coat of priming. The priming coat shall be as specified and the primer shall be in accordance with the recommendation of the manufacturer. Before applying the primer, the plastered surface shall be washed with a solution of 100 gm of zinc sulphate to one litre of water and then allowed to dry. Succeeding coats shall not be applied until the previous coat has been approved by the Owner/Owner's representative. The first coat shall always be of a lighter tint and shall be applied with care. In case the finish is not up to the standards, the entire surface shall be sand-papered and a fresh coat or coats of distemper shall be supplied without any extra cost.

All decorative mouldings, cornices, bands etc. shall be finished according to detailed drawings. All splashes of distemper shall be removed by the Contractor at his own cost.

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The surface to be coated with water proof cement paint shall be washed and brushed down. As soon as the moisture has disappeared, the surface shall be given one coat of paint. Care shall be taken so that the paint does not dry out too rapidly. After four to six hours, water shall be sprinkled over the surface to assist curing and prevent cracking. After the first coat has dried (24 to 48 hours), the second coat shall be applied in a similar manner. The finished surface shall be kept moist by occasional sprinkling with water for seven days after painting.

**Painting**

**Preparation of surface**

The surfaces of iron and steel work to be painted shall be cleaned free of dirt, oil, rust, millscale and be thoroughly dry before painting. Cleaning, degreasing, derusting and descaling wherever necessary shall be carried out as specified in IS:1477 (Part I). All galvanised iron surfaces shall be pre-treated with a compatible primer according to the manufacturer's direction.

The surfaces of wood shall be rubbed down smooth. All nails and screws shall be sunk below the surface and filled with mastic after applying an under coat. Small knots that do not justify cutting and sap streaks shall be covered with minimum two coats of pure shellac coating applied thinly and extended 25 mm beyond the area. All large, loose or resinous knots shall be removed and filled with sound wood. All work shall be done as per IS:2338.

**Application**

Painting of iron and steel work shall generally be carried out as per IS:1477.

The paint manufacturer's specification/instructions shall be followed as far as possible at all times. Particular attention shall be paid to the following:

a. Proper storage to avoid exposure, as well as extremes of temperature.

b. Surface preparation prior to painting

c. Mixing and thinning

d. Application of paints and the recommended time limit on time intervals between coats.

Painting operations shall not proceed until the Owner/Owner’s representative has the opportunity to inspect the condition of prepared surface to be painted. Paint shall be thoroughly mixed and not more than 1/2 kg of recommended thinner per 4.5 kg litres of paint shall be added if thinning is necessary. Exterior paint shall not be performed during the period of inclement weather. Interior painting may proceed during such periods only with the approval of the Owner/Owner’s representative. Prior to application of subsequent coat, the Owner/Owner’s representative shall be given the opportunity to inspect the prior coat. Should the work be judged by the Owner/Owner’s representative be inferior, a supplementary coat shall be applied at no additional cost.

The number of coats including the primer coat shall be applied as specified. Each coat shall be allowed to dry sufficiently before the succeeding coat is applied.

The type of intermediate and finish coat and the number of coats to be applied shall be as specified. Intermediate and finish coats may be oil bound, bituminous, aluminium or other types of paints. The intermediate and finish coats for structural steel work, sheet metal work and cast iron work shall be applied as specified in IS:1477 (Part II).

**Acceptance Criteria**

a) All the painted surface shall be uniform and pleasing in appearance.

b) The colour, texture etc. shall match exactly with those of approved samples.

c) All stains, splashes and splatters of paints shall be removed from surrounding surface.

### 5.5.14 Water Proofing

**Scope**

This specification covers the requirements in respect of materials, workmanship and quality for water proofing of roofs and underground structures.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the contract, shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

| | |
|---|---|
| IS:1322 | Bitumen felts for water proofing and damp proofing |
| IS:1346 | Code of practice for waterproofing of roofs with bitumen felts |
| IS:1580 | Bituminous compound for water proofing and caulking purposes. |
| IS:1609 | Code of practice for laying damp-proof course using bitumen felts |
| IS:2645 | Integrated cement water proofing compounds (1987) |
| IS:3067 | Code of practice for general design details and preparatory work for damp-proofing and water-proofing of building. |
| IS:7193 | Specification for glass fibre base coal tar pitch and bitumen felts. |

**Materials**

**Bituminous Polymeric membrane for roof water proofing.**

Bituminous Polymeric membrane used for waterproofing of roofs shall be 5 layered membrane consisting of a central core of 90 microns thick High Molecular High Density Polyethelene (HMHDPE) film protected on both sides with polymeric asphaltic mix and further covered on both sides with protective thermofusible HMHDPE film. For precast roofs, the top HMHDPE layer shall be substituted with embossed aluminium foil 75 microns thick. Product to be used for cast-in-situ roof slab shall be MULTIPLAS STANDARD and that for roof with precast slab panels shall be MULTIPLAS ALUMINIUM or approved equivalent.

**Bituminous polymeric membrane for underground damp proofing.**

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The membrane used for waterproofing underground structures shall be 7 layered membrane similar to 5 layered roofing membrane, but reinforced with a non woven polyester mat of minimum 140 g/m² for additional mechanical strength and covered with additional layer of polymeric asphalt. Product to be used shall be MULTIPLAS HYPER or approved equivalent.

**Bitumen Felt**

It shall conform to IS:1322.

**Fibre Glass Tissue Reinforced Bitumen Felt**

It shall conform to IS: 7193, consisting of reinforced glass fibre base coated on both sides with bitumen modified with thermo plastic polymers.
Bonding Materials

Bonding materials used for applying the polymeric bituminous membrane on surfaces shall be fibre and solvent based, rubber modified bituminous primer of density 0.92 g/cm3 with viscosity 500 to 10,000 cps. Ordinary bitumen wherever used shall be of blown type conforming to IS:702 or residual bitumen conforming to IS:73 or a mixture thereof.

**Water proofing admixture**

The water proofing admixture shall conform to IS: 2645 and shall be approved by the Owner/Owner's representative.

**Cement**

Cement shall conform to IS 455 or IS:1489.

**Aggregates**

The aggregates shall conform to IS:383. Fine aggregate shall be river sand or pit sand from approved pits. Coarse aggregate shall be stone chips of size not exceeding 6 mm.

**Metal Flashings**

Metal flashings shall be of 18 g or 20 G galvanised iron.

**Workmanship**

**Waterproofing of roof**

- **With polymeric bituminous membrane**

The roof slabs shall be cleaned of all dust, dirt, grit etc. and if rough it shall be made reasonably smooth either by clipping of projections or by applying a thin coat of cement slurry of cement sand and water. The roof surface shall be regraded prior to waterproofing with cement mortar or concrete screed to provide a minimum slope of 1:75 for cast-in-situ roofs and 1:50 for precast roofs. At the places of drain outlets, projecting pipes, parapet walls and expansion joints etc. the surface shall be prepared in indicated in IS : 1346.

Over the hardened and finished surface of roof slab, suitable approved primer such as MULTIPLAS PRIMER or approved equivalent is coated at the rate of 250 g/cm². The waterproofing membrane is unrolled over the coated surface with overlaps of 100 mm and bonded completely to the substrate.

The overlaps are then sealed by flame. Installation of the waterproofing membrane shall be strictly as per the manufacturer's instructions and supervision.

In case of roofs with parapets, a chase 75 mm deep shall be cut in the parapet masonry at about 150 mm above the roof level and the membrane shall be laid as flashings in widths with a minimum overlap of 100 mm. The lower edge of the flashing shall overlap the membrane laid on the flat portion, and the upper edge of the flashing shall be tucked into the groove made in the parapet. After the flashing has been properly bonded, the chase shall be cleaned and shall be filled up with cement mortar 1 : 4 flush with the face of the wall, and allowed to set by adequate curing.

For gutters, the membrane shall be laid over a primer coat, and finally painted with a coat of hot bitumen at not less that 1.5 Kg/sg.m. The membrane treatment shall be carried down into the outlet pipes to a minimum depth of 100 mm.

After the treatment is over, the surface shall be covered with 20 mm plaster of cement mortar 1:4 reinforced with chicken wire wesh marked off into squares 600 mm wide with expansion joints provided at a distance of 3 metres for cast-in-situ accessible roofs.

- **With hessian based bitumen fells**

The roof slab shall be cleaned of all dust, dirt, grit etc. and if rough it shall be made reasonably smooth either by chipping of projections or by applying a thin coat of cement slurry of cement, sand and water.

The roof surface shall be regraded prior to waterproofing either with cement mortar or lime-surkhi mortar. At the places of drain outlets, projecting pipes, parapet walls and expansion joints etc. the surface shall be prepared as indicated in IS:1346.

The workmanship in general shall conform to IS:1346 unless otherwise specified. Over the hardened and finished surface of the roof slab, a thin layer of approved bitumen primer shall be first brushed over the roof surface and allowed to dry.

The felt shall be first cut to the required lengths and laid out flat on the roof in position at right angles to the direction of run-off gradient and shall be brushed clean of dusting materials. Each length of felt thus laid in position shall be rolled up for a distance of half of its length. Then the bonding material heated to correct temperature shall be poured on to the roof across the full width of the rolled felt as the latter is steadily rolled out and pressed down. Excess bonding material shall be squeezed out at the ends and removed as the laying proceeds. When the first half of the strip of felt has been bonded to the roof, the other half shall be rolled up and then unrolled on to the hot bonding material in the same way.

Minimum overlaps of 100 mm shall be allowed at the end and the sides of strips of felt. All overlaps shall be firmly bonded with hot bitumen. The laying of the second layer of felt shall be so arranged that the joints are staggered with those of the layer beneath it.

In case of roofs with parapets, a chase 75 mm deep shall be cut in the parapet masonry at about 150 mm above the roof level and the felt shall be laid as flashings in widths with a minimum overlap of 100 mm. The lower edge of flashing shall overlap the felt laid on flat portion of the roof and the upper edge of the flashing shall be tucked into the groove made in the parapet. After the flashings have been properly bonded, the chase shall be cleaned and shall be filled up with cement mortar (1:4) flush with the face of the wall and allowed to set by adequate curing.

In case of drain mouths, waterproofing shall be done as specified for the roof excepting that the treatment shall be carried inside the drain pipes overlapping at least 100 mm.

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For gutters, a priming coat shall first be applied. Over this, a specified number of layers of felt shall be laid and bonded together with hot bitumen and finally painted with a coat of hot bitumen at not less than 1.5 kg per sq. metre. The felt layers laid separately in the gutters shall be overlapped with the corresponding layers on the roof proper. The felt treatment shall be carried down into the outlet pipes to a minimum depth of 100 mm.

After the treatment is over, the surface shall be covered by pea-sized gravel or grit at the rate of 0.6 cu.m per 100 sq.m. On flashings and at drain mouths a finish of two coats of approved bituminus primer shall be provided.

- **With fibre glass tissue reinforced bitumen felt**

Water proofing for roofs shall be according to the guide lines in IS:1346. Other requirements shall be the same as those for hessain based bitumen felt.

- **With brick lime concrete and pressed flat tiles**

The exposed surfaces of the roof slab shall be thoroughly cleaned. A layer of brick lime concrete shall be laid over the cleaned surface. Brick lime concrete shall be 1:2:4 by volume using 20 mm down graded brick bats. The slope of the lime concrete layer shall be 1:100 and the minimum thickness shall be 80 mm. The slope of the draining surfaces shall be formed on all the sides as necessary.

Care shall be taken to check the quantity of water. The quantity of water shall be so as to make the concrete just workable. Cement sand mortar 1:3 with 2% mixture of "Accoproof"(or approved equivalent water proofing agent) shall be laid over the underbed to a thickness of 20 mm. Pressed flat tiles are set over the mortar and pointed with cement mortar 1:3 with 2% "Accoproof" (or approved equivalent water proofing agent).

**Damp proofing of underground structures**

- **With polymeric bituminous membrane**

Prior to application of the membrane, the surface shall be coated with MULTIPLAS PRIMER or equivalent applied at the rate of 250 g/m2. Application procedure will be similar to roof water proofing, strictly as per manufacturer's instructions and supervision. Membranes shall be fastened with the vertical surfaces for height exceeding 4,5 mtrs. Half brick thick brick work in cm 1 : 4 shall be provided as protection to waterproofing on external side faces.

- **With hessian based bitumen felts**

Damp proofing for underground structures wherever indicated shall be done as per recommendations of IS:1609, for heavy treatment with three layers of felt. The method of laying damp proofing treatment shall be as per IS:1609.

- **With fibre glass tissue reinforced bitumen felt**

It shall be done as per guidelines laid in IS:1609 and those specified for hessian felts. The felt layers shall be fastened to the wall surface wherever the height exceeds 4.5 metres. Half brick wall in CM 1.4 shall be erected as protection to the external face of the water proofing.

**Acceptance Criteria**

The slopes and surface level shall be such as to allow quick draining of water without leaving any pool anywhere. The finishing course shall be fully secured and shall have an even density. There shall not be any bubble formation or crushed or squeezed insulation or underbed.

The Contractor shall give a guarantee in writing for all works executed under this specification supplemented by a separate and unilateral guarantee from the specialised agency for the waterproofing treatment work. The guarantee shall be for materials and workmanship for five (5) years.

### 5.5.15 False Ceiling and False Flooring

**Scope**

This specification covers the requirements in respect of materials, workmanship and quality for suspension system and ceiling panels required for false ceiling work and false flooring work.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed here under :

| | |
|---|---|
| IS:848 | Synthetic resin adhesives for plywood |
| IS:1642 | Code of practice for fire safety of buildings. |
| IS:2095 | Gypsum plaster boards |
| IS:2441 | Code of practice for fixing ceiling coverings. |
| IS:3087 | Wood particle boards for general purposes. |
| IS:3129 | Low density particle board. |
| IS:4671 | Expanded polystrene for thermal insulation purposes |

**Materials**

**Ceiling Panels for False Ceiling**

Ceiling panels shall be of best quality material in thickness and properties specified. The Contractor shall submit test certificate to the Owner/Owner's representative for approval before bulk supply.

The ceiling panels may be of the following types manufactured by reputed manufacturers

- **Teakwood particle board**

Teakwood particle board shall conform to IS:3087 (3 layer flat pressed particle board bonded with BWP type phenol Formaldehyde Synthetic resin conforming to IS:848), satisfying the requirements of Class I of IS:1642 and treated with antifungus Chemicals. The bottom (facing the floor) of tiles shall be painted with two coats of acrylic emulsion paint over a coat of primer.

- **Gypsum board**

Gypsum board shall conform to IS;2095 and shall have the following properties

| | | |
|---|---|---|
| Thermal conductivity | : | 0.16 W/mK |
| Thermal resistant | : | 0.06 to 0.09 $m^2$ K/W |
| Fire propagation | : | Class-1 |

- **Aluminium panels**

Aluminium panels shall be square edged plain panels, 84 mm wide x 15 mm deep with 25 mm recessed flanges, formed out of 0.5 mm thick aluminium alloy electrically powder coated in standard colours. LUXALON 84C or approved equivalent shall be used.

**Floor Panels for False Flooring**

- Particle board with PVC tiles

- Cement fill metallic panels with antistatic HPL tiles

Floor panels for false flooring shall be of 600x600x32 mm cement fill metallic false flooring panels with 1.2 mm thick antistatic, high abrasion resistance, high pressure laminate tiles on faced on top (Lloyd insulations or approved equivalent) unless otherwise specified. All steel works and stools shall be provided with two coats of polyurethane paint over a coat of approved primer. Each panel shall have PVC beading on all edges. The floor panels shall be of completely removable type. The clearance under the floor shall be as per drawing, The floor panels shall be cut wherever required for providing suitable outlets for cables etc.

The false flooring Panel shall be provided for the area of cable route as per requirement and the other areas shall be covered with PVC antiskid flooring.

**Installation**

The Contractor shall prepare a layout for false ceiling showing the framing and the cut outs for AC/Electrical fixtures and other services and get the same approved before commencement of work.

**Suspension system for false ceiling boards**

Suspension system shall consist of the grid supporting the ceiling panels, intermediate runner supports for the grid if any and hangers, wall angles etc. required to suspend the grid or the runners from structural walls, slabs and beams or trusses. Anodized aluminium grid ceiling system from the approved supplier shall be used. All members of the suspension system shall be of sufficient strength and rigidity to carry the ceiling boards or sheets in a true and level plane without exceeding

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a deflection of 1/360th of their span. Samples of suspension system shall be submitted to the Owner/Owner's representative and approval obtained.

Main runners shall be extruded anodized (25 microns) aluminium Tee section of minimum 25 mm x 35 mm size. Secondary runners shall be aluminium Tee section of minimum size 25 mm x 25 mm. Wall angles shall be of minimum size 38 mm x 38 mm. Generally the grid dimensions of 610 mm x 610 mm shall be adopted.

Angle cleats or other suitable fixing device shall be fixed to the structural beam or slab above for fixing of hangers. Main runners shall be hung by M.S. flats or galvanised tie rod at maximum 1.2 m centres. Extra hangers shall be provided at light fixtures that are supported from the ceiling system. The spacing of main and cross runners shall be to suit the ceiling panel size and as recommended by the supplier. The cross runners shall intersect the main runners at perfect right angles and positively locked together with intersection clips. Cutouts for light fixtures, diffusers etc. shall be the exact dimensions and in exact locations.

**Suspension system for aluminium panels**

The panels shall be supported on formed carriers, 15 mm wide at top and 43 mm deep, made out of 0.91 min. thick aluminium alloy electrically powder coated in stain black with protruding cars to hold panels in a module of 100 mm (16 mm gap between the panels) at a maximum spacing of 1.3 metres. Carriers shall be suspended from the slab/roof by 4 mm dia galvanised steelwire/rod hangers with height adjustment suspension springs made out of galvanised spring steel hangers, fixed to slab by J hooks and nylon inserts. Edges of the ceiling shall be trimmed with suitable matching edge profiles to cover the gap between the false ceiling and the walls.

**Supporting arrangement for false flooring**

The supporting arrangement for particle board false flooring shall consist of pedestal made out of aluminium zinc, alloy rod with check nut into 20 mm. dia and 10 mm thick base plates. The pedestal shall be fixed on the floor @ 600 mm c/c with araldite (or other approved method) including surface preparation. The pedestal heads will receive main end cross M.S. cold roll formed 40 mm x 40 mm x 2.5 mm thick channels including provision of additional angles 50 x 50 x 6 mm and ISMC 100 at cable entries and sides of well as required. The pedestals will have level adjustments to ± 25 mm for levelling. Each pedestal shall be able to support a load of 2500 kg without deformation. All steel framework shall be hot dip galvanised.

The supporting arrangement for cement fill metallic panels false flooring shall consist of seamless pipe 25 mm. outer dia and 12 mm thick base plates. The pipes shall be fixed on the floor @ 600 mm c/c with 50x6 mm metal screw with nilon rowal plug. The pipe heads will have MS check nut and M18x 100 long studs with jackhead zinc plated of size 90x90x4 mm thick over which GI stringer 30x20x1.5 thk having pre punched holes 6 mm dia for the fixing of panels.

**Fixing of Ceiling and Floor Panels**

The Contractor shall submit sample panels and get the approval of the Owner/Owner's representative. Installation of ceiling and floor panels shall be strictly as per manufacturer's instruction. The hold down clips for ceiling panels shall be used at the rate of minimum one per 1.2 metre length of perimeter or as per manufacturer's specification. These shall however be omitted in access panels which shall be located as per the instruction of the Owner/Owner's representative.

Finished ceiling and floor shall be at the correct plane and present a pleasing and uniform appearance, free from sags, wraps, disfigured or damaged boards. Joints, exposed grids etc. shall be in true lines and symmetrically placed.

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**Acceptance Criteria**

Finished ceiling and floor shall be at the correct plane and present a pleasing and uniform appearance, free from sags, warps, disfigured or damaged boards. Joints, exposed grids etc. shall be in true lines and symmetrically placed in manner shown on drawings. Cutouts for light fixtures, diffusers, cable ducts etc. shall be to the exact dimensions and in exact locations.

### 5.5.16 Roof Insulation

**Scope**

This specification covers the requirements in respect of materials and workmanship for under deck roof insulation.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Indian Standards Institution and all other such as may be published by them during the currency of the contract shall govern in respect of design, workmanship, quality and properties of materials and method of testing.
The relevant available code is listed hereunder:

IS: 8183 Bonded mineral wool.

**Materials**

The materials for insulation shall be resin bonded mineral wool insulation of Group I as per IS: 8183 with aluminium facing.

**Workmanship**

Slotted angle 50 x 50 x 6, 50 mm long shall be fixed to the underside of the slab at 600 mm centres in both direction. The insulation board or rolls shall be fixed to the underside of the slabs at 600 mm centres in both directions with the aluminium foil face at the bottom with a suitable adhesive. The insulation material shall be held in position by means of the 25 mm x 24 SWG net tied to the slotted angles. The joints if any of the wire netting shall be butted and lightly laid down with GI wire.

### 5.5.17 Water Supply, Drainage and Sanitary Works

**Scope**

This specification covers the requirements in respect of materials, installation and quality for water supply, drainage and sanitary works.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed hereunder:

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**Roof Drainage System**

| | |
|---|---|
| IS:1230 | Cast iron rain water pipes and fittings |
| IS:1626 | Asbestos cement building pipes, gutters and fittings (spigot and socket type) |
| IS:1729 | Specification for sand cast iron spigot and socket soil, waste and ventilating pipes, fittings and accessories. |
| IS:1742 | Code of practice for building drainage. |
| IS:2527 | Code of practice for fixing rainwater gutters and down pipes for roof drainage |
| | Pipes and fittings for sanitary plumbing and drainage |
| IS:404 | Lead pipes |
| IS:405 | Lead sheet and strip |
| IS:458 | Concrete pipes (with and without reinforcements) |
| IS:651 | Salt glazed stoneware pipes and fittings |
| IS:77 | Glazed fire clay sanitary appliances |
| IS:774 | Flushing cistern for water-closets and urinals (other than plastic cisterns) |
| IS:775 | Cast iron brackets and supports for wash basins and sinks |
| IS:778 | Copper alloy gate, globe and check valves for water works purposes. |
| IS:781 | Cast copper alloy screw down bib taps and stop valves for water services |
| IS:782 | Caulking lead |
| IS:783 | Code of practice for laying of concrete pipes |
| IS:804 | Rectangular pressed steel tanks |
| IS:1172 | Code of basic requirement for water supply drainage and sanitation |
| IS:1239 | Mild steel tubes and 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:1703 | Ball valves (horizontal plunger type) including floats for water supply purposes |
| IS:1711 | Self closing taps for water supply purposes |
| IS:1726 | Cast iron manhole covers and frames |
| IS:1742 | Code of practice for building drainage |

| | |
|---|---|
| IS:1795 | Pillar taps for water supply purposes |
| IS:2065 | Code of practice for water supply in buildings |
| IS:2104 | Water meter boxes (domestic type) |
| IS:2326 | Automatic flushing cisterns for urinals (other than plastic cisterns) |
| IS:2470 | Code of practice for installation of septic tanks |
| IS:2548 | Plastic seats and covers for water-closet |
| IS:2556 | Vitreous sanitary appliance (vitreous china) |
| IS:2963 | Copper alloy waste-fittings for wash basins and sinks |
| IS:3004 | Plug cocks for water supply purposes |
| IS:3006 | Chemically resistant glazed stoneware pipes and fittings |
| IS:3076 | Low density polyethylene pipes for potable water supplies |
| IS:3114 | Codes and practice for laying of cast iron pipes |
| IS:3311 | Waste plug and its accessories for sinks and wash basins |
| IS:3486 | Cast iron spigot and socket drain pipes |
| IS:3597 | Methods of test for concrete pipes |
| IS:4127 | Code of practice for laying of glazed stoneware pipes |
| IS:4346 | Washers for use with fittings for water services |
| IS:4984 | Specification for high density polyethylene (HDPE) pipes for potable water supplies, sewage and industrial effluents |
| IS:4985 | Unplasticized PVC pipes for potable water supplies |
| IS:5219 | Cast copper alloy traps (`P' & `S' (Part-I) traps) |
| IS:5329 | Code of practice for sanitary pipe work above ground for buildings |
| IS:5961 | Cast iron gratings for drainage purposes |
| IS:7634 | Code of practice for plastic pipe work for potable water supplies |
| IS:8008 | Injection moulded high density polyethylene (HDPE) fittings for potable water supplies |
| IS:10124 | Fabricated PVC fittings for potable water supplies |

**Materials**

**Sanitary Fittings**

All sanitary fittings shall be procured from approved vendors and shall conform to the requirements of the relevant IS Codes listed above. The sizes shall be as specified in the General Technical Specification, where not specified, the same shall be as per Owner/Owner's representative's approval.

Glazed earthenware fittings shall be of Hindustan Sanitaryware, Parryware or approved equivalent make, white colour and one piece construction. All metallic fixtures like taps, stop cocks, soap holders etc. shall be of Chromium Plated (CP) brass, Jaguar, GEM or approved equivalent make. PVC fixtures shall be of CALIPLAST or approved equivalent make. All wall fittings shall be fixed with wooden cleats and CP brass screws and washers.

**Pipes and Fittings**

Pipes and specials shall be of standard quality conforming to IS:3486.

Stoneware pipes shall conform to IS:651.

RCC pipes for underground sewer shall be P1 class conforming to IS:450.

Cast Iron rain water pipes shall conform to IS:1230.

Water supply lines of GI, PVC, HDPE shall conform to IS:239, IS:4985 and IS:4984 respectively. PVC fittings for water supply lines shall conform to IS:10124.

The Contractor shall submit to the Owner/Owner's representatives samples of all materials, fittings and appliances for approval well in advance of starting the work. All materials, fittings and appliances used in the work shall conform to the approved samples.

**General**

All water supply, drainage and sanitary works shall be executed by a licensed or authorised plumbing supervisor or a license or authorised plumber and shall be in accordance with the requirements of IS:1742 and other relevant codes.

For items such as earthworks, excavation, concrete, brick work, stonework, painting etc. relevant specifications for these shall apply, unless otherwise specified.

Unless otherwise specified, all exposed work such as cisterns, brackets etc. shall be painted with one coat of red oxide paint and two coats of oil paint of approved colour.

The diameter of pipes and fittings wherever mentioned shall mean the internal diameter or nominal bore, unless otherwise specified.

The job shall include the cost of making necessary chases, holes etc, in walls, floors and in other places and also making good on completion of the works. Any damage caused to floors, walls etc. during execution of the sanitary and plumbing works shall be made good by the Contractor at his own cost to the satisfaction of the Owner/Owner's representative.

**Installation**

All execution will be done on the basis of drawings /instruction given by the Owner/Owner's representative. Fittings meant for operation shall be located and oriented to allow easy reach and operation, maintenance, repairs and replacements of pipes, fittings and fixtures must be conveniently possible.

**Cast iron soil and waste pipe line**

- **Laying**

The laying of cast iron pipelines shall commence only after the bottom of the trench at various points have been levelled and aligned in accordance with the drawings. The sides of the trenches shall be as vertical as possible, and the width at the bottom shall be 400 mm wider than the diameter of the pipe. Where joints are made, the trench shall be widened suitably to provide room for caulking joints. Shoring and timbering shall be used where required. For pipes buried in the ground, the Contractor shall take care to maintain always a minimum cushion of earth over the pipes as indicated in the drawings. All pipes, water mains, cables etc. met within the course of excavation shall be carefully protected and supported. All pipes and fittings shall be sounded with a light hammer and check properly to detect any crack or blow holes before laying. The excavated material shall be thrown on one side of trench and the pipes stacked on the other side. The inside of socket and the outside of spigot shall be thoroughly cleaned of all foreign matter before laying. The pipes shall be laid with their socket ends facing the direction of the flow. The pipes shall be lowered in the trenches by a method as approved by the Owner/Owner's representative. The pipes shall then be jointed by caulking as specified under jointing. After each section of the pipeline has been laid it shall be tested for water tightness before backfilling the trench. On successful completion of testing, the trench shall be backfilled with the excavated earth in layers of 200 mm and shall be watered and rammed. Any subsidence occurring in the line of trenches after backfilling shall be repaired by the Contractor at his own cost. Where the pipelines cross roads, the sides of the trenches shall be suitably shored.

When the pipe line has to be laid above ground vertically by the side of wall, it shall be securely fixed to the wall with wooden plugs and nails.

- **Jointing**

The type of jointing for C.I. pipes conforming to IS: 3486 shall be socket and spigot either with molten lead or lead wool and gasket conforming to IS:782.

If the joints used are spigot and socket type, the spigot shall be carefully centred in the socket by one or more laps of clean white hemp spun yarn with about 25 mm overlap. Sufficient yarn only shall be forced into the socket to leave a correct depth of lead for caulking. The pipe shall then be examined again for line and level and the proper depth of each joint shall be tested before running the molten lead. For pouring of molten lead a ring of hemp rope shall be wrapped round the pipe at the end of the socket and the joint shall be covered with stiff damp clay. The rope shall then be removed carefully leaving a V-shaped large hole at the top of the joint to pour the molten lead. Lead shall be poured in one operation only. After a section of convenient length of pipe has been laid, lead shall be caulked sufficiently with caulking tools and hand hammered till the excess lead removed and the joint shall be made neat and clean. Depth of lead in joints from the top of socket shall be 37 mm for 150 mm dia pipes and 25 mm for 100 mm dia pipes.

The type of joint CI pipes conforming to IS:1729 shall be socket and spigot with cement and sand mortar (1:1) and gasket yarn.

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The spigot shall be carefully inserted and centered in the socket by one or more laps of thin clean hemp spun yarn and shall be forced into the socket to leave a correct depth of 30 mm all-round and level and the proper depth of each joint shall be tested before inserting the cement mortar. The joints shall then be carefully be levelled to the edge of the socket. Each joint shall be adequately cured by covering with wet clothes and pouring water at frequent intervals.

The packing ring or washer for the flanged joints shall be rubber for the full diameter of the flange with proper pipe hole and bolt holes cut out suitably. The packing shall be smeared with graphite paste or a mixture of red lead and white lead and shall be introduced between the flanges of both the pipes and nuts tightened in opposite pairs keeping the longitudinal axes of adjoining pipe lines in exactly the same straight line. Lead washers shall be provided along with bolts to prevent any leakage through bolt holes.

**Stoneware pipes**

- **Laying**

The laying of stoneware pipelines shall commence only after the bottom of the trench at various points have been levelled as shown in the drawings. The centre line excavated to correct depth, slope and width at all points. The pipes shall be carefully laid to the alignment, levels and gradients as shown on the drawings. The trench shall be excavated wide enough under the sockets to allow hands to pass for making joints. The pipes between manholes shall be laid truly in straight lines and without any vertical or horizontal deviations on a bed of concrete as shown on the drawings. While laying pipes, portion of concrete under each socket shall be dug and taken off so that the barrel of the pipe gets full support on the concrete bed. Pipes shall be haunched with concrete tangentially upto the crown of the diameter of the pipe as shown on the drawings. When it crosses under a road, the pipe shall be fully encased in concrete as shown on drawings. The Contractor shall take precautions to maintain always a minimum cushion of earth over the pipes as indicated in the drawings. All pipes shall be carefully examined with a light hammer of soundness before laying. After each section of the pipelines has been laid, the joints shall be allowed to set properly and shall be inspected and tested as directed by the Owner/Owner's representative. Backfilling of the trench shall be carried out only after the approval. After testing, the trench shall be backfilled with selected earth in layers of 200 mm and shall be watered and thoroughly rammed. All pipes, water mains, cables etc. met within the course of excavation shall be carefully protected and supported.

When the pipelines cross roads, the trenches shall have vertical sides with suitable shoring. Any subsidence in the line of trench after backfilling shall be repaired by the Contractor at his own cost.

- **Jointing**

The type of jointing for stoneware pipes shall be socket and spigot type. The inside of the socket shall be first painted with a thin layer of cement mortar (1:2) and a gasket of yarn dipped in cement slurry shall be inserted in the socket of the pipe with the wooden caulking tool and wooden mallet in such a way that the gasket shall fully encircle the spigot with a slight overlap. When the spigot end received the gasket, it shall be wrapped round with two or three turns of treated spun yarn at its ends before being inserted into the socket. The rest of the joint shall then be completely filled with cement sand mortar (1:1) having very little water and the joint shall be levelled to form a smooth splayed fillet at an angle of 45o. All excess of cement mortar left inside the pipe joint shall be neatly cleaned off and the joint shall be adequately cured by covering with wet gunny bags and pouring water at frequent intervals. In jointing stoneware pipes, care shall be taken that the pipes are kept concentric and the socket, specially on the underside shall be completely filled with cement mortar. Where settlement of earth is envisaged, the joint shall be made with bitumastic filler or any other materials as approved by the Owner/Owner's representative.

**Concrete pipes**

- **Laying**

The laying and jointing of pipes shall conform to IS:783. The trench shall be checked for proper level, gradient and alignment before lowering the pipes.

The pipes shall be lowered cautiously to prevent disturbance of the bed and sides of the trench. The heavy pipes shall be lowered by means of proper shear legs, chain pulley blocks or as directed by Owner/Owner's representative. Great care should be taken to prevent sand etc. from entering the pipes.

Laying of pipes shall proceed up grade of slopes. The error of grade shall not be rectified by packing up earth underneath the pipes. If required, concrete shall be used for packing. The ends of the pipes shall be kept closed to keep dirt, mud and foreign materials, out. Adequate provision shall be made to prevent floating of pipe in the event of flooding of trenches. The body of the pipe for its entire length shall rest on an even bed in the trench and places shall be excavated to receive the collar for the purpose of jointing.

- **Jointing**

The type of jointing for concrete pipes shall be with loose concrete collars and the joints shall be packed from either side with spun yarn dipped in cement slurry as specified for jointing stoneware pipes. Stiff cement mortar (1:1) shall be filled from both sides and splayed at an angle of 45o on both sides. The joint shall be adequately cured as specified for joints in stoneware pipes.

**Cast iron rainwater pipes**

Cast iron rainwater pipes fixed to the external walls shall be blocked out atleast 20 mm from the plastered surfaces by means of cast iron bobbins. The rainwater pipes at the roof level shall be fitted with a cast iron bend with a masonry bell mouth of suitable size fitted with a cast iron grating. The bottom of the down pipe shall be fitted with a shoe fixed 150 mm above ground/apron level of the building. The socket and spigots of pipes and fittings shall be jointed as specified for cast iron soil and waste pipe line.

**Galvanised steel water supply pipes**

Screwed galvanised steel pipes shall be jointed with screwed joints and screwed fittings of the same materials as that of the pipes. Any burns remaining on the pipe ends after the treads are out shall be removed. An approved jointing compound together with a grummet of a few strands of fine yarn shall be used for jointing pipes and fittings. Any pipe threads exposed after jointing shall be painted or in the case of underground piping thickly coated with approved bituminous compound to prevent corrosion.

The depth at which the underground water supply pipe is to be laid be as shown on the drawings. The service pipe passing into or beneath the building shall be laid at least 200 mm below the ground floor level and accommodate in a previously laid sleeve in the structure where it enters the building. The space between the sleeve and the pipe at its entry into and exit from the building shall be filled with a bituminous material for a minimum of 150 mm at both ends.

Piping shall not be buried in walls or floors as far as possible. However, when unavoidable, piping shall be buried for the shortest distance necessary and adequate protection shall be provided against damage.

Galvanised steel piping shall be secured by iron or steel clamps and hooks when fixed on walls.

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All pipe work shall be completely watertight and the joints shall be such that there are no projections of jointing materials or the like in the interior of pipes. Before the pipe line is commissioned, all piping and fittings shall be flushed clean.

**High Density Polyethylene water supply pipes**

All high density polyethylene pipes shall have screwed ends and shall be jointed with screwed fittings of the same materials of that of the pipes. Any burrs remaining on the pipe ends after cutting threads shall be removed. If necessary, an approved jointing compound with a few strands of fine yarn may be used for jointing pipes and fittings. All exposed high density polyethylene pipes shall be installed with PVC saddles screwed on 25 mm thick wooden blocks securely fixed on walls at suitable intervals, not exceeding 1 m. Pipe wherever installed in wall chasing shall be fixed as in the case of galvanised steel pipes.

**PVC water supply pipes**

All exposed pipes shall be installed with PVC saddles screwed on 25 mm thick wooden blocks securely fixed on walls at suitable intervals, not exceeding 1 m. Pipe wherever installed in wall chasing shall be fixed as in the case of galvanised steel pipes.

**Inspection pits and trap pits**

Construction of pits shall commence only after the pipes have been laid in position to true line and levels as shown on the drawings and to the satisfaction of the Owner/Owner's representative.

- **Inspection pits**

Unless otherwise specified, all inspection pits shall be constructed with rubble masonry in cement mortar (1:4). Half round channels of size suitable for the inlet and outlet pipe diameters shall be formed on the floor of the pit with PCC 1:3:6. The floor of the pit shall be haunched towards the channel as shown on the drawings. Inside of pits shall be finished with cement-sand plaster (1:4) and finished smooth with cement punning. Care shall be taken to avoid unevenness on the surface and sharp bends in the channel. The invert level after finishing shall be as shown in the drawings or as indicated by the Owner/Owner's representative.

- **Intercepting/master trap pits**

The pits for the glazed stoneware master trap shall be constructed as indicated in the drawings. The construction and finishing of the pit shall be haunched towards the intercepting/master trap.

- **Gully trap pits**

Gully trap pits shall be constructed as indicated in the drawings. The construction and finishing of the pit shall be as described above for inspection pits. The cast iron grating shall be set flush with the finished ground/floor level.

**Sanitary appliances**

All sanitary appliances shall be fixed in position rigidly on floor and walls as indicated in the drawings or as directed by the Owner/Owner's representative. All appliances shall be from the approved manufacturer and of approved colour.

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- **Indian Water Closet - Squatting type (IWC)**

Squatting type water closet shall be fitted on trap and shall be jointed with gasket yarn and cement mortar. Rim of the pan shall be levelled properly and set flush with the finished floor. The pan shall be connected to PVC low level push button/lever type cistern of 10 litre capacity. The flushing cistern shall be supported on a pair of CI cantilever brackets firmly embedded in the wall in cement mortar (1:4) or screwed to wall with suitable plugs. The flush pipe from the cistern shall be 32 mm dia tested quality Chromium Plated (CP) pipe and connected to the pan inlet by means of hemp and putty joint.

- **European Water Closet (EWC)- pedestal type**

Pedestal type water closet shall be rigidly fixed on the finished floor by means of 75 mm long brass screws with suitable plugs. The flushing cistern shall be PVC low level push button/lever type cistern of 10 litres capacity. The cistern shall be supported on a pair of cast iron or rolled steel cantilever brackets firmly fixed on wall with brass screws and suitable plugs. The flush pipe from the cistern shall be 40 mm dia chromium plated brass end and fitted to the closet by means of rubber adopter. The closet shall be provided with double plastic seat cover conforming to IS: 2548 and chromium plated hinges.

- **Urinals**

Standing type urinals shall be firmly fitted on finished wall by means of 50 mm long brass screws and suitable plugs. Height of the lip from the standing point shall be as shown in the drawings. Urinals shall be fitted with automatic flushing cistern of 10/15 litres (2/3 urinals) capacity. Flushing pipes shall be of CP pipes of 25 mm dia and connected to the urinal with 15 mm dia PVC connector fitted with brass cap and lining at one end. The joint to the inlet of urinal shall be neatly finished with putty joints.

The arrangement of waste pipes and discharge to the floor trap shall be as shown on the drawings or as directed by Owner/Owner's representative. For single urinal the discharge may be direct to the floor trap through a 40 mm dia waste pipe. For a range of urinals, the discharge may be collected in a common waste pipe of 50 mm dia leading to the floor trap. Each urinal shall be connected to the common discharge pipe by 40 mm dia waste pipes. Alternatively, the discharge from each urinal through 40 mm dia pipe shall be lead to the 100 mm W.G half round channel laid on the floor leading to the floor trap.

- **Wash hand basin**

Wash hand basin shall be fitted in position to true level on a pair of cast iron brackets plugs. The basin shall be fitted with 15 mm dia approved quality CP pillar tap and 32 mm dia waste fittings. The type of waste pipe and their connections shall be as shown in the drawings or as directed by the Owner/Owner's representative.

- **Sink**

Stainless steel sink of shall be levelled properly and fitted in position on a pair of cast iron cantilever brackets firmly embedded in the wall in cement mortar (1:4). The sink shall be fitted with chromium plated brass waste fittings of standard size. The type of waste pipes and their connections shall be as shown on the drawings or as directed by the Owner/Owner's representative.

- **Other miscellaneous fittings (e.g. mirror, towel rails, soap cases etc.)**

All such fittings shall be of type and sizes specified in General Technical Specification and shall be fitted in position true to line, level and plane as shown on the drawings or as directed by the Owner/Owner's representative.

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**Water tanks**

Water storage tanks shall be of SINTEX brand or approved equivalent make, unless otherwise specified.

In case large volume tank is to be constructed, the same shall be of GI, Masonry or RCC. They shall be fitted with a ball valve of the inlet pipe. A mosquito proof overflow pipe shall be fixed to the tank with the pipe invert about 25 mm above the top of water line. Approved type of stop valve shall be provided for every outlet pipe. All outlet and inlet pipes shall be fixed as shown in the drawings. Inside surface of galvanised steel tanks shall be painted with anti-corrosive drinking water paints.

All storage tanks, water supply fittings and pipes before being put into commission shall be disinfected with liquid chlorine by the Contractor at his own cost.

**Testing and Acceptance Criteria**

All sanitary appliances and fittings shall be inspected and tested as per the requirements of IS:1742. All defects and deficiencies detected shall be promptly rectified by the Contractor to the satisfaction of Owner/Owner's representative.

**Soil and waste pipe line**

On completion of laying, the cast iron, soil, waste and ventilation pipelines shall be tested by the Contractor at his own cost to detect leakages and any other defects in the pipelines.

Test shall be conducted using proper apparatus with attachment for smoke making machine for applying smoke to the pipelines under pressure. Only cotton waste of brown paper soaked in cresote oil shall be used and fired to obtain dense and pungent smoke. While conducting smoke test, top of soil, waste and ventilation pipes shall be kept open till smoke starts coming out of the openings. The openings shall then be securely plugged with expanding rubber or any other approved plug. The floor traps and other openings for connecting sanitary fixtures shall be sealed with water or other approved plug. The floor traps and other openings for connecting sanitary fixtures shall be sealed with water or other approved plug. The entire pipeline shall be tested in suitable sections as directed by the Owner/Owner's representative. The entire length of the pipelines including all joints under tests shall be closely observed for any sign of smoke leakage.

**Galvanised steel water supply pipes**

After the laying and fixing of all galvanised steel water supply pipes and fittings are completed, the line shall be slowly and carefully charged with water to a test pressure of 5 kg per sq cm or the specified working pressure plus 50% as may be prescribed by the Owner/Owner's representative. Care shall be taken that air in pipelines is completely exhausted while filling the pipelines with water. This pressure shall be maintained for at least one hour, unless otherwise specified.

## 5.5.18 Tank Pads

**Scope**

This specification covers the requirements in respect of materials, workmanship and quality for bituminous works, crushed rock ring and ring walls for tank pads.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their later editions published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed hereunder:

| | |
|---|---|
| IS:383 | Coarse and fine aggregating from natural sources for concrete. |
| IS:2720 Part VII - | determination of water content-dry density relation using light compaction. |
| IS:2720 Part VIII - | determination of water content - dry density relation using heavy compaction. |
| IS:2720 Part IV - | grain size analysis |
| IS:1478 | Classification and identification of soils for general engineering purposes. |
| IS:803 | Code of practice for design, fabrication and erection of vertical mild steel cylindrical welded oil storage tanks. |
| IS:73 | Paving Bitumen |

**Materials**

**Bitumen**

Bitumen used for anti-corrosive layer shall be of grade 80/100 or equivalent.

**Sand**

Sand shall be clean, dry, coarse, hard, angular free from coatings of clay, dust and mix of vegetable and organic materials and shall conform to IS:383 grading Zone II or III. Silt content shall not be more than 5%.

**Moorum**

Moorum for filling shall consist of coarse and granular moorum containing not more than 20% cohesive fines such as clay (grain size less than 0.074 mm). The moorum shall be 20 mm and down size grading and shall be taken from approved quarries.

**Stone Aggregates for crushed Rock Ring**

Stone aggregates for the crushed rock ring shall be 50 mm and down grade size and shall be of granite or such other approved materials.

**Stone chippings for premix carpet**

Stone chippings for premix carpet shall be hard blue granite or approved locally available stone. The grading shall be normally 12 mm down size and 6 mm down size in the ratio 3:2 respectively.

Cement, steel and aggregates for R.C.C. works in dyke wells

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The material specifications for the above shall be the same as in Clause 5.4.5

**Workmanship**

**Sub Grade Preparation**

The surface of the natural soil exposed at the bottom of excavated pit shall be thoroughly compacted by rolling arising 8 - 10 ton road roller or other means as directed by Owner/Owner's representative to obtain 95% of maximum laboratory/ standard proctor dry density for the soil as per IS:2720 part VII. The minimum number of passes shall be five. The rolling shall also be done outside the tank pad area for atleast 1.5 m beyond the edge of tank pad. Relevant clauses in Section for Earthwork shall also apply.

**Sand/Moorum Filling**

The sand/moorum shall be spread in layers not exceeding 15 cm in loose thickness over the areas. Each layer shall be uniform in density, quality of materials and moisture content before compaction. The moisture content shall be within two percent (2%) of optimum moisture content (OMC) on the dry side of OMC as per IS:2720. Compaction of each layer shall be done by mechanical means as per directions of Owner/Owner's representative. Only inaccessible reaches shall be worked manually.

Each layer shall be uniformly compacted to obtain 95% standard proctor density or 85% relative density. If the material fails to achieve the required density, the layer should be reworked with necessary alteration in the composition, so that the required compaction is obtained.

Further layer shall be placed only after the layer has been compacted to the required density. The finished surfaces must be dressed to required grade and slope. Excess material must be removed from compaction site.

**Crushed Rock Ring**

The stone aggregates for the above shall be laid in layers of 150 mm thickness (compacted thickness) and each layer shall be compacted to obtain a hard core ring wall to the satisfaction of Owner/Owner's representative. The surface shall be checked from time to time during spreading and compaction to ensure a finished surface true to levels and grade as per drawings. Use of fine aggregates such as sand or finer stone aggregates may be required to fill voids and pockets to obtain a uniform compacted hard core. Over the final compacted layer of stone aggregate, sand shall be evenly spread and compacted by tamping/ rolling.

**Anti Corrosive Layer**

Anti corrosive layer shall consist of screened coarse sand mixed with 80/100 bitumen or equivalent, 8 to 10% by volume. The bitumen shall be treated to a temperature of 75oC to 190oC with 3% kerosene if required and sand shall be thoroughly mixed with it in mixing drum to give uniform mixture and shall be laid over the compacted surface of the pad in line, grade and levels as shown in the drawings or as directed by the Owner/Owner's representative. Bitumen shall not be treated beyond the temperatures limits given above. The layer shall be tamped to form hard mass of uniform compacted thickness specified. The anticorrosive layer shall be made in one layer for a 50 mm thickness. For higher thickness it should be laid in two layers after application of a tack coat of bitumen. These layers shall be finished to grade as specified.

**Premix carpet**

The crushed rock ring where provided and the areas on which the premix is to be laid (generally the areas exposed to sun & rain) shall be thoroughly cleaned of all dust and loose materials. On the cleaned surface a tack coat at the rate of 1.0 Kg/m² of hot bitumen shall be uniformly applied by sprayers. The applied binder shall be evenly brushed. The binder bitumen 80/100 shall be heated to the temperature of about 190°C with 3% kerosene, if required and mixed with stone chippings at the rate of 6.1 m3 for 400 Kg of bitumen for 100 sq. m of surface of 50 mm thick carpet. Mixing shall continue until the aggregate is well coated.

The premix carpet shall be laid in two layers of 30 mm and 20 mm. After compacting and laying the first layer of 30 mm, a tack coat of hot bitumen at the rate of 1 Kg/m² shall be uniformly applied to the surface by means of sprayer and second layer of 20 mm thick shall be laid, tamped and compacted to the satisfaction of the Owner/Owner's representative. Sand shall be spread on the final surface at the rate of 0.5 m3/100 m2.

**Reinforced Concrete Works for Ring Wall**

Reinforced concrete works shall be done as per specifications laid down in Clause 4.5.0.

The ring wall shall be cast in quick succession and completed within a period of maximum 7 days. It is desirable that it is cast in alternate lengths along the perimeter at first keeping the horizontal reinforcements independent on the next cast panels. Intermediate panel lengths shall be cast after 3 days to provide some relief from shrinkage strain.

**Tolerances**

The top surface of tank pad shall be to true level & line within the tolerance limit specified below.

- Where concrete ring wall is provided, the differential level shall be within plus or minus 3 mm in any 10 metres of circumference and within plus or minus 6 mm in total circumference.

- Where concrete ring walls are not provided, the differential level shall be within plus or minus 3 mm in any 3 metres of circumstance and within plus or minus 12 mm in the total circumference.

## 5.5.19 Water Bound Macadam (WBM), Roads

**Scope**

This specification covers the requirement in respect of materials, workmanship and quality for road works like sub-grade preparation, sub-base layer, water bound macadam, drains, pipe culverts etc.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

Specification for road and bridge works of Ministry of shipping & Transport (Roads wing) Published by IRC.

| | |
|---|---|
| IRC -19 | Standard specification and code of practice for Water Bound Macadam |
| IRC SP 11 | Hand Book of quality control for construction of roads and runways |
| IS: 458 | Specification for concrete pipes |
| IS: 783 | Code of practice for laying of concrete pipes |
| IS: 2720 | Methods of test of soil (All parts) |

**Sub Grade**

**Excavation**

After the earthwork in cutting and the earthwork in embankments have been done properly up to the final road level with gradients and camber as per drawings and proper consolidation of the filling is completed, earthwork in box cutting shall be taken in hand. Before starting of Box cutting, the Contractor shall obtain Owner/Owner's representative's approval of cutting and embankment work.

The surface of the formation for a width equal to that of the sub-base course shall be properly prepared before any further courses are laid. Surface shall be cut to a depth below the ground level equal to depth of sub-base course due allowance being made for compaction. Preparation of sub-grade also includes removal of any and all foreign substance accumulation and removing undulations up to 150 mm by filling and cutting as required. The sub-grade shall be dressed parallel to the finished profile.

The excavated spoils shall be transported and utilized in filling of low areas or as directed by the Owner/Owner's representative. The filling shall be done in layers or as directed by the Owner/Owner's representative. The filling shall be done in layers of 150 mm and clods and lumps shall be broken and consolidation done to the satisfaction of the Owner/Owner's representative.

In case of presence of weak soil-pockets below the formation, the Contractor shall excavate and remove such soil to an extent as instructed by the Owner/Owner's representative. Extra depth shall then be filled up with 38 mm down stone-metal and voids in metal shall be filled up with moorum. Then, the filling shall be rammed and rolled uniformly with a road-roller of 8 tonnes minimum weight. These operations of removing week soil pockets and filling with stone-metal shall be done by the Contractor.

If, by mistake the depth of box cutting is made more than required, the Contractor shall make up the extra depth by metal consolidation, as specified above, at his own cost.

After the top layer/WBM course is laid and compacted, the existing surface at the shoulders of the road must be scarified. Fresh quantity of approved earth must be extracted from the surplus earth obtained by box cutting spreading in layers for building up the berms. The layer of earth must be compacted by at least three passes of 8 - 10 tonne rollers. The edges must be well compacted by suitable means to prevent edge slips and the work properly trimmed and dressed.

**Rolling**

After the box cutting is completed, the sub-grade shall be compacted with powered road roller 8-12 tonnes. The roller shall run over the sub-grade till the soil is evenly and densely compacted, to achieve a dry density of not less than 95% of maximum density as obtained from standard proctor compaction test. There shall be a minimum of five (5) roller passes. All the undulations on the surface which develop due to rolling shall be made good with earth and quarry spills as approved by

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Owner/Owner's representative and the sub-grade re-rolled. The top of the sub grade shall be dressed evenly to the required camber and necessary drainage arrangement at the time of rolling shall be provided. Care shall be taken to avoid excessive rolling of the formation. If, after rolling the formation is higher than required, the excess earth shall be removed by carefully cutting and dressing and the formation shall be rolled as specified above. In case after rolling the formation is depressed below the required level, the Contractor shall continue the process of filling and rolling as above till the correct level is attained up to a limit as decided by the Owner/Owner's representative at Contractor's cost.

**Soling (Sub-Base)**

This work shall consist of laying and compacting rubbles or boulders on prepared sub-grade in accordance with the requirements of this specification. The material shall be laid in one or more layers as shown on the drawings and according to lines, grades and cross sections shown on the drawings or as directed by the Owner/Owner's representative.

**Materials**

The materials to be used for the work shall be rubbles or boulders and gravel from approved quarries. The maximum size of stone shall be 150 mm. The length and breadth of stone shall not be more than twice of its depth. The stones shall be hard, tough and durable and free of earth, loam or vegetable matter. The flaky material shall not be used.

**Construction**

The soling shall be laid as per the cross section as shown on the drawing and the finished thickness after consolidation shall be as directed by the Owner/Owner's representative. The boulders shall be laid flat with their broad faces resting over the sub-grade to have good seating. The stones shall be hand packed as close as possible and bedded firmly. The voids in the soling shall be filled with stone chips and small stones and hammered and wedged into position. Gauge pegs shall be driven into indicate the thickness of the stones to be laid. Any hollows formed during rolling shall be filled in with spills during the process of consolidation so as to conform to the gradient, camber and cross section of the road and leave an even finished solid surface.

The soling shall be rolled by a 8 to 12 tons power roller after blinding with approved quality moorum. The shoulder shall be rolled first to wedge the stones firmly at the edges and then rolling shall proceed towards the centre. The rolling shall be done longitudinally at the shoulder and worked towards the centre of the pavement overlapping on each successive trip by at least one-half of the width of the roller while starting and 300 mm width while finishing. In case of super elevated strips, the rolling shall commence from the inner edge and proceed towards the outer edge.

The roller shall be operated at the lowest speed possible. The speed in any case shall not be greater than 3 km per hour. Rolling shall be continued till a satisfactory surface is obtained. Wherever use of power roller is not feasible, suitable hand roller may be used as per instructions of the Owner/Owner's representative.

The soling if not done as per the specification, if instructed by the Owner/Owner's representative the whole soling over the defective portion shall be taken out, re-laid and compacted with a road roller as specified earlier, by the Contractor at his own cost.

**Sand-Gravel Sub-Base**

The work shall consist of laying and compacting of a mix of sand and gravel in specified proportion over a prepared sub-grade to the required lines, grades and cross-section in layers as per requirement of this specification.

**Materials**

Sand shall be medium hard, strong, free from organic and deleterious matter and shall be from a source approved by the Owner/Owner's representative. Sea sand shall not be approved.

Gravel shall be clean, well graded and free from any vegetation organic clay or other materials and shall be from a source approved by the Owner/Owner's representative.

**Construction**

The sand and gravel shall be mixed thoroughly in specified proportions by approved means. The moisture content shall be brought to within two (2) percent of the optimum moisture content for the mixed materials as per IS:2720 (Part viii).

The sand gravel mix shall be spread over the prepared sub-grade in layer not exceeding 200 mm thick (uncompacted thickness) and compacted by power rollers (8-10 tonnes) to achieve 85% relative density. The layer shall be compacted to the required camber, slope and line.

Further layer shall be placed only after the layer already laid has been compacted to the required density and approved by the Owner/Owner's representative based on the test results. The finished surface shall be dressed to required camber and level and excess material removed and disposed off by the Contractor at his own cost as instructed by the Owner/Owner's representative.

**Water Bound Macadam (Sub-Base/Base Coarse)**

Water bound macadam shall consist of clean, crushed aggregates mechanically interlocked by rolling and bonded together with screenings, binding material, where necessary and water, laid on a prepared surged or sub-base, as the case may be, and finished in accordance with the requirements of these specifications and in conformity with the lines, grades and cross-sections shown on the drawings or otherwise directed by the Owner/Owner's representative.

**Materials**

- **Coarse Aggregate**

Coarse aggregate shall be of crushed blue granite. Aggregate shall be hard and durable and shall be free from excess of flat, elongated, soft and disintegrated particles, dirt and other objectionable matter and shall be from a source approved by the Owner/Owner's representative.

**Crushed aggregate shall meet the following requirements**:-

i) Flat or elongated pieces shall not be more than 15%.

ii) Los Angeles Abrasion value shall not be more than 40% or Aggregate Index value shall not be more than 30%.Coarse aggregate shall be graded as follows :

| Size Range | IS Sieve designation | Percentage passing by weight |
|---|---|---|
| 63 - 40 mm | 80 mm | 100 |
| | 63 mm | 90 - 100 |
| | 50 mm | 35 - 70 |
| | 40 mm | 0 - 15 |
| | 20 mm | 0 - 5 |

Following test shall be conducted on samples of aggregate :

i) Sieve analysis

ii) Impact tests

iii) Water absorption test - Maximum water absorption shall be 1%

iv) Wetting and drying - The samples shall be subjected to alternate wetting and drying for 3 days and shall not show signs of disintegration.

- **Screenings**

Screenings shall generally be of same material as the coarse aggregate and meet the following gradings :

| Size of screening | IS Sieve designation | Percentage passing by weight |
|---|---|---|
| 10 mm | 10 mm | 100 |
| | 4.75 mm | 85 - 100 |
| | 150 microns | 10 - 30 |

Where non-plastic material like moorum is specified, the liquid limit and plastic limit of such material shall be below 20 and 6 respectively and the fraction passing 75 microns sieve shall not exceed 10%.

- **Binding Materials**

Gravel of suitable plasticity available from local quarries may be used as binding materials and the same shall be approved by the Owner/Owner's representative.

When sample of the binding material is wetted and squeezed in hand the following characteristics shall be noted:

i) The material shall be extremely gritty.

ii) It can be formed into definite shapes that retain their form even when dried.

iii) When the wetted sample is patted in the palm of the hand it will compact into a dense cake that cannot be penetrated easily with a blunt stick.

**Construction**

- **Preparation of Base**

The sub-grade /sub-base to receive the water bound macadam coarse shall be prepared to the specified grade and camber and made free of dust and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm.

- **Inverted Choke**

If the water bound macadam is to be laid directly over the sub-grade, without any other intervening pavement course, a 25 mm course of screenings shall be spread on the prepared sub-grade before application of the coarse aggregate is taken up.

- **Spreading Coarse Aggregate**

The coarse aggregates shall be spread uniformly upon the prepared surface. The spreading shall be done from stockpiles along the side of the roadway or directly from vehicles. In no case shall the aggregate be dumped in heaps directly on the surface prepared to receive the aggregate nor shall hauling over the uncompacted or partially compacted base be permitted.

The surface of the aggregates spread shall be carefully checked with template and all high or low spots remedied by removing or adding aggregate as may be required. No segregation of large or fine particles shall be allowed and the coarse aggregate as spread shall be of uniform gradation with the pockets of fine material.

The coarse aggregate shall not normally be spread more than three (3) days in advance of the subsequent construction operations.

- **Rolling**

Immediately following the spreading of the coarse aggregate, rolling shall be started with three wheeled power rollers of 8 to 10 tonne capacity or tandem roller or vibratory rollers of approved type. The weight of the roller shall depend upon the type of the aggregate and be indicated by the Owner/Owner's representative.

Except on super elevated portions where the rolling shall proceed from inner edge to the outer, rolling shall begin from the edges gradually progressing towards the centre. First the edge/ edges shall be compacted with roller running forward and backward. The roller shall then move inwards parallel to the centre line of the road, in successive passes uniformly lapping preceding tracks by at least one half width.

Rolling shall continue until the aggregates are thoroughly keyed and the creepage of aggregates ahead of the roller is no longer visible. During rolling slight sprinkling of water may be done, if necessary.

Rolling shall not be done when the sub-grade is soft or yielding or when it causes as wave-like motion in the sub-grade or sub-base course. Wherever use of power roller is not feasible, suitable hand roller may be used as per the instructions of the Owner/Owner's representative.

The rolled surface shall be checked transversely and longitudinally with templates. If irregularities noticed, which exceed 12.5mm when tested with a 3m straight edge, the surface shall be loosened and aggregates added or removed as required and re-rolled until the entire surface conforms to desired camber and grade. In no case shall use of screenings be permitted to make up depressions.

- **Applications of Screenings**

After the coarse aggregate has been rolled, screenings to completely fill the interstices shall be applied gradually over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done while the screenings are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregate. The screenings shall not be dumped in piles but be spread uniformly in successive thin layers either by the spreading motion of hand shovels or by mechanical spreaders, or directly from trucks. Trucks operating for spreading the screenings shall be so driven as not to disturb the coarse aggregate.

The screenings shall be applied at a slow and uniform rate (in three or more application) so as to ensure filling of all voids. This shall be accompanied by dry rolling and brooming with mechanical brooms, hand brooms or both. In no case shall the screenings be applied so fast and thick as to form cakes or ridges on the surface in such a manner as would prevent filling of voids or prevent the direct bearing of the roller on the coarse aggregate. These operations shall continue until no more screenings can be forced into the voids of the coarse aggregate.

The spreading, rolling and brooming of screenings shall be carried out in only such lengths of the road which would be completed within one day's operation.

- **Sprinkling and Grouting**

After the screenings have been applied, the surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the wet screenings into voids and to distribute them evenly. The sprinkling, sweeping and rolling operations shall be continued, with additional screening as necessary, until the coarse aggregate has been thoroughly keyed, well-bonded and firmly set in its full depth and a grout has been formed of screening. Care shall be taken to see that the base or sub-grade does not get damaged due to the addition of excessive quantities of water during construction.

- **Application of Binding Material**

After the application of screenings, the binding material where it is required to be used shall be applied successively in two or more thin layers at a slow and uniform rate. After each application, the surface shall be copiously sprinkled with water, the resulting slurry swept in with hand brooms, or mechanical brooms to fill the voids properly, and rolled during which water shall be applied to the wheels of the rollers if necessary to wash down the binding material sticking to them. These operations shall continue until the resulting slurry after filling of voids, forms a wave ahead of the wheels of the moving roller.

- **Setting and Drying**

After the final compaction of water bound macadam course, the road shall be allowed to dry overnight. Next morning hungry spots shall be filled with screenings or binding materials as directed, lightly sprinkled with water if necessary and rolled. No traffic shall be allowed on the road until the macadam has set. The Owner/Owner's representative shall have the discretion to stop hauling traffic from using the completed water bound macadam course if in his opinion it would cause excessive damage to the surface.

- **Second Layer of WBM (where specified)**

Before laying the second layer of WBM, the surface shall be scarified and reshaped to the required camber and profiles and all ruts, depressions, pot holes etc. made good. The second layer shall be laid after the surface preparation is approved by the Owner/Owner's representative.

The specification for second layer of WBM shall be similar to the first.

**Pipe Culverts**

**Materials**

The drainage pipes unless otherwise shown on drawings or instructed by the Owner/Owner's representative, shall be made of RCC (Hume pipe) and shall be either Class NP2 or NP3.

Pipe culverts shall be made of reinforced concrete pipe (Hume Pipe) and shall be of class NP2 or NP3 as decided by the Owner/Owner's representative or shown in the drawing. All pipes shall meet the requirements of IS:458 and shall be procured from approved manufacturers with collars as per manufacturers standard specifications. The Bidder shall specifically mention the particular manufacturer's product he proposes to use.

Cement to be used shall be either Portland slag cement with minimum 50 % slag or Portland pozzolana cement.

Aggregate shall be as per IS: 383 - Maximum size shall not exceed one third the thickness of the pipe or 20 mm whichever is smaller. For bedding concrete for laying the pipes, the maximum size of aggregate shall be 38 mm.

Fine aggregate for concrete shall be as per IS: 383.

**Laying of Pipes**

Laying of Hume pipes and collars shall be done as per IS:783. Pipes shall be laid either in trenches or on supports as per drawing and/or Owner/Owner's representative's instructions. All pipe sections and collars shall be inspected carefully for defects before laying in the trenches. Broken or defective pipe shall not be used and shall be properly marked and removed from site as soon as the defects are detected. Pipes shall be laid true to line and grade as specified in the drawings and/or Owner/Owner's representative's instruction. The bedding of the pipes shall be 'First class bedding' or ordinary bedding as per IS:783. The profile of cutting of trenches, free working space provided on each side of the pipe, etc. shall be decided at site by the Owner/Owner's representative as per site condition. Side slope, shoring, bailing out water etc. as required shall be done by the Contractor. Side slips, if there be any, shall be removed by the Contractor. After laying of the pipes are completed, backfilling of the trenches shall be done in layers of 150 mm, clods and lumps broken, watered and compacted with iron rammers to the satisfaction of the Owner/Owner's representative. The surplus spoils shall be transported and filled in low areas within the plant area, as instructed by the Owner/Owner's representative. The filling shall be done as per specification.

All pipes and fittings shall be gradually lowered into the trench or placed on the supports by approved means taking due care not to damage them.

Under no circumstances the pipes shall be dropped into the trench or on supports from a height. The joints of pipes shall be grouted with 1:2 cement - sand mortar and the procedure of jointing shall be as per IS:783.

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Pipes laid in trenches in earth shall be bedded evenly and firmly and as far up the haunches of the pipes as consistent with the load expected to be transmitted from the backfill through the pipe to the bed. This shall be done either by excavating the bottom of the trench to fit the curve of the pipe or by compacting the earth under and around the curve of the pipe to form an even bed.

Where the pipe is laid in trench in rock, hard clay, shale or other hard materials, the space below the pipe shall be excavated and replaced with an equalising bed of concrete (1:4:8 mix), sand or compacted earth as approved by the Owner/Owner's representative. In no place shall the pipe be laid directly on such hard material.

If end protection wall is shown in drawing, the wall shall be constructed with first class quality locally available bricks from approved source. All civil works connected with the protection work, like concrete, brick masonry, plastering etc. shall be done as per relevant Indian Standards and in accordance with approved construction drawings. All materials used shall also conform to Indian Standards.

### 5.5.20 Bitumen Roads

**Scope**

This specification covers the requirement in respect of materials, workmanship and quality for bitumen roads like bitumen macadam, premix carpet etc. Moreover, for specification for base course, sub-base course of roads, the technical specification 5.5.19 (Technical Specification for road works construction roads) shall be referred.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by Indian Road Congress and Bureau of Indian Standards shall govern in respect of design, workmanship, quality and properties of materials and methods of testing.

Some of relevant available codes are listed here under.

| | |
|---|---|
| IRC - 47 | Standard specification and code of practice for bitumen road. |
| IRC - 48 | Standard specification for bitumen roads surface dressing using pre coated aggregates. |
| IRC - SP - 11 | Hand book of quality control for construction for roads and runaways. |
| IS:73 | Specification for paving bitumen. |
| IS:217 | Specification for cut back bitumen. |
| IS:454 | Specification for digboi type cut back bitumen. |
| IS:1200 | Method of measurement for road work (Part-17) including air field pavements. |

**Execution**

**Tack Coat**

- **Description**

The work shall consists of application of a single coat of low viscosity liquid bituminous material to an existing road surface preparatory to another bituminous construction.

- **Materials**

Binder: The binder used for tack coat shall be bitumen of a suitable grade as directed by the Owner/Owner's representative and conforming to IS:73, 217 or 454, as applicable, or any other approved cutback.

**Construction Operations**

- **Preparation of Base**

The surface on which the tack coat is to be applied shall be thoroughly swept and scraped clean of dust and any other extraneous material before the application of the binder.

- **Application of Binder**

Binder shall be heated to the temperature appropriate to the grade of bitumen used and approved by the Owner/Owner's representative and sprayed on the base at the rate specified below. The rate of spread in terms of straight-run bitumen shall be 5 kg. per 10 square metre area for an existing bitumen treated surface and 10 kg per 10 square metre area for an untreated water bound macadam surface. The binder shall be supplied uniformly with the aid of sprayers.

The tack coat shall be applied just ahead of the oncoming bituminous construction.

**Semigrout (Bituminous Macadam Binder Course)**

This work shall consist of construction, in a single course, 115 mm thickness of compacted crushed aggregates premixed with a bituminous binder, laid immediately after mixing, on a base prepared previously in accordance with the requirements of these specifications and in conformity with the lines, grades and cross sections shown on the drawings or directed by the Owner/Owner's representative.

**Materials**

- **Binder**

The binder shall be straight run bitumen of a suitable grade as directed by the Owner/Owner's representative complying with IS:73.

The aggregates shall satisfy the physical requirements set forth in Table-I.

**Table I**
**Physical Requirements of Aggregates for Bituminous Macadam**

| | | |
|---|---|---|
| Los Angeles Abrasion * | IS:2386 | 35% Maximum (Part IV) |
| Aggregate Impact Value * | IS:2386 | 30% Maximum (Part IV) |
| Flakiness Index | IS:2386 | 35% Maximum |
| Stripping Value | IS:6241 | 25% Maximum |
| Water Absorption | IS:2386 | 2% Maximum value |

* Aggregates may satisfy requirements of either of the two tests

The aggregates for bituminous macadam for different thickness shall conform to the grading A or B given in Tables II & III.

**Table II**

**Aggregates Grading for 115 Mm Compacted Thickness of Bituminous Macadam**

| Sieve | Percent by weight passing the sieve | |
|---|---|---|
| Designation | Grading A | Grading B |
| 63 mm | 100 | |
| 50 mm | 90-100 | |
| 40 mm | 35-65 | 100 |
| 25 mm | 20-40 | 70-100 |
| 20 mm | - | 50-80 |
| 12.5 mm | 5-20 | - |
| 4.75 mm | 10-30 | |
| 2.36 mm | - | 5-20 |
| 75 micron | 0-5 | 0-4 |

**Table III**

**Aggregates Grading for 50 Mm Compacted Thickness of Bituminous Macadam**

| Sieve | Percent by weight passing the sieve | |
|---|---|---|
| Designation | Grading A | Grading B |
| 50 mm | 100 | |
| 40 mm | 90-100 | |
| 25 mm | 50-80 | 100 |
| 20 mm | - | 70-100 |
| 12.5 mm | 10-30 | - |
| 10 mm | 35-60 | |
| 4.75 mm | - | 15-35 |
| 2.36 mm | - | 0-20 |
| 75 micron | 0-5 | 0-4 |

- **Proportioning of Materials**

The binder content for premixing shall be 3.5 and 4.0 percent by weight of the total mix for aggregate grading A and B respectively, except when otherwise directed by the Owner/Owner's representative.

The quantities of aggregates to be used shall be sufficient to yield the specified thickness after compaction.

- **Variation in Proportioning of Materials**

The Contractor shall have the responsibility for ensuring proper proportioning of materials and producing a uniform mix. A variation in binder content of ± 0.3 percent by weight of total mix shall, however, be permitted for individual specimens taken for quality control tests.

**Construction of Operation**

- **Weather and Seasonal Limitations**

Bituminous macadam shall not be laid during rainy weather or when the base course is damp or wet.

- **Preparation of Base**

The base on which bituminous macadam is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross sections as directed by the Owner/Owner's representative. The surface shall be thoroughly swept and scraped clean and free from dust and foreign matter.

- **Tack Coat**

A tack coat shall be applied over the base.

- **Preparation and Transport of Mix**.

Hot mix plant of adequate capacity shall be used for preparing the mix.

The temperature of binder at the time of mixing shall be in the range 150°C - 165°C and that of aggregates in the range 125°C 150°C provided that the difference in temperature between the binder and aggregate at no time exceed 25°C.

Mixing shall be thorough to ensure that the homogenous mixture is obtained in which all particles of the aggregates are coated uniformly.

The mixture shall be transported from the mixing plant to the point of use in suitable vehicles. The vehicles employed for transport shall be clean and be covered over in transit if so directed by the Owner/Owner's representative.

- **Spreading**

The mix shall be spread immediately after mixing by means of a self propelled mechanical paver with suitable screeds capable of spreading, tampling and finishing the mix to the specified lines, grade and cross sections. However, in restricted locations and in narrow widths, where the available plants cannot operate in the opinion of the Owner/Owner's representative, he may permit manual laying of the mix.

The temperature of mix at the time of laying shall be in the range 110 Deg - 135 Deg C.

In multilayer construction, the longitudinal joint in one layer shall offset that in the layer below by about 150 mm. However, the joint in the topmost layer shall be at the centre line of the pavement.

Longitudinal joints and edges shall be constructed true to the delineating lines parallel to the centreline of the road. All joints shall be cut vertical to the full thickness of the previously laid mix and the surface painted with hot bitumen before placing fresh material.

- **Rolling**

After the spreading of mix, rolling shall be done by 8 to 10 tonne power rollers or other approved plant. Rolling should start as soon as possible after the material has been spread. Rolling shall be done with care to keep from unduly roughening the pavement surface.

Rolling of the longitudinal joint shall be done immediately behind the paving operations. After this, the rolling shall commence at the edges and progress towards the centre longitudinally except that on super-elevated portions, it shall progress from the lower to the upper edge parallel to the centre line of the pavement.

The initial or breakdown rolling shall be done as soon as it is possible to roll the mixture without cracking the surface or having the mix pick up on the roller wheels. The second or intermediate rolling shall follow the breakdown rolling as closely as possible and be done while the paving mix is still at a temperature that will result in maximum density. The final rolling shall be done while the material is still workable enough for removal of roller marks.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding fresh material. The rolling shall then be continued till the entire surface has been rolled to compaction, there is no crushing of aggregate and all roller marks have been eliminated. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. The roller wheels shall be kept damp if necessary to avoid the bituminous material from sticking to the wheels and being picked up. In no case shall fuel lubricating oil be used for this purpose.

Rolling operations shall be completed in every respect before the temperature of the mix falls below 80 deg C.

Rollers shall not stand on newly laid material while there is a risk that it will be deformed thereby. The edges along and transverse of the bituminous macadam laid and compacted earlier shall be cut to their full depth so as to expose fresh surface which shall be painted with a thin surface coat of appropriate binder before the new mix is placed against it. Wherever use of power roller is not feasible, suitable hand roller may be used as per the instructions of the Owner/Owner's representative.

The bituminous macadam shall be provided with final surfacing without any delay. If there is to be any delay, the course shall be covered by a seal coat before allowing any traffic over it.

**Open Graded Premix Carpet**

- **Description**

This work shall consist of laying and compacting an open-graded carpet of 5 cm thickness in a single course composed of suitable small sized aggregates premixed with a bituminous binder on a previously prepared base, to form a wearing course, in accordance with the requirements of these specifications.

- **Materials**

- **Binder**

The binder shall be bitumen of a suitable grade, as directed by the Owner/Owner's representative and satisfying the requirements of IS: 73, 217, 454 or other approved cutback as applicable.

- **Aggregate**

The aggregate shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They shall be obtained by crushing rock and be free of elongated and flaky pieces, soft and disintegrated materials and vegetable or other deleterious matter. They shall preferably be hydrophobic type.

The aggregates shall satisfy the quality requirements set forth in Table I except that the Flakiness Index shall be limited to a maximum of 30%.

- **Proportioning of Materials**

The materials shall be proportioned as per quantities given in Table IV.

**Table IV**

Quantities of Materials Required for 10 sq.m.
of Road Surface for 5 cm Thick open-graded

Premix Carpet

Aggregates of carpet

| | | |
|---|---|---|
| a) | Stone chippings - 12 mm size; passing 20 cm sieve and retained on 10 mm sieve | 0.18 cu.m |
| b) | Stone chippings - 10 mm size; passing 12.5 mm sieve and retained on 6.3 mm sieve | 0.09 cu.m |

Binder for premixing (quantities in terms of straight run bitumen)

| | | |
|---|---|---|
| a) | For 0.18 cu.m of 12 mm size stone chippings at 52 kg per cu.m | 9.5 kg |
| b) | For 0.09 cu.m of 10 mm size stone chippings at 56 kg per cu.m | 5.1 kg |
| | Total | 14.6 kg |

**Construction Operation**

- **Weather and Seasonal Limitations**

Open graded premix carpet shall not be laid during rainy weather or when the base course is damp wet or when the atmospheric temperature in shade is 16 deg C or below.

- **Preparation of Base**

The underlying base on which the bituminous carpet is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross section in accordance with Table V as directed by the Owner/Owner's representative. The surface shall be well cleaned by removing caked earth and other foreign matter with wire brushes, sweeping with brooms and finally dusting with sacks as necessary.

- **Tack Coat**

A tack coat complying with relevant clause above shall be applied over the base preparatory to laying of the carpet. Application of tack coat shall, however, not be necessary when the laying of carpet follows soon after the provision of the bituminous course.

- **Preparation of Premix**

Mixers of approved type shall be employed for mixing the aggregates with the bituminous binder.

The binder shall be heated to the temperature appropriate to the grade of bitumen approved by the Owner/Owner's representative, in boilers of suitable design avoiding local overheating and ensuring a continuous supply.

The aggregates shall be dry and suitably heated to a temperature as directed by the Owner/Owner's representative before these are placed in the mixer. After about 15 seconds of dry mixing, the heated binder shall be distributed over the aggregates at the rate specified.

The mixture of binder with chipping shall be continued until the chippings are thoroughly coated with the binder. The mix shall be immediately transported from the mixer to the point of use in suitable vehicles or wheel barrows. The vehicles employed for transport shall be clean and be covered over in transit if so directed.

- **Spreading and Rolling**

The premixed material shall be spread on the road surface with rakes to the required thickness and camber or distributed evenly with the help of a drag spreader, without any undue loss of time. The camber shall be checked by means of camber boards and inequalities evened out. As soon as sufficient length of bituminous material has been laid rolling shall commence with 8 to 10 tonne power rollers, preferably of smooth wheel tandem type, or other approved plant. Rolling shall begin at the edges and progress toward the centre longitudinally, except that on the super elevated portions it shall progress from the lower to upper edge parallel to the centre line of the pavement.

When the roller has passed over the whole are once, any high spots or depressions which become apparent shall be corrected by removing or adding premixed materials. Rolling shall then be continued until the entire surface has been rolled to compaction and all the roll remarks eliminated. In each pass of the roller preceding track shall be overlapped uniformly by at least 1/3 width. The roller wheels shall be kept damp to prevent the premix from adhering to the wheels and being picked up. In no case shall fuel/lubricating oil be used for this purpose. Wherever use of power roller is not feasible, suitable hand roller may be used as per the instructions of the Owner/Owner's representative.

Rollers shall not stand on newly laid material while there is a risk that it will be deformed thereby.

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The edges along and transverse of the carpet laid and compacted earlier shall be cut to their full length so as to expose fresh surface which shall be painted with a thin surface coat of appropriate binder before the new mix is placed against it.

- **Seal Coat**

A seal coat conforming to relevant clause shall be applied to the surface immediately after laying the carpet. No traffic shall be allowed on the road till the seal coat has been placed.

**Seal Coat**

- **Description**

This work shall consist of application of a seal coat (Type-B) for sealing the voids in a bituminous surface laid to the specified levels, grade and camber.

Seal coat shall are of two types as given below:

Type A Liquid seal coat comprising of an application of the bituminous binder followed by a cover of stone chippings.

Type B Premixed seal cost comprising of a thin application of fine aggregate premixed with bituminous binder.

**Materials**

- **Binder**

The binder shall be bitumen of a suitable grade as directed by the Owner/Owner's representative and conforming to the requirements of IS: 73, 217, and 454 as applicable or any other approved cutback.

The quality of binder to be utilized, in terms of straight run bitumen shall be 9.8 kg and 6.8 kg per 10 square metre area for Type A and Type B seal coat respectively.

- **Stone Chippings for Type A Seal Coat**

The stone chippings shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They shall be free of elongated or flaky pieces, soft or disintegrated stone, vegetable or other deleterious matter. Stone chippings shall be of 6 mm size defined as 100 percent passing through 10 mm sieve and retained on 2.36 mm sieve. The quantity used for spreading shall be of 0.09 cu.m. per 10 sq.m. area. The chippings shall satisfy the quality requirements spelled out in Table I except that the upper limit for flakiness Index shall be 30%.

- **Fine Aggregate for Type B Seal Coat**

The fine aggregate shall be sand or fine grit and shall consist of clean, hard, durable, uncoated dry particles and shall be free from dust, soft or flaky material, organic matter or other deleterious substances. The aggregate shall pass 1.7 mm sieve and be retained on 180 micron sieve. The quantity used for premixing shall be 0.06 cu.m. per 10 sq.m. area.

**Construction Operations**

- **Preparation of Base**

The seal cost shall be applied immediately after the laying of bituminous course which is required to be sealed. Before application of seal coat materials the surface shall be cleaned free of any dust or other extraneous matter.

- **Construction of Type A Seal Coat**

The binder shall be heated in boilers of suitable design, to the temperature appropriate to the grade of bitumen approved by the Owner/Owner's representative and sprayed on the dry surface in a uniform manner preferably with the help of mechanical sprayers. Excessive deposits of binder caused by stopping or starting of the sprayer or through leakage of any other reason shall be suitably corrected before the stone chippings are spread.

Immediately after the application of binder, stone chippings in a dry and clean state, shall be spread uniformly on the surface, preferably by means of a mechanical gritter, otherwise manually so as to cover the surface completely. If necessary, the surface shall be broomed to ensure uniform spread of chippings.

Immediately after the application of the cover material, the entire surface shall be rolled with a 8 - 10 tonne smooth wheeled roller. Rolling shall commence at the edges and progress towards the centre except in super elevated portions where it shall proceed from the inner edges to the outer. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. While rolling is in progress additional chippings shall be spread by hand in whatever quantities required to make up irregula-rities. Rolling shall continue until all aggregate particles are firmly bedded in the binder and present a uniform closed surface.

- **Construction of Type B Seal Coat**

Mixers of approved type shall be employed for mixing the aggregates with the bituminous binder.

The binder shall be heated in boilers of suitable design, to the temperature appropriate to the grade of bitumen approved by the Owner/Owner's representative. Also the aggregates shall be dry and suitably heated to a temperature directed by the Owner/Owner's representative before the same are placed in the mixer. Mixing of binder with aggregates to the specified proportions shall be continued till the later are thoroughly coated with the former.

The mix shall be immediately transported from the mixing plant to the point of use and spread uniformly on the bituminous surface to be sealed.

As soon as sufficient length has been covered with the premixed material, the surface shall be rolled with 8 - 10 tonne smooth wheeled power rollers. Rolling shall be continued till the premixed material completely seals the voids in the bituminous course and a smooth uniform surface is obtained. Wherever use of power roller is not feasible suitable hand roller may be used as per the instructions of the Owner/Owner's representative.

**Opening to Traffic**

In the case of Type B seal coat, traffic may be allowed soon after final rolling when the premixed material has cooled down to the surrounding temperature. However, as regards Type A seal coat traffic shall not be permitted until the following day.

**Repair of Existing Roads**

Pot holes or patches and ruts in existing bitumen road, concrete road and WBM road shall be repaired by removal of all loose material by cutting in rectangular patches and replacing with suitable materials. The repair shall be done as under:

Pot holes, patches and ruts shall be drained of water and out to regular shape with vertical sides, and then be filled either with

i) Coarse aggregate and screenings conforming to the specification for water bound macadam and compacted with rollers or other approved rammer

or

ii) premixed material conforming to the specification for open graded premix carpet and compacted with rollers or other approved means after painting the sides and bottom of the holes with a thin application of bitumen or a combination of both as directed by the Owner/Owner's representative.

Payment for (i) shall be done as per items for water bound macadam and for (ii) as per item for open graded premix carpet. Cutting removal of materials shall be paid under dismantling items.

In case, however it is found that there has been damage to the granular sub-base as well, the area of the damaged surface shall be repaired by removal of all loose materials, out to regular shape with vertical sides and relaid with graded material as per specification of granular sub-base and then surfaced with water bound macadam as per specification for the same.

Further any making up the level of existing soling shall also be done as per procedure given above for repair of granular sub-base and as directed by the Owner/Owner's representative. Measurements and payment will be based on the compacted volume only. The rate will be worked out based on quoted rates for soling of specified thickness.

**Quality Control & Tolerance**

The Contractor shall establish and maintain quality control for the various aspects of the work, method, materials and equipment used.

All works performed shall conform to the lines, grades, cross sections and dimensions shown on the drawings or as directed by the Owner/Owner's representative. Permitted tolerances for roadwork's are described hereinafter.

i) **Horizontal Alignment** :

Horizontal alignments shall be reckoned with respect to the centre line of the carriageway as shown on the drawings. The edges of the carriageway as constructed shall be correct within a tolerance of ± 25mm therefrom. The corresponding tolerance for edges of the roadway and lower layers of pavement shall be ± 40mm.

ii) **Longitudinal Profile** :

The levels of the sub grade and different pavement courses as constructed, shall not vary from those calculated with reference to the longitudinal and cross-profile of the road shown on the drawings or as directed by the Owner/Owner's representative beyond tolerances mentioned below :

| | |
|---|---|
| Sub-grade | ± 25mm |
| Sub-base | ± 20mm |
| Base course | ± 15mm |
| Wearing course | ± 10mm |

Tolerance in wearing course shall not be permitted in conjunction with the positive tolerance for base course if the thickness of the former is thereby reduced by more than 6mm.

iii) **Surface Regularity of Sub grade and Pavement courses** :

The surface regularity of completed sub-bases, base courses and wearing surfaces in the longitudinal and transverse directions shall be within the tolerances indicated in Table V.

The longitudinal profile shall be checked with a 3 metre long straight edge, at the middle of each traffic lane along a line parallel to the centre of the road. The transverse profile shall be checked with a set of three chamber boards at intervals of 10 metres.

**Table - V**
**Permitted Tolerances of Surface Regularity for Pavement Courses**

| Sl | Type of construction | Longitudinal Profile with 3 metre straight edge Cross Profile | | | | | |
|---|---|---|---|---|---|---|---|
| | | Maximum Permissible undulation mm | Maximum number of undulations permitted in any 300 metres length exceeding (mm) | | | | Maximum permissible variation from specified profile under camber template (mm) |
| | | | 18 | 12 | 10 | 6 | |
| 1 | Earthen sub grade | 25 | 30 | - | - | - | 15 |
| 2 | Granular sub base | 15 | - | 30 | - | - | 12 |
| 3 | Water bound macadam with oversize metal (40-90 mm size) | 15 | - | 30 | - | - | 12 |
| 4 | Water bound macadam with normal size metal (20-50mm and 40-63 mm size), Bituminous penetration Macadam | 12 | - | - | 30 | - | 8 |
| 5 | Surface dressing ** (two coat over WBM (20-50 mm or 40-63 mm size metal), bituminous penetration macadam or built-up spray grout | 12 | - | - | 30 | - | 8 |
| 6 | Open graded premix carpet, mix seal surfacing | 10 | - | - | - | 30 | 6 |
| 7 | Bituminous macadam | 10 | - | - | - | 20*** | 6 |
| 8 | Semi-dense carpet | 10 | - | - | - | 20*** | 6 |
| 9 | Asphaltic concrete | 8 | - | - | - | 10*** | 4 |
| 10 | Concrete pavements | 8 | - | - | - | 10*** | 4 |

Notes

1 ** For surface dressing in all other cases, the standards of surface evenness will be the same as those for the surface receiving the surface dressing.

2. *** These are for machine laid surfaces. If laid manually due to unavoidable reasons, tolerance upto 50% above these values in this column may be permitted at the discretion of the Owner/Owner's representative. However, this relaxation does not apply to the values of maximum undulation for longitudinal and cross profiles mentioned in columns 3 and 8 on the table.

3. Surface evenness requirements in respect of both the longitudinal and cross profile should be simultaneously satisfied.

### 5.5.21 Steel Chimney

**SCOPE**

This specification covers the specific requirements for construction of Steel Chimney. General construction requirements shall be as per other standard specification included in section 5.3.7 In case of conflict between this specification and other specification, the requests given in this specification shall provide.

**CODES AND STANDARDS**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest additions as published by Bureau of Indian Standards and all other such as may be directed published by them during currency of the contract, shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed here under :

| | |
|---|---|
| IS: 6533 | Code of Practice for Design and Construction of Steel Chimneys |
| IS: 800 | Code of practice for use of structural steel in general building construction |
| ICAO | International Civil Aviation Organisation (ICAO). |
| DGCA | Instructions of Director General of Civil Aviation, India. |
| BS: 4076 | Specifications for steel chimneys |
| CICIND | Model code for concrete chimneys |
| ASCE | Design and Construction of steel chimney liners prepared by Task Document committee on steel chimney liners. Fossil power committee (Power division published by ASCE-1975). |

**GENERAL**

Contractor shall provide and maintain at the site necessary number and type of machinery and equipment including survey instruments in good working condition for proper setting out and timely completion of the works covered under this specification. All arrangements for transporting the equipment to and from the site shall be done by the Contractor at his own expense.

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It shall be ensured by the Contractor that work shall proceed uninterrupted even in the event of power failures. As such, adequate number of diesel operated equipment (such as concrete mixers, vibrators, etc.) shall be provided by the Contractor, as an alternative arrangement, in case, electrically operated equipment are proposed to be brought to site.

All materials supplied by the Contractor shall be of the best quality and shall conform to this specification. Approval in writing shall be obtained from Owner/Owner's representative, before any alternative or equivalent material is proposed to be used by the Contractor.

Contractor shall furnish Manufacturer"s test certificate for the materials supplied by him. Where such certificates are not available, and where the Owner/Owner's representative so desires the specimen from the materials supplied to site shall be got tested at a recognized and approved testing laboratory at Contractor's cost.

**MATERIAL, CONSTRUCTION REQUIREMENTS & SPECIFICATIONS**

**Material**

**Structural Steel**

The structural steel to be used for steel chimney shall be as per IS-2062 Grade-A unless specified otherwise in tender drawings.

Welding electrodes shall be of a make approved by Owner/Owner's representative. All electrodes shall conform to IS-814 unless specified otherwise to suit the requirement of shell plate and welding procedure. Contractor shall conduct all tests at site, as directed by Owner/Owner's representative to get his approval for use on Job. Manufacturer's batch certificates shall be submitted at least 2 weeks prior to commencement of welding.

**Base Plate and Holding Down Bolts**

The material shall conform to the requirement ofiS-2062 Grade-A and IS-432 Grade-l unless specified otherwise in tender drawings.

**Concrete work in Foundation**

This shall conform to provisions of clause No. 5.3.5

**Receipt and Storing of Material**

All steel parts furnished by supplier shall be checked, sorted out, straightened, and arranged by grades and qualities in stores.

All sections shall be free from surface defects such as pitting, cracks, laminations, twists etc.
Use of defective materials shall not be permitted and all such defective material shall be removed from the site immediately.

Welding electrodes shall be stored separately by qualities and lots inside a dry and enclosed room, in compliance with IS-9595 and as per instructions given by the Owner/Owner's representative. Electrodes shall be kept perfectly dry to ensure satisfactory operation and weld metal soundness.

**Fabrication and Erection**

All fabrication and erection shall be done in accordance with IS-800, IS-9595 and based on the fabrication drawings adhering strictly to work points and work lines on the same.

FORMT9-P REV-A (MUM)

All connections shall be welded connections except for ladders and platforms unless specified otherwise. Welding shall be done as per IS-9595. Welding procedures shall be conducted and approved as per IS-7307. Approval of welders shall be as per IS-7310.

The vertical butt weld seam shall be staggered at about 120° between adjacent sections of chimney shell.

Any defective material used shall be replaced by the contractor at his own expense.

Any faulty fabrication pointed out at any stage of work shall be made good by the contractor at his own cost.

Radiography examination shall be carried out to a minimum aggregate weld length of 3 meters in a chimney. However, the weld length radiographed shall not be lower than 5% of total weld length of the chimney.

Atleast one spot of 300mm length shall be radiographed for each thickness produced.

If the random radiography of a weld in any joint reveals unacceptable defects, two further welds in the group represented by the weld shall be radiographed to the same extent. If these further welds show no unacceptable defects, the group of welds represented by the weld shall be accepted.However,the first defective weld shall be repaired. If one of the two further welds show unacceptable defects, each weld in the group shall be radiographed. Unacceptable welds shall be repaired and then radiographed.

Radiography shall be carried out using x-ray or Gama ray as decided by the Owner/Owner's representative.

**PAINTING**

All painting work shall be carried out with the best quality of materials and workmanship and in accordance with the best engineering practice and instructions of the Owner/Owner's representative. The compatibility of the paint system shall suit the environment envisaged in and around the plant and confirmed by the paint manufacturer.

**Surface preparation**

The surface to be painted shall be cleaned by chipping, scraping hammering and wire brushing. On completion of cleaning the detached rust, mill scale and other deleterious material shall be removed by clean rag and/or washed by water or steam and thoroughly dried with compressed air jet if required before application of paint.

**Internal surface painting**

**Unlined Chimney Shell**

One coat of suitable priming paint to the interior surface shall be provided.

If required suitable protective treatment shall be used to withstand the corrosive, abrasive and thermal effects of the flue gases.

**Lined Chimney Shell**

If required one coat of a suitable priming paint shall be used followed by two coats of a finish paint or paints applied in accordance with the instructions of the manufacturer.

FORMT9-P REV-A (MUM)

**External surface painting**

The outer surface shall be given two coats of epoxy zinc chromate primer followed by two coats of epoxy high build finish coating of approved quality and shade. Where aviation warning signals are required, top 20m of the outer face of the chimney shell shall be painted with two coats of above finish coat of more than one colour in horizontal alternate bands of minimum 5m width to give a perfect contrast. The bands at extremities shall be of darker colour.

**Structural Steel Members**

All structural steel works such as walkways, platforms, handrails, ladders etc. shall be given two coats of high build chlorinated rubber zinc phosphate primer followed by two coats of chlorinated rubber paint of approved quality.

**CHIMNEY FOUNDATION**

Concreting of the foundation (pile cap) shall be carried out in segments only after the steel reinforcement for the entire foundation has been placed and tied in position. Only vertical construction joints with joggles shall be permitted between any two segments. Horizontal construction joints shall not be permitted.

### 5.5.22 Fencing & Gate

**Scope**

This specification covers the requirements in respect of materials, workmanship and quality for chainlink/barbed wire fencing fixed on M.S. angle posts or RCC precast posts.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the Contract, shall govern in respect of design, workmanship, quality and properties of materials and methods of testing. Some of the relevant available codes are listed hereunder:

| | |
|---|---|
| IS:278 | Galvanised steel barbed wire for fencing |
| IS:1161 | Steel tubes for structural purposes |
| IS:2062 | Steel for general structural steel purposes |
| IS:2721 | Galvanised steel chainlink fencing |

**Materials & Installation**

Angle Iron Post

Angle Iron Post shall be rolled angle section conforming to IS:2062 and shall be double dip galvanised.

**Precast Concrete Posts**

Concrete mix shall be M20 as per IS:456. Reinforcement shall be M.S. and/or torsteel bars.

FORMT9-P REV-A (MUM)

Posts shall be cast in smooth steel forms made to correct dimensions as per drawing and concrete shall be compacted by table vibrators or needle vibrator to give smooth finish. Curing of concrete shall be done by submerging the posts in water tank for minimum 15 days.

Precast posts shall be installed in PCC 1:3:6 foundation, with a minimum embedment depth of at least 600 mm. Damage to the post shall be avoided during installation of the posts in position, aligning and levelling.

Diagonal post bolted to the vertical posts shall be provided at every eighth bay and on either side of the corner posts. Spacing of the posts shall be not greater than 3 m or as per drawing whichever is less.

All hardware used shall be of hot-dip galvanised steel.

**Chain link fence**

Chainlink shall conform to IS;2761. It shall be procured in rolls of appropriate length and width and shall consist of 10 G hot dip galvanised steel wires woven in the form of zigzag mesh giving an opening size of 50 mm square.
Chainlink shall be secured to the posts with 6 mm dia GI hooks/rings.

Tension wire shall be provided passing through the mesh at top, centre and bottom of the erected chainlink mesh and shall be of 3 mm dia hot dip galvanised wire and shall be stretched to keep the chainlink in taut position. 25 mm x 6 mm GI flat stretcher bar shall be provided at the end posts to tie the tension wires.

**Barbed wire fence**

Barbed wire shall conform to IS:278

Barbed wire shall be made from hot dipped galvanised wire of 12 G, 2 ply with barbs of 16G spaced at 100 mm.

Barbed wire shall be procured in bundles of standard weights and shall be fully stretched across the posts and secured with G.I. hook bolts and washers.

Spacing of horizontal wires shall not be greater than 225 mm or as specified in the drawing. Diagonal wires shall be provided in each bay between two adjacent posts. No wire shall be left loose or sagging.

**Gate**

Gate shall be fabricated out of tubular sections conforming to IS:1161 and shall be hot dipped galvanised. Outer frame shall be 65 NB (medium) tube and diagonal 50 NB (medium) tube. 50 mm sq. welded mesh with 4 mm dia GI wire fabric shall be welded to 25 mm x 6 mm thick GI flat which in turn shall be welded to the outer tubular frame. The gate shall be provided with 20 mm wide x 80 mm dia flat M.S. roller at the bottom. The gate frame shall be fixed to GI tubular post or RCC post.

### 5.5.23 Concrete Roads and Pavements

**Scope**

This specification covers the requirement in respect of materials, workmanship and quality for concrete roads and pavements. However, for general requirements, testing etc. the technical specification for plain & reinforced concrete work shall be referred.

**Codes and Standards**

Unless specifically mentioned otherwise, all applicable codes and standards in their latest edition as published by Indian Road Congress and Bureau of Indian Standards shall govern in respect of design, workmanship, quality and properties of materials and method of testing.

Some of the relevant available codes are listed here under :

| | |
|---|---|
| IS:269 | Ordinary and low heat Portland cement |
| IS:455 | Specification for Portland slag cement |
| IS:456 | Code of practice for plain & reinforced concrete |
| IS:1200 | Method of measurement for road work including air field (Part-17) pavements |
| IS:1489 | Specification for Portland pozzolana cement |
| IS:1838 | Specification for performed fillers for expansion joints in concrete pavement and structures. |
| IS:1834 | Specification for hot applied sealing compounds for joints in concrete |
| IS:6509 | Code of practice for installation of joints in concrete pavements |
| IS:8112 | Specification for 43 grade ordinary Portland cement |
| IRC:15 | Standard specification and code of practice for construction of concrete roads |
| IRC:58 | Guidelines for the design of rigid pavements for highways |

**Materials**

Cement to be used shall be either Portland slag cement with minimum 50 % slag or Portland pozzolana cement.

This should comply with the requirements of IS:269, IS:455, IS:1489 or IS:8112

**Aggregates (General)**

Aggregates should comply with the requirements of IS:389 - Specification for coarse and fine aggregates from natural sources for the concrete work. In order to make good the concrete for roadwork it is important to avoid crushed aggregates of poor particle shape. Weather rock, and very angular, flaky or splintery aggregates should not be used.

**Coarse aggregates**

This should be furnished in at least two separate sizes with separation at 20 mm when combined material graded from 5 to 38 mm is specified and at 25 mm when combined material graded from 20 to 50 mm is specified. Gap graded single sized coarse aggregate as alternate to the continuously graded may be used particularly where grading of fine aggregate is fine to very fine.

**Fine aggregate**

Fine aggregate shall be natural sand and should comply with IS:383. Bulking due to presence of moisture in the fine aggregate should be accounted for when the volumetric batching is employed.

**Water**

Water is used in mixing or curing of concrete shall be clean and potable quality.

**Reinforcement**

Bar mats

This shall conform to the requirements of IS:432/IS:1786/IS:1139. The bars shall be of the size and spacing shown on the plans. All junctions of longitudinal and transverse bars shall be securely tied or welded together.

**Load transfer devices**

Dowel and tie bars shall be of plain round steel bars conforming to the requirements of IS:432.

**Expansion joint filler**

The material for filling the expansion joints shall be of premoulded, non-extruding and resilient type of approved quality. The premoulded joint filler shall be of thickness shown on the drawings or as stated in the bill of qualities. It shall be 25 mm less in depth than the thickness of the slab and of the full width between road forms. Holes to accommodate dowel bars shall be bored or punched out accurately. The joint filler shall comply with the requirements of IS:1838 - Specification for Preformed Fillers for Expansion Joints in concrete, non-extruding and resilient type (bitumen impregnated fibre).

**Joint sealing compound**

The sealing compound shall comply with the requirements of IS:1834 - Specification for Hot Applied Sealing Compound for joints in concrete.

**Waterproofing under layer**

Waterproofing paper used as under layer be of a brand of approved quality. The paper shall be unrolled with an overlap of not less than 10 cm.

**Forms**

All side forms shall be of mild steel unless use of wooden sections are specifically permitted. The steel forms shall be of M.S. channel sections and their depth equal to the thickness of the pavements.

The sections shall have a length of at least 3 m except on curves where shorter sections may be used. Side shuttering shall be provided at curves as per the drawings or as directed. When set to grade and staked in place, the maximum deviation of the top surface of any section from a straight line shall not exceed 3 mm in vertical plane and 5 mm in horizontal plane. The method of connection between sections shall be such that the joint formed shall be free from movement in any direction. the use of bent, twisted or worn out forms will not be permitted. At least 3 stake pockets for bracing pins or stakes shall be provided for each 3m of form and the bracing and support must be ample to prevent the springing of the forms under pressure of the concrete, or the weight of machinery operating on the forms, Contractor shall arrange for sufficient number of forms so that the forms in position are not disturbed within 12 hours of concreting or longer if in the opinion of the Owner/Owner's representative it would be necessary.

**Workmanship**

**Form setting**

Forms shall be jointed neatly and shall be set with exactness to the required grade and alignment. After the forms are placed and aligned, the earth under the base of the form shall be thoroughly damped in an approved manner. Sufficient rigidity shall be obtained to support the forms in such a position during the entire operation of compaction and finishing. All forms shall be cleaned and oiled each time before they are used.

**Placing of reinforcements**

The overall dimensions of the bar mats shall be such that when properly placed into the work, the extreme longitudinal wires of the mat will be located not less than 50 mm nor more than 100 mm from the edges of the slab. Except for dummy joints, the length of the bar mat shall be such that when properly placed into the work, the reinforcement will be clear of transverse joints by not less than 50 mm and not more than 100 mm when measured from the centre of the joint to the ends of the longitudinal wire of the fabric.

While overlapping the bar mats in either direction, the overlap shall be at least equal to the spacing between the bars in the respective direction.

The bar mats shall be placed in position as shown on the drawings. For placing the top layer of the reinforcement, the first stage of concreting shall be brought up to the level of the reinforcement and lightly compacted by a screed vibrator to obtain uniform level. The reinforcement bar mats shall then be placed on the compacted layer of the concrete and then the remaining depth shall be filled in with concrete. The time lag between laying of the two courses shall not exceed the initial setting time of the cement used. Displacement of the reinforcement during concreting operation shall be prevented.

**Fixing dowel bars**

The dowel bars in expansion joints and transverse construction joints shall be placed and supported in such a manner that they will be truly parallel with the gradient and the centreline to the pavement, and they shall be remain in position during the placement and compaction of the concrete. They shall be placed at the mid depth of the slab and the drawings. Half length of the dowel bars shall be painted with one coat of hot bitumen of approved make or equivalent as shown on the drawings or as directed by the Owner/Owner's representative.

**Fixing tie bars**

Tie bars in longitudinal joints shall be placed approximately the mid depth of the slab and shall be securely held in the slabs on both sides of the joints.

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**Transporting and placing of concrete**

The concrete shall be mixed in quantities required for immediate use and shall be deposited in position to the required depth and width of the pavement, sections, in successive batches and in continuous operation without the use of intermediate forms or bulk continuous between joints. The spreading shall be as uniform as possible to avoid re-handling of concrete.

**Compaction and finishing**

The surface of the pavement shall be compacted either by means of power driven finishing or by a vibration screed. For areas where the width of the slab is very small, hand compaction and finishing may be adopted. Immediately after the tamping or screeding has been completed and before the concrete has hardened the surface shall be inspected for irregularities with a profile checking template and any needed corrections made by adding or removing of concrete followed by further compaction and finishing.

**Floating**

As soon as practicable after the concrete has been struck off and a compacted it shall be further smoothened and compacted by means of longitudinal float operation from a foot bridge.

**Straight edging**

After the longitudinal float has been completed and excess water has been disappeared but while the concrete is still plastic, the slab surface shall be tested for truness with a 3 metre straight edge swung from handles 1 metre longer than one half width of the slab. Any depressions found shall be filled immediately with freshly mixed concrete, struck, compacted and refinished. High areas shall be cut down and refinished. No extra payment shall be made for the removal of the rejected concrete and for laying of the fresh concrete. Unless otherwise specified, and for laying of the pavement surface shall be obtained by belting or brooming or by a combination of both as directed by the Owner/Owner's representative.

**Edging**

After belting and / or brooming has been completed, but before the concrete has taken its initial set, the edges of the slab shall be carefully finished with a edger of 6 mm radius and the pavement edge shall be left smooth and true to line.

**Joints**

**Expansion Joints**

Expansion joints shall be formed at the intervals shown on the drawing at right angles of the longitudinal axis of the pavement. The width of the joint shall be as shown on the drawing and shall be straight, truly vertical and shall extend from the bottom of the slab. The expansion joint shall be filled with an approved pre-moulded joint filler, which shall extend from the bottom of the slab to 25 mm below the finished surface of the concrete. A timber or metal cap shall be fitted temporarily on the top of the joint filler and the top of this cap shall be flush with the finished surface. Care shall be taken that filler and the cap are set accurately in position and are maintained in position during placing and compaction of concrete. After the pavement has been struck off and finished the metal cap shall be removed. Under no circumstances shall any concrete be left above the expansion joint material or across the joint at any point. After about 15 days of concreting the cavity on the top of the joint filler shall be carefully cleaned of all loose materials and sealed with an approved joint sealing compound. the sealing shall not be done until the concrete is quite dry. The sealer and any

primer required shall be applied strictly in accordance with manufacturer's instructions. The joints shall be sealed flush with the surface of the concrete. The end of the sliding half of the dowel bar shall be provided with a PVC or G.I. sheets cap at least 75 mm long and minimum 25 mm length of this cap shall be filled with cotton waste dipped in hot bitumen as shown on the drawings.

**Longitudinal and transverse construction joints**

These shall be of top champhered and sealed type and shall be formed by placing the concrete against the face of the slabs concrete earlier. The face of the old concrete slabs shall be painted with bitumen before placing of fresh concrete.

Tie bars shall be used at construction joints and shall be of the dimensions and at spacings as shown on the drawings.

**Curing**

Immediately after finishing operations have been completed the entire surface of the newly laid concrete shall be covered against rapid drying and cured in accordance with the following methods.

Failure to provide sufficient cover material of whatever kind required or inadequate supplies of water to take care of both curing as well as other requirements shall be adequate cause for immediate suspension of concreting.

**Initial curing**

Immediately after completion of finishing operations, the surface of the pavement shall be entirely covered with wetting burlap, cotton or jute mats. The mats used shall be of such length (or width) that as laid they will extend at least 450 mm beyond the edges of the slab. the mats shall be placed so that the entire surface and both the edges of the slab are completely covered. The covering shall be placed as soon as the concrete has set sufficiently to prevent marring of the surface. Prior to being placed, the mats shall be thoroughly saturated with water and shall be placed with the wettest side down. The mats shall be so placed and weighed down as to cause them to remain in intimate contact with the surface covered, and the covering shall be maintained fully wetted and in position for 24 hours after the concrete has been placed or until the concrete is sufficiently hard to be walked on without suffering damage. Water shall be gently sprayed so as to avoid damage to the fresh concrete. If it becomes necessary to remove a mat for any reason, the concrete slab shall not be exposed for a period of more than half an hour.

Worn burlap or burlap with holes will not be permitted. Burlap reclaimed from previous use other than curing concrete shall be thoroughly washed prior to use for curing purposes. If burlap is furnished in strips, the strip shall be laid overlap at least 150 mm. Burlap shall be placed from suitable bridges. Walking on freshly laid concrete to facilitate placing burlap is not permitted.

**Final curing**

Upon removal of the burlap the slab shall be thoroughly wetted and then finally cured as under :

"Exposed edges of the slab shall be banked with a substantial berm of earth. Upon the slab shall then be laid a system of transverse and longitudinal dykes of clay about 50 mm high immediately covered with a blanket or sandy soil free from stones to prevent the drying up and cracking of clay. The rest of the slab shall then be covered with sufficient sandy soil so as to produce a blanket of earth not less than 37 mm depth after wetting. The earth covered shall be thoroughly wetted while it is being placed on the surface and against the sides of the slab and kept thoroughly saturated with water for 14 days and thoroughly wetted down during the morning of the 15$^{th}$ day and shall thereafter remain in place until the concrete has attained the required strength and permission is given, the covering shall be removed and the pavement cleaned and swept. If the earth covering

becomes displaced during the curing period, it shall be replaced to the original depth and shall be re-saturated".

**Removing of Forms**

Forms shall not be removed from freshly placed concrete until it has set at least 12 hours. They shall be carefully removed and in such a manner that no damage will be done to the edges of the pavement. After the forms have been removed, the ends of all joints shall be cleaned and any honeycombed areas painted up with 1:2 mortar, after which the sides of the slabs shall be covered with earth to the level of the top of the slab. All ditches and drains shall be so placed as to provide effective drainage.

**Opening to Traffic**

Traffic shall be excluded from the newly constructed pavement for a period of 28 days. Before the pavement is opened to traffic it shall be cleaned and the joints shall be filled and trimmed or topped out as required. The joint or line of separation between adjacent strips or slabs of concrete, when the pavement is constructed in lanes or strips, shall be cleaned and filled with bituminous material as directed.

# VOLUME - IV

## SECTION – 6

## LIST OF TENDER DRAWINGS

## SECTION – 6

## LIST OF TENDER DRAWINGS

**Note : The following drawings are attached as part of this EPC tender specification in the end.**

**(A) GENERAL:**

| Sl. No. | Drawing No. | Rev | Title |
|---|---|---|---|
| 1. | 4427-00-16-47-0001 | F1 | Over All Plot Plan |
| 2. | 3114-00-16-50-0005 | 0 | Area Classification Plan (Overall) |
| 3. | 1-38101-00213 | 0 | Hazardous Area Classification Diagram |

**(B) MECHANICAL:**

| Sl. No. | Drawing No. | Rev | Title |
|---|---|---|---|
| 1. | 10-5111168-G-001 | C | Plot Plan |
| 2. | 00-5111168-G-002 | B | Key plan showing Terminal Points (In Existing Plant Area) |
| 3. | 10-5111168-M-002 | B | Symbols & Legends (Equipment & Piping) |
| 4. | 10-5111168-M-003 | B | Symbols &Legends (Control & Instruments) |
| 5. | 10-5111168-M-004 | B | P & I Diagram for Steam System |
| 6. | 10-5111168-M-005 (Sheet 1 of 2) | B | P & I Diagram for LP Feed Water System |
| 7. | 20-5111168-M-005 (Sheet 2 of 2) | B | P & I Diagram for HP Feed Water System |
| 8. | 10-5111168-M-006 | B | P & I Diagram for Condensate System |

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| Sl. No. | Drawing No. | Rev | Title |
|---|---|---|---|
| 9. | 10-5111168-M-007 (Sheet 1 of 4) | C | P & I Diagram for Natural Gas System (Fuel Gas Conditioning System) |
| 10. | 10-5111168-M-007 (Sheet 2 of 4) | B | P & I Diagram for Natural Gas System (Gas Dew Point Heater & PCV) |
| 11. | 10-5111168-M-007 (Sheet 3 of 4) | C | P & I Diagram for Natural Gas System (Gas supply to GT – 4) |
| 12. | 20-5111168-M-007 (Sheet 4 of 4) | B | P & I Diagram for Natural Gas System (HRSG-4 PCV Skid) |
| 13. | 10-5111168-M-010 | B | P & I Diagram – Cooling Water System |
| 14. | 10-5111168-M-011 (Sheet 1 of 2) | B | P & I Diagram – HRSG (HP Section) |
| 15. | 10-5111168-M-011 (Sheet 2 of 2) | B | P & I Diagram – HRSG (LP Section) |
| 16. | 10-5111168-M-012 (Sheet 1 of 3) | B | P & I Diagram for Compressed Air System |
| 17. | 30-5111168-M-012 (Sheet 2 of 3) | B | P & I Diagram for Instrument Air Distribution System |
| 18. | 30-5111168-M-012 (Sheet 3 of 3) | B | P & I Diagram for Service Air Distribution System |
| 19. | 10-5111168-M-015 | C | P&I Diagram for DM Water Distribution System & CW Make up System |
| 20. | 20-5111168-M-017 | B | P&I Diagram for Potable water distribution system |
| 21. | 10-5111168-M-116 | C | Fire hydrant Layout |
| 22. | 30-5111168-M-018 | B | P&I Diagram for Service water distribution system |
| 23. | 20-5111168-M-020 | B | Flow Scheme for Fire Protection System |
| 24. | 20-5111168-M-022 | C | P&I Diagram for HP/MP/LP Process Steam System |

| Sl. No. | Drawing No. | Rev | Title |
|---|---|---|---|
| 25. | 20-5111168-M-023 | B | Hook-up Points |
| 26. | 5111168-M-SK-001 (Sheet no.1 of 2) | B | Flow Scheme for Water Treatment Plant |
| 27. | 5111168-M-SK-001 (Sheet no.2 of 2) | B | Flow Scheme for Effluent Discharge |
| 28. | 30-5111168-M-SK-002 | B | Schematic Layout of AC System |
| 29. | 30-5111168-M-SK-003 | B | Schematic Layout of Ventilation System |
| 30. | 20-5111168-M-SK-004 | B | Typical Details of Fire Fighting Equipment and Support |

**(C) ELECTRICAL:**

| Sl. No. | Drawing No. | Rev | Title |
|---|---|---|---|
| 1. | 10-5111168-E-201 (Sheet 1 of 2) | C | Key Single Line Diagram |
| 2. | 10-5111168-E-201 (Sheet 2 of 2) | C | Key Single Line Diagram |
| 3. | 20-5111168-E-202 (Sheet 1 of 2) | B | Typical Metering & Protection Scheme of GTG / STG |
| 4. | 20-5111168-E-202 (Sheet 2 of 2) | B | Typical Metering & Protection Scheme of GTG / STG |
| 5. | 00-5111168-E-203 | B | 66 kV System Single Line Diagram |
| 6. | 10-5111168-E-204 | B | SCADA Architecture Diagram |
| 7. | 10-5111168-E-401 | B | Equipment Layout for Switchgear Room |
| 8. | 10-5111168-E-402 | B | Equipment Layout for 66 kV GIS Building Area |

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**(D) CIVIL:**

| Sl. No. | Drawing No. | Rev | Title |
|---|---|---|---|
| 1. | 10-5111168-C-002 | B | Site Grading Plan |

**(E) CONTROL & INSTRUMENTATION:**

| Sl. No. | Drawing No. | Rev | Title |
|---|---|---|---|
| 1. | 20-5111168-I-351 | B | DCS Configuration Diagram |
| 2. | 10-5111168-I-354 | B | Equipment Layout for Control Room at EL(+) 9.000M |

# VOLUME - IV

# SECTION - 7.0

# SCHEDULES TO BE FILLED IN BY THE BIDDERS

## SECTION - 7.0
## SCHEDULES TO BE FILLED IN BY THE BIDDERS

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## SCHEDULE - 1
## TECHNICAL DATA SHEET [TO BE FILLED BY THE BIDDER]

### 1.0.0 TECHNICAL DATA SHEET – MECHANICAL

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| **1.0.0** | **Heat Mass Balance Diagrams** | | |
| a) | HMBD shall indicate mass flow rate, temperature, pressure and enthalpy of condensate, FW, Steam, CW, Fuel, Air and Flue gas sides. Pinch, approach, terminal temperature difference across heaters shall also be indicated. | Doc. Reference Numbers | |
| b) | **Load Cases :**<br>1. 100% combined cycle load with 0% make-up to steam turbine cycle at site reference conditions<br>2. 100% combined cycle load with 3% make-up to steam turbine cycle at site reference conditions<br>3. 100% combined cycle load with 0% make-up to steam turbine cycle at 15°C, 70% RH<br>4. 100% combined cycle load with 3% make-up to steam turbine cycle at 15°C, 70% RH<br>5. Minimum possible gas turbine load plus 40 TPH, HP process steam<br><br>Following HMBD's to be submitted during Detailed Engineering<br>1. 100% combined cycle load with 0% make-up to steam turbine cycle at 43°C<br>2. 100% combined cycle load with 3% make-up to steam turbine cycle at 43°C<br>3. Part load conditions at 80%, 60% with 0% and 3% make-up to steam turbine cycle at site reference conditions, 15°C, 70% RH and 43°C . | | |
| c) | Specific Site Reference Conditions – Refer Vol. II / Section 1 General technical specification under CL. 9.6.3.<br>Site ambient conditions – Refer Vol. II / Section 1 General technical specification under CL. 5.0.0 | | |

| | | | |
|---|---|---|---|
| | | | |
| **1.1.1** | **Plant Data** | | |
| a) | Configuration | | |
| b) | No of shaft | | |
| c) | Plant Design Life | Years | |
| d) | Cyclic Loading | | |
| e) | No. of Hot start | | |
| f) | No. of Warm start | | |
| g) | No. of cold start | | |
| h) | Rated frequency | Hz | |
| i) | Rated switchyard Voltage | kV | |

### 1.1.0 GAS TURBINE GENERATOR & AUXILIARIES

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| **1.0.0** | **General** | | |
| a) | Manufacturer | | |
| b) | Model number | | |
| c) | No. of GTG | | One (1) |
| d) | Arrangement | | |
| e) | Operating frequency range | Hz | |
| **2.0.0** | **Design Parameters at ISO Conditions – Natural Gas Fuel** | | |
| a) | Output at generator terminal | MW | |
| b) | Total Auxiliary power consumption for GTG & auxiliaries | MW | |
| c) | Net calorific value of fuel | kcal/Scm$^3$ | |
| d) | Fuel (NG) consumption for fuel net calorific value | Sm$^3$/hr. | |
| e) | Heat rate for net calorific value | kcal/kWh | |
| f) | NOx level in exhaust gas | ppm dry Volume basis | |
| g) | Compressor mass flow | kg/s | |
| h) | Compressor outlet temp | °C | |
| i) | Pressure ratio | | |
| j) | Air fuel ratio | | |
| k) | Turbine inlet temperature | °C | |
| l) | Turbine exhaust flue gas temp. | °C | |
| m) | Flue gas exhaust mass flow | kg/s | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| n) | Time from startup to 100% base load (stage wise curves to be furnished ) | | |
| | i) Cold Start | min. | |
| | ii) Warm start | min. | |
| | iii) Hot start | min. | |
| **3.0.0** | **Operational Data** | | |
| **4.0.0** | **Layout Data** | | |
| a) | Total size of gas turbine generator unit (l x w x h) | mmxmmxmm | |
| b) | Weight of Gas turbine generator complete unit | Ton | |
| c) | Capacity of overhead crane | Ton | |
| **5.0.0** | **Gas turbine Air compressor** | | |
| 5.1.0 | **Design data at ISO condition (15 deg C, 70% RH)** | | |
| a) | Type of compressor | | |
| b) | No. of compressor stages | nos. | |
| c) | Rated quantity of air flow rate | tph | |
| d) | Normal rated power input to compressor | kW | |
| e) | Rated Efficiency | % | |
| f) | Compressor speed | rpm | |
| g) | Outlet air pressure and temperature | bar/°C | |
| h) | No. and type of bearings | nos. | |
| i) | Number of Boroscope inspection port | nos. | |
| 5.2.0 | **Materials of construction (full specification as per ASTM / BS / DIN)** | | |
| a) | Casing | | |
| b) | Shaft | | |
| c) | Rotor discs | | |
| d) | Rotating blades | | |
| e) | Stationary blades | | |
| f) | Rotating blades shroud / lacing wire | | |
| g) | Bearing & Liners | | |
| h) | Casing bolts & nuts | | |
| 5.3.0 | **Compressor washing / cleaning Method** | | |
| a) | Quantity of washing agent required per washing | $m^3$ | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| b) | Capacity of storage tank | $m^3$ | |
| c) | Recommended frequency of compressor washing | Fired hours | |
| d) | Recommended level of fall in electrical output for washing | kW | |
| **6.0.0** | **Combustion System** | | |
| a) | Type | | |
| b) | No. of combustion chambers | nos. | |
| c) | No. of burners per combustion chamber | nos. | |
| d) | No. of igniters per combustion chamber | nos. | |
| e) | Type of burner | | |
| f) | Fuel pressure at burner | Bar | |
| g) | Design heat loading per combustion chamber | kcal/h | |
| h) | Maximum fuel burning capacity per combustor | kcal/h | |
| i) | Minimum Stable load for continuous Operation | % | |
| j) | Materials of construction | | |
| | i) Combustion chamber | | |
| | ii) Combustion wrapper | | |
| | iii) Flame tubes | | |
| | iv) Fuel piping | | |
| k) | Type of flame detectors | | |
| l) | No. of flame detectors | nos. | |
| m) | Frequency of nozzle cleaning | hrs. | |
| n) | Expected life of combustor liner in EOH (Equivalent Operating Hours) | hrs. | |
| **7.0.0** | **Gas Turbine** | | |
| a) | No. of shafts | | |
| b) | No. of stages | | |
| c) | Shaft Speed | | |
| d) | Operating frequency range | | |
| e) | Type of casing | | |
| f) | Type of rotor construction | | |
| g) | No. and type of air seals used | | |
| h) | No. of air ports | | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| i) | Number of bearing and type | | |
| j) | Design data at ISO condition (15 deg C, 70% RH) | | |
| | i) Gross power developed at shaft | MW | |
| | ii) Number of stages | nos. | |
| | iii) Turbine efficiency | % | |
| k) | **Materials of construction (full specification as per ASTM / DIN / BS)** | | |
| | i) Turbine casing | | |
| | ii) Turbine stationary blading (for various sages) | | |
| | iii) Turbine rotor blades (for various stages) | | |
| | iv) Nozzles | | |
| | v) Turbine rotor disc | | |
| | vi) Turbine casing bolts & nuts | | |
| | vii) Turbine blades protective coating (for various stages) | | |
| | viii) Shaft seal material | | |
| l) | **Absolute Bearing Pedestal vibration:** | - | |
| | i) Location of Maximum vibration level | - | |
| | ii) Velocity | mm/s | |
| | iii) Amplitude | microns | |
| m) | **Absolute shaft vibration:** | - | |
| | i) Location of Maximum vibration level | - | |
| | ii) Velocity | mm/s | |
| | iii) Amplitude | microns | |
| n) | Number of vibration detectors and type | nos. | |
| o) | Maximum permissible shaft eccentricity | mm | |
| p) | Over speed ( trip) | rpm | |
| q) | Turning Gear Speed | rpm | |
| r) | Number of speed sensor for over speed trip and speed control | rpm | |
| s) | Expected life of turbine blades and nozzles | hrs. | |
| t) | Expected life of bearings | hrs. | |
| u) | No. of intrascope points / viewing points and their position | | |
| v) | Number of measuring ports for exhaust gas temperature. | nos. | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| w) | **Turbine Blade water washing:** | | |
| | i) Method | | |
| | ii) Cleaning medium | | |
| | iii) Frequency of water washing recommended | hrs. | |
| | iv) Auxiliary Power Consumption | kW | |
| x) | **Expected Life in EOH** | | |
| | i) Blades and nozzles | hrs. | |
| | ii) Blade Coating | hrs. | |
| | iii) Bearings | | |
| y) | Exhaust Gas composition (Argon, Nitrogen, Oxygen, Carbon di-oxide, Water, Sulphur di-oxide) | % | |
| **8.0.0** | **Intake air filter** | | |
| a) | Manufacturer | | |
| b) | Type | | |
| c) | Design air flow | tph | |
| d) | Type of filter | | |
| e) | No. of filter elements | nos. | |
| f) | Air flow per filter element | kg/s | |
| g) | Air velocity - design | m/s | |
| h) | Particle size at filter outlet | microns | |
| i) | Media material | | |
| j) | Expected life of filter material | hrs. | |
| k) | Method of cleaning the filters | | |
| l) | Temperature/ pressure of purging air | °C/bar | |
| m) | Flow of purge air | kg/s | |
| n) | Filtration efficiency | % | |
| **9.0.0** | **Intake air silencer** | | |
| a) | Location | | |
| b) | Type | | |
| c) | No. of silencers | nos. | |
| d) | Sound absorbent | | |
| e) | Baffle material | | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| f) | Noise level at 1m from the outline of the air filter housing | dB(A) | |
| **10.0.0** | **Inlet air ducting** | | |
| a) | Material of construction | | |
| b) | Size | mmxmmxmm | |
| c) | Flow velocity in duct | m/s | |
| d) | Thickness of duct | mm | |
| e) | Particulars of inside protection with suitable coatings. Whether ducting are suitably designed to prevent undue vibration? | | |
| f) | Expansion joints | | |
| | i) Type | | |
| | ii) Number | nos. | |
| | iii) Material of construction | | |
| g) | Necessary galvanised supports provided | | |
| h) | Turning vanes at all bends provided | | |
| i) | Manholes / access doors for inspection provided | | |
| **11.0.0** | **GT Exhaust Diffuser** | | |
| a) | Size | | |
| b) | Duct / Insulation Thickness | | |
| c) | Insulation Type | | |
| d) | Diffuser Base Material | | |
| e) | Insulation Material | | |
| f) | Type of Expansion Joint | | |
| **12.0.0** | **Exhaust Gas Ducting** | | |
| a) | Material of construction | | |
| b) | Size | m x m x m | |
| c) | Flow velocity in duct | m/s | |
| d) | Thickness of duct | mm | |
| | Design Temperature | $^{o}$C | |
| e) | Design Pressure | Bar | |
| **13.0.0** | **Expansion joints** | | |
| | i) Type | | |
| | ii) Number | nos. | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| | iii) Material of construction | | |
| | iv) Insulation Type | | |
| | v) Insulation Material | | |
| | vi) Maximum Velocity in the duct | | |
| **14.0.0** | **Diverter Damper** | | |
| a) | Size | $m^2$ | |
| b) | Temperature | °C | |
| c) | Pressure | mbar | |
| d) | Materials | | |
| e) | Actuation | | |
| f) | Insulation | | |
| g) | Associated seal air fans<br>1. Nos.<br>2. Capacity | | |
| **15.0.0** | **Guillotine Damper** | | |
| a) | Size | $m^2$ | |
| b) | Temperature | °C | |
| c) | Pressure | mbar | |
| d) | Materials | | |
| e) | Actuation | | |
| f) | Insulation | | |
| g) | Associated seal air fans<br>1. Nos.<br>2. Capacity | | |
| **16.0.0** | **Lubrication and Governing Oil System** | | |
| a) | Quantity required for lubrication | $m^3/h$ | |
| b) | Quantity required for Jacking oil system | $m^3/h$ | |
| c) | Quantity required for control oil system | $m^3/h$ | |
| d) | Number and type of bearing | | |
| e) | Temperature of oil at inlet to bearing | °C | |
| f) | Temperature of oil return from bearing | °C | |
| g) | Lube oil pressure | bar | |
| h) | Jacking oil pressure | bar | |
| i) | Control oil pressure | bar | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| j) | Make up quantity | $m^3$/day | |
| k) | **Oil reservoir** | | |
| | i) Total quantity of oil in the system | $m^3$ | |
| | ii) Capacity of the oil reservoir | $m^3$ | |
| | iii) Operating capacity of the oil reservoir between high and low levels | $m^3$ | |
| | iv) Oil reservoir tank material | | |
| l) | **General** | | |
| | i) Whether pumps are provided with flame proof construction | | |
| | ii) Suction pressure | Bar (g) | |
| m) | **Main lube oil pumps** | | |
| | i) Type / Make | | |
| | ii) Number | | |
| | iii) Capacity | $m^3$/h | |
| | iv) Discharge pressure | bar (g) | |
| | v) Drive type / rating | kW | |
| | vi) Material of construction | | |
| | - Impeller | | |
| | - Shaft | | |
| | - Casing | | |
| 16.1.0 | **Auxiliary lube oil pump** | | |
| a) | Type/ Make | | |
| b) | Number | | |
| c) | Capacity | $m^3$/h | |
| d) | Discharge pressure | bar | |
| e) | Drive motor rating type/make | kW | |
| f) | Material of Construction | | |
| | - Impeller | | |
| | - Shaft | | |
| | - Casing | | |
| 16.2.0 | **Emergency lube oil pump** | | |
| a) | Type / Make | | |
| b) | Number | | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| c) | Capacity | $m^3/h$ | |
| d) | Discharge pressure | bar (g) | |
| e) | Continuous motor rating | kW | |
| f) | Material of Construction | | |
| | - Impeller | | |
| | - Shaft | | |
| | - Casing | | |
| 16.3.0 | **Main Jacking oil pumps** | | |
| a) | Type / Make | | |
| b) | Number | | |
| c) | Capacity | $m^3/h$ | |
| d) | Discharge pressure | bar (g) | |
| e) | Drive motor rating type/make | kW | |
| f) | Material of construction | | |
| g) | - Impeller | | |
| | - Shaft | | |
| | - Casing | | |
| 16.4.0 | **Auxiliary hydraulic oil pump (if applicable)** | | |
| a) | Type / Make | | |
| b) | Number | | |
| c) | Capacity | $m^3/h$ | |
| d) | Discharge pressure | bar (g) | |
| e) | Drive motor rating type/make | kW | |
| f) | Material of construction | | |
| | - Impeller | | |
| | - Shaft | | |
| | - Casing | | |
| 16.5.0 | **Lube oil filter** | | |
| a) | Type / Make | | |
| b) | Numbers | nos. | |
| c) | Size of the mesh | Microns | |
| d) | Material | | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| e) | Material of piping downstream of filter | | |
| 16.6.0 | **Hydraulic Oil filters** | | |
| a) | Type / Make | | |
| b) | Numbers | nos. | |
| c) | Size of the mesh | Microns | |
| d) | Material | | |
| e) | Material of piping downstream of filter | | |
| 16.7.0 | **Oil coolers** | | |
| a) | Type / Make | | |
| b) | No. of coolers | | |
| c) | No. operating during full load operation | | |
| d) | Oil capacity of each cooler | $m^3/h$ | |
| e) | Oil side pressure drop | bar | |
| f) | Oil temperature | | |
| | Inlet / Outlet | °C/°C | |
| g) | Water flow through each cooler | $m^3/hr$ | |
| h) | Water temperature | | |
| | - Inlet / outlet | °C/°C | |
| i) | Water side pressure drop | bar | |
| j) | Materials of construction | | |
| | - Shell | | |
| | - Tube | | |
| | - Tube sheet | | |
| 16.8.0 | **Oil Purifier** | | |
| a) | Manufacturer | - | |
| b) | Number | no. | |
| c) | Type | - | |
| d) | Capacity | % | |
| e) | Rating of drive | kW | |
| 16.9.0 | **Vapour Extractors** | | |
| a) | Type of Drive | | |
| b) | Numbers | | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| c) | Motor rating | kW | |
| 16.10.0 | **Control Oil System (if applicable)** | | |
| a) | Control Oil Tank Capacity | $m^3$ | |
| b) | No. of Pumps | | |
| c) | Capacity of pump | $m^3/h$ | |
| d) | Type of drive & Motor rating | | |
| e) | Type of Control oil cooler | | |
| f) | No. of control oil coolers | nos. | |
| **17.0.0** | **Bearings** | | |
| a) | No. and type of bearings in gas turbine | | |
| b) | Optimum operating temp | °C | |
| a) | Max. operating temp. | °C | |
| b) | Lining material | | |
| c) | Min. pressure at which lube oil is required | bar | |
| **18.0.0** | **Axial thrust bearing** | | |
| a) | Number | | |
| b) | Type | | |
| c) | Optimum operating temp | °C | |
| d) | Max. Operating temp. | °C | |
| e) | Lining material | | |
| f) | Min. pressure at which lube oil is required | bar | |
| **19.0.0** | **Governing system** | | |
| a) | Type of governing | | |
| b) | Steady state speed regulation | % | |
| c) | Temporary speed variation when full load is thrown off | % | |
| d) | Permanent rate of speed variation when full load is thrown off | % | |
| e) | Speed drop characteristics and range of adjustment | | |
| **20.0.0** | **Turning Gear or Barring system** | | |
| a) | Type / Make | | |
| b) | Barring speed | rpm | |
| c) | Power required (if motor driven) | | |
| d) | Manual hand barring provided | Yes/No | |

| Sl. No. | Description | Unit | Data | |
|---|---|---|---|---|
| e) | **Starting Device** | | | |
| | i) Type / Make | | | |
| | ii) Output rating | kW | | |
| | iii) Number of successive starts permitted | nos. | | |
| **21.0.0** | **Over speed Protection Mechanism** | | | |
| a) | Type | | | |
| b) | Numbers | | | |
| **22.0.0** | **Boroscope Equipment** | | | |
| a) | Type / Locations | | | |
| b) | Number | | | |
| **23.0.0** | **Reduction Gear box (Between Gas Turbine and Generator) - if provided** | | | |
| a) | Make / Type / Design code | | | |
| b) | Input shaft speed | rpm | | |
| c) | Output shaft speed | rpm | | |
| d) | Efficiency | % | | |
| e) | Lubricating oil requirement | l/s | | |
| f) | Maximum permissible shock loading | | | |
| g) | Service factor | | | |
| h) | Designed power transmission capacity | kW | | |
| **24.0.0** | **Couplings** | | **Gas Turbine & Reduction Gear box** | **Generator & Gear box** |
| a) | Material of construction | | | |
| b) | Rating | MW | | |
| c) | Service factor | | | |
| d) | Efficiency | % | | |
| e) | Weight | kg | | |
| **25.0.0** | Package fire protection system | | | |
| **26.0.0** | Weight of heaviest part to be handled by crane during maintenance. | Tonnes | | |

## 1.2.0 HEAT RECOVERY STEAM GENERATOR AND AUXILIARIES

| Sl. No. | Description | Unit | Data | |
|---|---|---|---|---|
| **1.0.0** | **General** | | | |
| a) | Make | | | |
| b) | Pressure levels | | | |
| c) | Orientation of HRSG | | | |
| d) | Dry running capability | min. | | |
| e) | Range of sliding pressure | | | |
| f) | Steam temperature control range | % | | |
| g) | Type of Circulation | | | |
| **2.0.0** | **Codes and Standard** | | | |
| a) | Pressure Parts Design Code | | | |
| b) | Non pressure parts design code | | | |
| c) | Performance Testing of HRSG | | | |
| d) | Safety valve | | | |
| **3.0.0** | **Heat Transfer Surface (Superheater)** | | HP | LP |
| | (Below details reg. heat transfer surface shall be provided for Evaporator, Economizer, and condensate pre heater sections) | | | |
| a) | Type (Plain / finned tubes) | | | |
| b) | Arrangement (Staggered / inline) | | | |
| c) | Design pressure / Temperature | bar & $^{o}$C | | |
| d) | Type of fin (continuous / Segmental) | | | |
| e) | Fin material | | | |
| f) | Total Heat Transfer surface area | $m^2$ | | |
| **4.0.0** | **Material of construction** | | | |
| a) | Steam Line | | | |
| | HP main steam line | | | |
| | LP steam line | | | |
| b) | Headers | | | |
| | HP / LP Superheater, | | | |
| | HP / LP Evaporator | | | |
| | HP / LP Economiser | | | |

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| Sl. No. | Description | Unit | Data | |
|---|---|---|---|---|
| | Preheater | | | |
| c) | Tubes | | | |
| | • HP / LP Superheater, | | | |
| | • HP / LP Evaporator | | | |
| | • HP / LP Economiser | | | |
| d) | Preheater | | | |
| e) | HRSG casing | | | |
| **5.0.0** | **Steam Drum** | | **HP** | **LP** |
| a) | Number | no. | | |
| b) | Welding | | | |
| c) | Material of construction | | | |
| d) | Type of dished end | | | |
| e) | Material of construction | | | |
| f) | Material of drum internals | | | |
| g) | Test pressure | bar(a) | | |
| h) | Design pressure | bar(a) | | |
| i) | Design temperature | °C | | |
| j) | Steam separator details | | | |
| k) | • No. of cyclones | | | |
| | • No. of Primary Scrubbers | | | |
| | • No. of secondary scrubbers | | | |
| l) | Storage time between NWL and drum dry | | | |
| m) | Number of manhole | | | |
| **6.0.0** | **Super Heater Attemperator** | | | |
| a) | Type | | | |
| b) | Location | | | |
| c) | Number | | | |
| **7.0.0** | **Safety Valve** | | | |
| a) | Superheater outlet | | | |
| | • Nos. | nos. | | |
| | • Capacity | TPH | | |
| | • Set Pressure | bar(a) | | |

| Sl. No. | Description | Unit | Data | |
|---|---|---|---|---|
| b) | Drum | | | |
| | • Nos. | no. | | |
| | • Capacity | TPH | | |
| | • Set Pressure | bar(a) | | |
| **8.0.0** | **Blow Down Tank** | | **CBD** | **IBD** |
| a) | Number | | | |
| b) | Capacity | $m^3$ | | |
| c) | Design pressure and Temperature | bar(a) | | |
| d) | Material of construction | | | |
| **9.0.0** | **Circulation System (if applicable)** | | | |
| a) | **HP Evaporator Circuit** | | | |
| | • Type | | | |
| | • Circulation ratio | | | |
| | • No. of pumps | | | |
| | • Motor capacity | | | |
| b) | **LP Evaporator Circuit** | | | |
| | • Type | | | |
| | • Circulation ratio | | | |
| | • No. of pumps | | | |
| | • Motor capacity | | | |
| **10.0.0** | **Purge Air fans** | | | |
| a) | Nos. | | | |
| b) | Capacity | | | |
| **11.0.0** | **Ducting (**Welded / Bolted) | | | |
| a) | Type | | | |
| b) | Design pressure and temperature | mmWC | | |
| c) | Gas velocity | m/sec | | |
| d) | External Duct plate | | | |
| | • Material | | | |
| | • Thickness | mm | | |
| | • Corrosion allowance | mm | | |
| | • Coefficient of expansion | mm/mm °C | | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| e) | Internal liner | | |
| | • Material | | |
| | • Thickness | mm | |
| | • Corrosion allowance | mm | |
| | • Coefficient of expansion | mm/mm °C | |
| f) | Duct reinforcement members/ stiffeners | | |
| | • Material | | |
| | • Size | | |
| g) | Flanges | | |
| | • Location | | |
| | • Dimension (LxWxT) | mm | |
| | • Material | | |
| **12.0.0** | **Insulation** | | |
| a) | Material | | |
| b) | No of layers | | |
| c) | Thickness per layer | mm | |
| d) | Insulation density | $kg/m^3$ | |
| e) | Insulation protection at Top | | |
| f) | Insulation protection at Bottom/sides | | |
| g) | Inner liner material & thickness | | |
| h) | Surface temperature of duct at design flow | °C | |
| **13.0.0** | **Non Metallic Expansion Joint** | | |
| a) | Manufacturer | | |
| b) | Type | | |
| c) | Quantity | nos. | |
| d) | Location | | |
| e) | Expected life | hours | |
| f) | Design temperature | °C | |
| g) | Design pressure | mmwc | |
| h) | Gas path internal size (width x height) | mmxmm | |
| i) | Length | mm | |
| j) | Longitudinal misalignment tolerable limit | | |

| Sl. No. | Description | Unit | Data | |
|---|---|---|---|---|
| k) | Angular misalignment tolerable limit | mm | | |
| l) | Longitudinal stiffness | N/mm | | |
| m) | Torsional stiffness | Nm/rad | | |
| n) | Maximum Thermal Movement | | | |
| | • Axial direction | mm | | |
| | • Lateral direction | mm | | |
| | • Vertical direction | mm | | |
| | • Material of construction | | | |
| o) | Bellows / fabrics | | | |
| p) | Liners | | | |
| q) | Inner sleeve / connecting webs | | | |
| r) | Back up bar / stiffeners | | | |
| s) | Flange material | | | |
| **14.0.0** | **Stack** | | Bypass | Main |
| a) | Type of stack | | | |
| b) | Design standard / code | | | |
| c) | Size at base (width x length) | mm x mm | | |
| d) | Size at top (dia.) | mm | | |
| e) | Stack height above ground level | m | | |
| f) | Design gas velocity | m/s | | |
| g) | Design metal temp. | °C | | |
| h) | Material of construction | | | |
| | • Stack | | | |
| | • Shield | | | |
| | • Cladding | | | |
| i) | Thickness of plate | | | |
| | • Stack | mm | | |
| | • Shield | mm | | |
| | • Cladding | mm | | |
| j) | Insulation material | | | |
| k) | Insulation thickness | mm | | |
| l) | Aviation warning lighting type | | | |

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| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| | | | |
| **15.0.0** | **Access Door in HRSG Ducting** | | |
| a) | Type | | |
| b) | Material | | |
| c) | Provision | | |
| d) | Location | | |
| e) | Size | | |
| **16.0.0** | **Insulation - Drum, Integral piping, Blowdown tank** | | |
| a) | Insulation Type | | |
| b) | Insulating Material | | |
| c) | Density | | |
| d) | Cladding Over Insulation | | |
| e) | Thickness of outer cladding | | |
| **17.0.0** | **Structures** | | |
| a) | Design Code | | |
| b) | Seismic co efficient | | |
| c) | Seismic zone | | |
| d) | Basic wind speed | | |
| e) | Live load | | |
| **18.0.0** | **Platforms** | | |
| a) | Number of levels | | |
| b) | Locations | | |
| c) | Clear width | mm | |
| **19.0.0** | **Floor Gratings** | | |
| a) | Type | | |
| b) | Opening Size | mmxmm | |
| c) | Grating Thickness | mm | |
| d) | Main Bearing bar thickness | mm | |
| e) | Painting | | |
| **20.0.0** | **Hand rails** | | |
| a) | Material | | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| b) | Size | NB | |
| c) | Painting | | |
| **21.0.0** | **Stairs both side of HRSG** | | |
| a) | Number | | |
| b) | Location | | |
| c) | Angle to Horizontal | Deg. | |
| d) | Clear width | mm | |
| e) | Riser height (Max.) | mm | |
| f) | Step Treads width (Min.) | mm | |
| g) | Painting | | |
| **22.0.0** | **Chemical Dosing system (HP & LP dosing for HRSG)** | | |
| a) | Type of Pumps | | |
| b) | No. of pumps | | |
| c) | Capacity of each pump | kg/s | |
| d) | Pump motor rating | KW | |
| e) | No. and Size of tank (OD x Ht.) | mm x mm | |
| f) | Weight of tank | | |
| g) | Type of mixer | | |
| h) | Speed | rpm | |
| i) | Motor rating | | |
| **23.0.0** | **HRSG Feed Pump** | | |
| | **General** | | |
| a) | Type | | |
| b) | Name of manufacturer | | |
| c) | Model No. | | |
| | **Codes and Standard** | | |
| a) | Feed Pump mechanical / Hydraulic Design | | |
| b) | Design of pressure parts | | |
| c) | Testing of HRSG feed pump | | |
| | **Performance and construction Details** | | |
| a) | No. of pumps (working + standby) | | |
| b) | No. of stages | | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| c) | Design temperature | °C | |
| d) | Rated Capacity | $m^3$/hr. | |
| e) | Rated Head developed | bar(g) | |
| f) | NPSH required | mwc | |
| g) | Minimum recirculation valve provided | Yes/No | |
| h) | Minimum recirculation flow | $m^3$/hr. | |
| i) | Pump input power | kW | |
| j) | Motor rating | kW | |
| k) | Pump efficiency | % | |
| l) | Motor efficiency | % | |
| m) | Maximum shut-off head | bar(g) | |
| n) | Head at runout flow | bar(g) | |
| o) | Head at minimum flow | bar(g) | |
| p) | Suction specific speed | US units | |
| q) | Critical speed of pump and motor assembly | rpm | |
| r) | Vibration peak to peak | | |
| s) | Provided with suction strainer | Yes/No | |
| t) | Cooling water requirements | $m^3$/hr. | |
| u) | Pump rated speed | rpm | |
| | **Materials of construction** | | |
| a) | Inner casing / Outer casing | | |
| b) | Impeller | | |
| c) | Diffuser / Volute | | |
| d) | Casing wearing rings-Material & Hardness | | |
| e) | Impeller wearing rings-Material & Hardness | | |
| f) | Shaft | | |
| g) | Shaft sleeve | | |
| h) | Stuffing box | | |
| i) | Bushing | | |
| j) | Gland | | |
| k) | Balancing device | | |
| l) | Key | | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| m) | Gaskets | | |
| n) | Mechanical seal | | |
| o) | Base plate | | |
| p) | Main bearing | | |
| q) | Thrust bearing | | |
| r) | Bearing Housing | | |
| **24.0.0** | **Others** | | |
| a) | Number and capacity of electromatic relief valve | | |
| b) | Startup curves for HRSG provided | | |
| c) | HRSG fill pump | | |
| d) | HRSG hydro test pump | | |
| e) | Off load water facility for HRSG | | |
| f) | Alkali boil out | | |
| g) | Acid cleaning | | |
| h) | Steam blowing of piping | | |
| i) | Ambient air quality monitoring equipment | | |

## 1.3.0 STEAM TURBINE GENERATOR & AUXILIARIES

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| **1.0.0** | **General** | | |
| a) | Manufacturer | | |
| b) | Type of turbine | | |
| c) | Model No. | | |
| **2.0.0** | **Design and performance Data** | | |
| a) | Design Standard | | |
| b) | Maximum Continuous Rating at generator terminal | kW | |
| c) | Turbine Normal Speed | rpm | |
| d) | Turbine Trip Speed | rpm | |
| e) | Operating frequency range | Hz | |
| f) | Shaft Vibration at each bearing house (Normal / Alarm / Trip) | Microns | |
| g) | Sensitivity of electro-hydraulic speed governing system including governor valves | % | |
| h) | Maximum increase in running speed in case of sudden total or partial load reduction | % | |
| i) | Maximum effective vibration velocity measured at bearing Housings. | | |
| j) | Critical speeds for rotor assembly | | |
| k) | Coupled critical speeds for turbine and generator together | | |
| l) | Maximum allowable temperature at turbine exhaust hood | $^{o}$C | |
| | **Dryness fraction at the turbine outlet during** | | |
| m) | 100% MCR | % | |
| n) | 75% MCR | % | |
| o) | 60% MCR | % | |
| **3.0.0** | **Casings** | | |
| a) | Number of casings | | |
| b) | Type of casing | | |
| **4.0.0** | **Rotors** | | |
| a) | Number of turbine shafts | | |
| b) | Type of Turbine shaft | | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| **5.0.0** | **Blading** | | |
| a) | Type of blading (reaction/impulse) | | |
| b) | Number of stages | | |
| c) | Method of moisture removal in last stage | | |
| d) | Type of blade protection against moisture erosion | | |
| **6.0.0** | **Material of construction** | | |
| a) | Outer casing | | |
| b) | Inner casing | | |
| c) | Blade carriers | | |
| d) | Rotor | | |
| e) | Nozzles | | |
| f) | Rotor blades | | |
| **7.0.0** | **Bearings** | | |
| a) | Number of journal/thrust bearings | | |
| b) | Type | | |
| c) | Maximum oil outlet temperature | °C | |
| **8.0.0** | **Couplings** | | |
| a) | HP / LP | | |
| b) | LP / Generator | | |
| **9.0.0** | **Main steam (HP) emergency stop valves** | | |
| a) | Number of valves | | |
| b) | Size (Diameter of one valve) | mm | |
| **10.0.0** | **Interceptor Valves** | | |
| a) | Number of valves | | |
| b) | Size (Diameter of one valve) | mm | |
| **11.0.0** | **Main steam control valves** | | |
| a) | Number of valves | | |
| b) | Size (Diameter of one valve) | mm | |
| **12.0.0** | **Governing System** | | |
| a) | Mode | | |
| b) | Type | | |
| c) | Dead band | | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| d) | Range adjustable of electrical governor | % | |
| **13.0.0** | **Electro-hydraulic Governing** | | |
| a) | Type/specification of control fluid | | |
| b) | Control fluid reservoir capacity | $m^3$ | |
| c) | Normal control fluid pressure | Bar | |
| **14.0.0** | **Oil system** | | |
| a) | Type/Specification of turbine lube oil | | |
| b) | Tank capacity | $m^3$ | |
| c) | Number of circulations (per hour) | | |
| d) | Lubrication oil system pressure | bar | |
| e) | Lubrication oil system capacity | $m^3$ | |
| f) | Lubrication oil system flow rate | $m^3$/hr. | |
| | **Main oil pump** | | |
| a) | Number of pumps | | |
| b) | Type | | |
| c) | Drive | | |
| d) | Rated capacity of the pump | $m^3$/hr. | |
| e) | Rated head developed by the pump | bar | |
| f) | Material of pump casing & impeller | | |
| | **Auxiliary oil pump (A.C Drive) / (D.C Drive)** | | |
| a) | Number of pumps | | |
| b) | Type | | |
| c) | Rated capacity of the pump | $m^3$/hr. | |
| d) | Rated head developed by the pump | bar | |
| e) | Motor rating | kW | |
| f) | Material of pump casing & impeller | | |
| | **Emergency oil pump** | | |
| a) | Number of pumps | | |
| b) | Type / Make | | |
| c) | Rated capacity of the pump | $m^3$/hr. | |
| d) | Rated head developed by the pump | bar | |
| e) | Motor rating | kW | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| f) | Material of pump casing & impeller | | |
| | **Jacking oil pump** | | |
| a) | Number of pumps | | |
| b) | Type | | |
| c) | Rated capacity of the pump | $m^3$/hr. | |
| d) | Rated head developed by the pump | bar | |
| e) | Rated power consumption | kW | |
| f) | Material of pump casing & impeller | | |
| | **Oil vapour extraction fans** | | |
| a) | Number of extraction fans | | |
| b) | Type / Make | | |
| c) | Rating | kW | |
| | **Oil cooler** | | |
| a) | Number of coolers | | |
| b) | Max. oil outlet temperature | °C | |
| c) | Tube material | | |
| | **Oil Purifier** | | |
| a) | Number | no. | |
| b) | Type | | |
| c) | Capacity | % | |
| d) | Rating | kW | |
| | **Lubrication oil filter** | | |
| a) | Number | no. | |
| b) | Type / Make | | |
| c) | Grade of filtration | μm | |
| **15.0.0** | **Control fluid pumps ( If applicable)** | | |
| a) | Number of pumps / Type | | |
| b) | Capacity | $m^3$ | |
| c) | Discharge pressure | Bar | |
| d) | Motor rating | kW | |
| | **Heaters (If Applicable)** | | |
| e) | Type / Number of heaters | | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| f) | Rating | kW | |
| | **Filters** | | |
| g) | Type / Number of filters | | |
| | **Coolers** | | |
| h) | Number of coolers in service/standby | | |
| i) | Tube Material | | |
| | **Conditioning Equipment** | | |
| j) | Type of conditioner | | |
| k) | Capacity of unit | $m^3$/hr. | |
| | **Oil Accumulators** | | |
| l) | No of accumulators | | |
| m) | Nominal Capacity | | |
| n) | Gas and Charge pressure | | |
| **16.0.0** | **Lube oil transfer system** | | |
| a) | Lube oil transfer tank capacity | | |
| b) | Tank material | | |
| | **Lube oil transfer pumps** | | |
| c) | Type/number of pump | | |
| d) | Rated Capacity | | |
| e) | Total dynamic head | | |
| **17.0.0** | **Turbine glands** | | |
| a) | Source of gland sealing steam during normal operation/low load operation | | |
| b) | Number of gland steam exhauster provided | | |
| c) | Sealing pressure and Temperature | bar (a) / $^oC$ | |
| **18.0.0** | **Turning device** | | |
| a) | Method of operation | | |
| b) | Turbine rotor speed | rpm | |
| c) | Drive | | |
| a) | Rating | kW | |
| **19.0.0** | **On load Throw off** | | |
| a) | Temporary speed rise | % | |
| b) | Permanent speed rise | % | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| **20.0.0** | Weight of heaviest part to be handled by crane during maintenance | Tonnes | |
| **21.0.0** | **Condenser** | | |
| a) | Manufacturer | | |
| b) | Type | | |
| c) | Design standard | | |
| d) | Type of joint to the condenser | | |
| e) | No. of passes | | |
| f) | Load case considered for design of the condenser. | | |
| g) | Design margin on heat load | % | |
| h) | Plugging Margin | % | |
| i) | Total heat load for condenser design | kcal/h | |
| j) | Steam flow | TPH | |
| k) | Steam Inlet temp. | °C | |
| l) | Steam pressure at condenser inlet | bar(a) | |
| m) | Condensate outlet temp. | °C | |
| n) | Cooling water Flow | $m^3$/hr. | |
| o) | Cooling water inlet temp. | °C | |
| p) | Cooling water temp. rise | °C | |
| q) | Cooling Water Pressure drop across condenser | mlc | |
| r) | Cooling Water Velocity | m/s | |
| s) | Cooling Water Velocity under 10% tube plugged condition | m/s | |
| t) | Heat transfer coefficient | kJ/m²s°C | |
| u) | Surface Area | m² | |
| v) | Fouling factor | m²s°C/kJ | |
| w) | Maximum oxygen content | mg/l | |
| x) | Cleanliness Factor | | |
| y) | Diameter of tubes and Thickness | mm | |
| z) | Tube length | mm | |
| aa) | Design pressure (Shell and Tube side) | bar (a) | |
| bb) | Hydrostatic test pressure | bar (a) | |
| cc) | Hot well capacity | min. | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| | **Material of construction** | | |
| a) | Tubes | | |
| b) | Tubes of air suction area | | |
| c) | Tube plates | | |
| d) | Shell | | |
| e) | Water Box | | |
| f) | Lining of water boxes | | |
| **22.0.0** | **Condensate Surge Tank** | | |
| g) | Type | | |
| h) | Design code | | |
| i) | Capacity | $m^3$ | |
| j) | Material of construction | | |
| **23.0.0** | **HRSG fill-up pump** | | |
| a) | Type | | |
| b) | Capacity | $m^3$/hr. | |
| c) | Discharge head | bar(a) | |
| d) | Time required to fill HRSG | | |
| **24.0.0** | **Air Evacuation Equipment (If Vacuum pump offered)** | | |
| a) | Number | | |
| b) | Capacity and margin on capacity | % | |
| c) | Design standard | | |
| d) | Dry air leakage | kg/s | |
| e) | Time duration to attain the vacuum required for the design condition of ..... bar | Hrs. | |
| f) | Rated capacity of each pump | kg/s | |
| g) | Motor rating | KW | |
| h) | No. of stages | - | |
| i) | Quantity of seal water required | kg/s | |
| **25.0.0** | **Air Evacuation Equipment (If Ejectors is offered)** | | |
| | **Normal Operation:** | | |
| a) | Number of ejectors | | |
| b) | Design capacity and margin on capacity | | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| c) | Design standard | | |
| d) | Type | | |
| e) | Suction pressure | bar | |
| f) | Suction temperature | °C | |
| g) | Dry air leakage | kg/s | |
| h) | Vacuum created | bar | |
| i) | Motive steam requirement | kg/s | |
| j) | Motive steam pressure | bar | |
| k) | Cooling water requirement | kg/s | |
| l) | Steam strainer | | |
| m) | No. of stages | | |
| n) | Source of cooling water | | |
| | **Material of Construction** | | |
| o) | Diffusers | | |
| p) | Nozzle | | |
| q) | Inter and after cooler shell | | |
| r) | Inter and after cooler tubes | | |
| s) | Tube Sheet | | |
| | **Hogging ejector** | | |
| a) | Number of ejectors | | |
| b) | Type | | |
| c) | Capacity | | |
| d) | Start-up time | | |
| e) | Suction pressure | bar | |
| f) | Suction temperature | °C | |
| g) | Max. discharge pressure | bar | |
| h) | Dry air leakage | kg/s | |
| i) | Vacuum created | bar | |
| j) | Motive steam requirement | kg/s | |
| k) | Motive steam pressure | bar | |
| | **Material Of Construction** | | |
| l) | Diffusers | | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| m) | Nozzle | | |
| **26.0.0** | **Condensate Extraction pumps, CEP** | | |
| a) | Number / capacity of pumps | | |
| b) | Type | | |
| | **Codes and Standard** | | |
| c) | Mechanical/Hydraulic Design | | |
| d) | Testing of CEP | | |
| | **Design and Performance Data** | | |
| e) | Rated capacity of the pump | $m^3$/hr. | |
| f) | Pump efficiency | | |
| g) | Run-out flow per pump | $m^3$/hr. | |
| h) | Minimum flow per pump | $m^3$/hr. | |
| i) | Rated head developed by the pump | bar | |
| j) | Shut-off head | bar | |
| k) | NPSH Required | mlc | |
| l) | Motor Rating | KW | |
| m) | Type of gland sealing | | |
| n) | Speed | rpm | |
| o) | Type of bearings | | |
| p) | Suction specific speed | US units | |
| | **Material of construction** | | |
| q) | casing | | |
| r) | Impeller | | |
| s) | Suction Strainer | | |
| t) | Diffuser and Guide vane | | |
| u) | Impeller Stages | | |
| v) | Shaft Sleeves | | |
| w) | Canister | | |
| x) | Pump and Drive shaft | | |
| **27.0.0** | **Gland Steam Condenser, GSC** | | |
| a) | Number of condensers | | |
| b) | Design code | | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| c) | Condensate flow through gland steam condenser. | t/h | |
| d) | Design | | |
| e) | Design Pressure | bar | |
| | **Materials** | | |
| f) | Tubes | | |
| g) | Tube plates | | |
| h) | Shell | | |
| | **Gland steam condenser exhauster** | | |
| i) | Number of exhausters | | |
| j) | Type | | |
| k) | Rating | kW | |
| **28.0.0** | **Deaerator** | | |
| a) | Type of deaerating feed water heater | | |
| b) | Type of spraying arrangement | | |
| | **Design and Performance Data** | | |
| c) | Design pressure | bar (a) | |
| d) | Design temperature | $^0$C | |
| e) | Net water storage capacity provided in feedwater storage tank up to normal water level | Cu. m. | |
| f) | Feed water outflow | t/h | |
| g) | Temperature of deaerated water | $^0$C | |
| h) | Condensate inflow | t/h | |
| i) | Temperature of condensate inflow | $^0$C | |
| j) | Heating steam quantity | t/h | |
| k) | Heating steam pressure | bar (a) | |
| l) | Heating steam temperature | $^0$C | |
| m) | Deaerating heater operating pressure | bar (a) | |
| n) | Pegging steam pressure at low loads / part loads | bar (a) | |
| o) | Pegging steam temperature at low loads / part loads | $^0$C | |
| p) | Load range as percent of MCR for pegging steam | % | |
| | **Sprayer assembly type** | | |
| q) | Number of sprayer assemblies | nos. | |

| Sl. No. | Description | Unit | Data | |
|---|---|---|---|---|
| r) | Condensate flow through each spray assembly | t/h | | |
| s) | Pressure drop under design condensate flow | bar (a) | | |
| t) | Material of sprayer assembly | | | |
| u) | Material of splash plate | | | |
| | **Spray valve assembly** | | | |
| v) | Tray Details (If applicable) | | | |
| w) | Construction | | | |
| x) | Tray thickness | mm | | |
| y) | Number of horizontal trays in one stack and number of stacks | no. | | |
| z) | Total number of trays | no. | | |
| | **Material of Construction** | | | |
| aa) | Deaerator - Shell and dished ends | | | |
| bb) | FW storage Tank - Shell and dished ends | | | |
| cc) | Tray and Tray enclosures | | | |
| dd) | Spray Valve | | | |
| ee) | Splash plates | | | |
| ff) | Steam Distribution plant | | | |
| gg) | Baffles | | | |
| **29.0.0** | **Steam bypass station** | | **HP** | **LP** |
| a) | Type | | | |
| b) | Manufacturer | | | |
| c) | Number of valves | | | |
| d) | Type of actuators | | | |
| e) | Capacity per valve @ design condition | % | | |
| f) | Spray water source | | | |
| g) | Spray water quantity | kg/s | | |
| | **Material** | | | |
| h) | Valve Body | | | |
| i) | Spindle | | | |
| j) | Seat | | | |
| k) | Disc | | | |

## 1.4.0 FUEL GAS SYSTEM

| Sl. No. | Description | Unit | Data | |
|---|---|---|---|---|
| **1.0.0** | **General** | | | |
| a) | Fuel gas pressure at Terminal Point | bar | | |
| b) | Fuel gas temperature at Terminal Point | $^{o}$C | | |
| **2.0.0** | **Gas Conditioning Skid, GCS** | | **Scrubber (Multi Cyclone Type)** | **Cartridge Filter** |
| a) | Numbers / skid | - | | |
| b) | Design & Manufacturing standard / code | - | | |
| c) | Rated Capacity (Gas) | $Nm^3/h$ | | |
| | **Design Conditions** | | | |
| d) | Pressure | bar(g) | | |
| e) | Temperature | °C | | |
| | **Material of Construction** | | | |
| f) | Shell | | | |
| g) | Internals | | | |
| h) | Filter Elements | | | |
| **3.0.0** | **Condensate Tank** | | | |
| a) | Number | | | |
| b) | Design & Manufacturing standard / code | | | |
| c) | Capacity | $m^3$ | | |
| d) | Tank Material | | | |
| **4.0.0** | **Condensate Vent Stack** | | | |
| a) | Diameter | m | | |
| b) | Height | m | | |
| c) | Stack Material | - | | |
| **5.0.0** | **Condensate Pump** | | | |
| a) | Number | - | | |
| b) | Type | - | | |
| c) | Design & Manufacturing standard / code | - | | |
| d) | Pumped fluid | - | | |
| e) | Duty capacity | $m^3/h$ | | |
| f) | Total head | Bar(g) | | |

| Sl. No. | Description | Unit | Data | |
|---|---|---|---|---|
| | **Material of Construction** | | | |
| g) | Casing | | | |
| h) | Impeller | | | |
| i) | Shaft | | | |
| **6.0.0** | **Gas Heaters** | | | |
| a) | Number | | | |
| b) | Type | | | |
| c) | Design & Manufacturing standard / code | | | |
| d) | Heat duty | kW | | |
| e) | Temperature Rise | $^{o}$C | | |
| **7.0.0** | **Pressure Control Station** | | | |
| **8.0.0** | **Final Filter (for GT# 4)** | | | |
| a) | Numbers | | | |
| b) | Type | | | |
| c) | Design & Manufacturing standard / code | | | |
| d) | Rated Capacity (Gas) | | | |
| | **Design Conditions** | | | |
| e) | Pressure | | | |
| f) | Temperature | | | |
| | **Material of Construction** | | | |
| g) | Shell | | | |
| h) | Internals | | | |
| i) | Filter Elements | | | |
| **9.0.0** | **Emergency Shut Down, ESD valve** | | **Gas Conditioning Skid** | **Gas Turbine** |
| a) | Size | NB | | |
| b) | Number | | | |
| c) | Type | | | |
| d) | Design & Manufacturing standard / code | | | |
| e) | Flange rating | | | |
| f) | Valve actuator type | | | |

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| Sl. No. | Description | Unit | Data | |
|---|---|---|---|---|
| | **Material of construction:** | | | |
| g) | Body | | | |
| h) | Trim | | | |
| i) | Stem | | | |
| j) | Plug | | | |
| k) | Seats | | | |
| **10.0.0** | Automatic inert gas purging at GT fuel skid | | | |
| **11.0.0** | **Gas Flow meter** | | | |
| a) | Type | | | |
| b) | Accuracy | | | |

## 1.5.0 CONDENSER & AUXILIARY COOLING WATER SYSTEM

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| **1.0.0** | **COOLING TOWER** | | |
| a) | Design & Manufacturing standard / code | | |
| b) | Type of construction | | |
| c) | Design Cold water temperature | °C | |
| d) | Design Cooling range | °C | |
| e) | Design tower inlet air wet bulb temperature including recirculation allowance | °C | |
| f) | Recirculation allowance. | °C | |
| g) | Cycle of concentration of circulating water | | |
| | **Tower Data** | | |
| h) | No. of cells (including spare ) | nos. | |
| i) | Flow through each cell | $m^3$/hr. | |
| j) | L/G ratio | | |
| k) | Drift loss | % | |
| l) | Evaporation loss | % | |
| m) | Active tower volume | $m^3$ | |
| n) | Total wetted surface | $m^2$ | |
| o) | Type of fill arrangement | | |
| p) | Type of drift eliminators | | |
| q) | Type of recovery stack | | |
| r) | No. of Distribution valves / cell and sizes | | |
| s) | Min. pressure head required at the spray nozzle header | bar(g) | |
| t) | Tower size | mxmxm | |
| | **Material Of Constructions** | | |
| u) | Casing | | |
| v) | Fills | | |
| w) | Louvers | | |
| x) | Nozzles | | |
| y) | Drift eliminator and its supports | | |
| **2.0.0** | **FAN DETAILS** | | |
| a) | Design & Manufacturing standard / code | | |

| Sl. No. | Description | Unit | Data | |
|---|---|---|---|---|
| b) | Type | | | |
| c) | Design Air flow rate | $m^3/s$ | | |
| d) | Material of fan blades and hub | | | |
| e) | Speed | rpm | | |
| f) | Fan Motor Power | kW | | |
| g) | Temperature of outgoing mixed air | °C | | |
| **3.0.0** | **PUMPS** | | **MCW** | **ACW** |
| a) | Number (W+S) | nos. | | |
| b) | Fluid handled | | | |
| c) | Design & Manufacturing standard/code | | | |
| d) | Pump type | | | |
| e) | Percentage of margin considered above design capacity | % | | |
| f) | Rated Capacity | $m^3/hr.$ | | |
| g) | Total developed Head | mwc | | |
| h) | Pump efficiency at rated capacity | % | | |
| i) | Power requirement at rated capacity | kW | | |
| j) | Submergence required | mWc | | |
| k) | Shut off head | mWc | | |
| l) | Possibility to start the pump on closed discharge | | | |
| m) | Type of radial bearings & Make | | | |
| n) | Type of thrust bearing & Make | | | |
| o) | Hydro static test pressure | bar (g) | | |
| p) | Type of coupling | | | |
| q) | Weight of pump set | ton | | |
| | **Materials of Construction** | | | |
| r) | Column | | | |
| s) | Suction bell | | | |
| t) | Casing | | | |
| u) | Impeller | | | |
| v) | Casing and Impeller wear rings | | | |
| w) | Impeller shaft | | | |

| Sl. No. | Description | Unit | Data | |
|---|---|---|---|---|
| x) | Shaft sleeves | | | |
| y) | Sealing | | | |
| z) | Base plate | | | |
| **4.0.0** | **RUBBER EXPANSION JOINTS** | | | |
| a) | Numbers required | nos. | | |
| b) | Design & Manufacturing standard / code | | | |
| c) | Fluid handled | | | |
| d) | Pressure – operating / design / test | mwc | | |
| e) | Vacuum (test) | mm of Hg | | |
| f) | No of arches | | | |
| g) | Companion flanges | | | |
| | **Material of Construction** | | | |
| h) | Main body | | | |
| i) | Relining ring | | | |
| j) | Outer cover | | | |
| k) | Bolts and nuts | | | |
| l) | Stretcher bolt plates | | | |
| **5.0.0** | **BUTTERFLY VALVES** | | | |
| a) | Design & Manufacturing standard / code | | | |
| b) | Location | | | |
| c) | Valve sizes and Number | mm | | |
| d) | Valve opening / closing time | | | |
| e) | Flow- maximum / normal | $m^3$/hr. | | |
| f) | Maximum / normal operating pressure | bar | | |
| g) | Actuator for BF valves | | | |
| | **Material of Construction** | | | |
| h) | Body | | | |
| i) | Disc | | | |
| j) | Shaft | | | |
| k) | Companion flanges | | | |
| **6.0.0** | **SUCTION STRAINER** | | | |
| a) | Type | | | |
| b) | Quantity | | | |

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| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| c) | Flow rate | $m^3$/hr. | |
| d) | Design pressure and temperature | $kg/cm^2$(g) & $^oC$ | |
| e) | Size of filter element | microns | |
| | **Material of construction** | | |
| f) | Body | | |
| g) | Strainer | | |
| **7.0.0** | **Tanks (if required)** | | |
| a) | Tank capacity | $m^3$ | |
| b) | Number offered | nos. | |
| c) | Location of the tank | m | |
| d) | Type and standards | | |
| e) | Materials of construction | | |

## 1.6.0 PLANT WATER SYSTEM & CHEMICAL TREATMENT SYSTEMS

| | | | |
|---|---|---|---|
| **A** | **DM PLANT** | | |
| **1.1.0** | **Mixed bed exchanger** | | |
| 1.1.1 | Design standard | | |
| 1.1.2 | Type | | |
| 1.1.3 | No. of units | | |
| 1.1.4 | Design pressure | | |
| 1.1.5 | Hydrostatic test pressure | | |
| 1.1.6 | Maximum flow rate | | |
| 1.1.7 | Rubber lining | | |
| 1.1.8 | Free board | | |
| 1.1.9 | Gross output of each exchanger per cycle | | |
| 1.1.10 | Minimum resin bed depth | | |
| 1.1.11 | Material of construction | | |
| 1.1.12 | Minimum shell / dish end thickness | | |
| 1.1.13 | Tolerance | | |
| 1.1.14 | Resin type | | |
| 1.1.15 | Method of regeneration | | |
| 1.1.16 | Under drain system | | |
| 1.1.17 | Accessories / Instrumentation | | |
| | | | |
| **1.2.0** | **Air scouring blowers (For MB units)** | | |
| 1.2.1 | Type | | |
| 1.2.2 | No. of units | | |
| 1.2.3 | Capacity & Head | | |
| 1.2.4 | Material of construction | | |
| 1.2.5 | Medium handled | | |
| 1.2.6 | Design temperature | | |
| 1.2.7 | Painting | | |
| | | | |
| **1.3.0** | **DM Water Storage Tank** | | |
| 1.3.1 | Design standard | | |
| 1.3.2 | No. of tanks | | |
| 1.3.3 | Material of construction | | |
| 1.3.4 | Working capacity of each tank | | |
| 1.3.5 | Type | | |
| 1.3.6 | Accessories / instruments | | |
| | | | |
| **1.4.0** | **pH Correction Dosing Station** | | |
| 1.4.1 | PH Correction Solution tank | | |
| 1.4.2 | No. of tank | no. | |
| 1.4.3 | Capacity of tank | Litres | |
| 1.4.4 | Material of construction | | |
| 1.4.5 | pH Correction Dosing Pump | | |
| 1.4.6 | No. of pumps | no. | |
| 1.4.7 | Capacity of pump | | |
| 1.4.8 | head of pump | | |
| 1.4.9 | Type | | |
| 1.4.10 | Material of construction | | |
| 1.4.11 | Motorised Agitator for above tank | | |

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| | | | |
|---|---|---|---|
| 1.4.12 | Quantity | | |
| 1.4.13 | Material of construction | | |
| | | | |
| **1.5.0** | **DM water transfer Pump for Hotwell make-up / HRSG Initial fill pump** | | |
| 1.5.1 | Type | | |
| 1.5.2 | Design standard | | |
| 1.5.3 | No. of pumps | | |
| 1.5.4 | Medium handled | | |
| 1.5.5 | Design temperature | | |
| 1.5.6 | Capacity of each pump | | |
| 1.5.7 | Head required | | |
| 1.5.8 | Material of construction | | |
| | i. Casing / impeller / shaft | | |
| | ii. Base plate | | |
| 1.5.9 | Shaft sealing arrangement | | |
| | | | |
| **1.6.0** | **Acid measuring tank** | | |
| 1.6.1 | Design standard | | |
| 1.6.2 | Material of construction | | |
| 1.6.3 | No. of tanks | | |
| 1.6.4 | Fluid handled | | |
| 1.6.5 | Capacity | | |
| 1.6.6 | Accessories / instruments | | |
| | | | |
| **1.7.0** | **Caustic dilution tank** | | |
| 1.7.1 | Design standard | | |
| 1.7.2 | Material of construction | | |
| 1.7.3 | Nos. | | |
| 1.7.4 | Fluid handled | | |
| 1.7.5 | Capacity | | |
| 1.7.6 | Accessories / instruments | | |
| | | | |
| **1.8.0** | **Agitators for caustic dilution tanks** | | |
| 1.8.1 | Quantity | | |
| 1.8.2 | Type | | |
| 1.8.3 | Material of construction | | |
| 1.8.4 | Impeller / shaft | | |
| 1.8.5 | Mounting | | |
| 1.8.6 | Impeller type | | |
| 1.8.7 | Transmission | | |
| | | | |
| **1.9.0** | **Ejectors** | | |
| 1.9.1 | Nature of fluid | | |
| 1.9.2 | No. of ejectors | | |
| 1.9.3 | Location | | |
| 1.9.4 | Injection fluid | | |
| 1.9.5 | Material of construction | | |
| | | | |

| | | | |
|---|---|---|---|
| | | | |
| **B** | **POTABLE WATER SYSTEM** | | |
| **1.1.0** | Potable water overhead tank | | |
| 1.1.1 | No. of tank | no. | |
| 1.1.2 | Capacity of each tank | Litres | |
| 1.1.3 | Material of construction | | |
| | | | |
| **C** | **SERVICE WATER SYSTEM** | | |
| **1.1.0** | Service water overhead tank | | |
| 1.1.1 | No. of tank | no. | |
| 1.1.2 | Capacity of each tank | Litres | |
| 1.1.3 | Material of construction | | |
| | | | |
| **D** | **EFFLUENT DISPOSAL SYSTEM** | | |
| **1.1.0** | **HRSG Blow down pit** | | |
| 1.1.1 | No. of tank | nos. | |
| 1.1.2 | Capacity | $m^3$ | |
| 1.1.3 | Location | | |
| 1.1.4 | Material of construction | | |
| | | | |
| **1.2.0** | **HRSG Blow down transfer Pump** | | |
| 1.2.1 | No. of pumps | nos. | |
| 1.2.2 | Design capacity of pumps | $m^3$/hr. | |
| 1.2.3 | Head of the pumps | bar ( g ) | |
| 1.2.4 | Material of construction | | |
| | i. Casing / impeller / shaft | | |
| | ii. Base plate | | |
| 1.2.5 | Shaft sealing arrangement | | |
| 1.2.6 | Design temperature | Deg. C | |
| | | | |
| **1.3.0** | **SSF backwash water storage tank** | | |
| 1.1.1 | No. of tank | nos. | |
| 1.1.2 | Capacity | $m^3$ | |
| 1.1.3 | Location | | |
| 1.1.4 | Material of construction | | |
| | | | |
| **1.4.0** | **SSF backwash water transfer pump** | | |
| 1.4.1 | No. of pumps | no. | |
| 1.4.2 | Design capacity of pumps | $m^3$/hr. | |
| 1.4.3 | Head of the pumps | bar ( g ) | |
| 1.4.4 | Material of construction | | |
| | i. Casing / impeller / shaft | | |
| | ii. Base plate | | |
| 1.4.5 | Shaft sealing arrangement | | |
| 1.4.6 | Design temperature | Deg. C | |
| | | | |

### 1.6.2 CW Treatment

| | | | |
|---|---|---|---|
| **1.0.0** | **Side Stream Filter, SSF** | | |
| 1.1.0 | Vessel design standard | | |
| 1.2.0 | Type | | |
| 1.3.0 | No. of units | | |
| 1.4.0 | Material of Construction | | |
| 1.5.0 | Gross capacity | $m^3$/hr | |
| 1.6.0 | Design pressure | | |
| 1.7.0 | Hydrostatic test pressure | | |
| 1.8.0 | Specific normal flow rate | $m^3/hr/m^2$ | |
| 1.9.0 | Back wash flow rate | $m^3/hr/m^2$ | |
| 1.10.0 | Filtering medium | | |
| 1.11.0 | Minimum bed depth | mm | |
| 1.12.0 | Minimum shell thickness | mm | |
| 1.13.0 | Minimum free board | | |
| 1.14.0 | Material of construction | | |
| 1.15.0 | Thickness tolerance / allowance | | |
| 1.16.0 | Other accessories / Instruments | | |
| 1.17.0 | Type of under drain and distributor system | | |
| 1.18.0 | Internal coating | | |
| 1.19.0 | External painting | | |
| | | | |
| **1.20.0** | **SSF Back wash tank** | | |
| 1.20.1 | Capacity | $m^3$ | |
| 1.20.2 | MOC | | |
| 1.20.3 | Quantity | | |
| | | | |
| **1.21.0** | **SSF Backwash pumps** | | |
| 1.21.1 | Capacity | $m^3$/hr. | |
| 1.21.2 | MOC | | |
| 1.21.3 | Quantity | | |
| | | | |
| **2.0.0** | **COOLING TOWER CHEMICAL DOSING SYSTEM.** | | |
| | | | |
| **2.1.1** | **Sulphuric Acid Dosing system** | | |
| **2.1.2** | **Bulk acid storage tank (Cooling Tower)** | | |
| i) | Design standard | | |
| ii) | Material of construction | | |
| iii) | Disposition | | |
| iv) | Quantity | nos. | |
| v) | Fluid handled | | |

| | | | |
|---|---|---|---|
| vi) | Total capacity of tanks | $m^3$ | |
| | | | |
| **2.1.3** | **$H_2SO_4$ unloading pump (Cooling Tower)** | | |
| i) | Type | | |
| ii) | Material of construction | | |
| | - Casing / impeller | | |
| | - Shaft | | |
| | - Base plate | | |
| iii) | Fluid handled | | |
| iv) | Quantity | | |
| v) | Capacity of each pump | | |
| vi) | Suction pressure | | |
| vii) | Shaft sealing arrangement | | |
| | | | |
| **2.1.4** | **$H_2SO_4$ measuring tank (Cooling Tower)** | | |
| i) | Design standard | | |
| ii) | Material of construction | | |
| iii) | Quantity | | |
| iv) | Fluid handled | | |
| v) | Capacity | | |
| vi) | $H_2SO_4$ Dosing Pump | | |
| vii) | Quantity | no. | |
| viii) | Capacity of each pump | | |
| ix) | Type | | |
| x) | Material of construction of pump head | | |
| | | | |
| **3.0.0** | **Bio dispersant / Biocide dosing system** | | |
| i) | Chemical Solution tank | | |
| ii) | Quantity | no. | |
| iii) | Capacity of each tank | Ltr. | |
| iv) | Material of construction | | |
| v) | Chemical Dosing Pump | | |
| vi) | Quantity | no. | |
| vii) | Capacity of each pump | | |
| viii) | Type | | |
| ix) | Material of construction of pump head | | |
| x) | Agitator for the above dosing tank | | |
| xi) | Type | | |
| xii) | Material of construction | | |
| xiii) | Impeller / shaft | | |
| xiv) | Mounting | | |
| xv) | Impeller type | | |

| | | | |
|---|---|---|---|
| xvi) | Transmission | | |
| xvii) | Quantity | no. | |
| | | | |
| **4.0.0** | **Scale cum corrosion inhibitor dosing system** | | |
| | | | |
| i) | Chemical Solution tank | | |
| ii) | Quantity | no. | |
| iii) | Capacity of each tank | Ltr. | |
| iv) | Material of construction | - | |
| v) | Chemical Dosing Pump | | |
| vi) | Quantity | no. | |
| vii) | Capacity of each pump | | |
| viii) | Type | | |
| ix) | Material of construction of pump head | | |
| x) | Agitator for the above dosing tank | | |
| xi) | Type | | |
| xii) | Material of construction | | |
| xiii) | Impeller / shaft | | |
| xiv) | Mounting | | |
| xv) | Impeller type | | |
| xvi) | Transmission | | |
| xvii) | Quantity | no. | |
| | | | |
| **5.0.0** | **NaOCl dosing system** | | |
| | | | |
| i) | Chemical Solution tank | | |
| ii) | Quantity | no. | |
| iii) | Capacity of each tank | Ltr. | |
| iv) | Material of construction | - | |
| v) | Chemical Dosing Pump | | |
| vi) | Quantity | no. | |
| vii) | Capacity of each pump | | |
| viii) | Type | | |
| ix) | Material of construction of pump head | | |
| x) | Agitator for the above dosing tank | | |
| xi) | Type | | |
| xii) | Material of construction | | |
| xiii) | Impeller / shaft | | |
| xiv) | Mounting | | |
| xv) | Impeller type | | |
| xvi) | Transmission | | |
| xvii) | Quantity | no. | |

## 1.7.0 CRANES AND HOISTS

| Sl. No. | Location | Hoist provided | Design standard | capacity (Tonnes) | Quantity |
|---|---|---|---|---|---|
| | | | | | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| **1.0.0** | **CRANE (for each crane)** | | |
| **1.1.0** | **General** | | |
| 1.1.1 | Manufacturer | | |
| 1.1.2 | Design according to standard | | |
| 1.1.3 | Stress class | | |
| 1.1.4 | Span | m | |
| 1.1.5 | Maximum deflection of crane bridge with nominal load and crab in Centre position | mm | |
| 1.1.6 | Highest & Lowest position of hook | m | |
| 1.1.7 | Lifting height | m | |
| 1.1.8 | Heaviest part to be lifted by the crane: type & weight | | |
| **1.2.0** | **Speeds** | | |
| 1.2.1 | Crane traveling speed: fast & precision | m/min. | |
| 1.2.2 | Crab traversing speed: fast & precision | m/min. | |
| 1.2.3 | Main Hoisting speed: fast & precision | m/min. | |
| 1.2.4 | Aux. hoist speed: fast & precision (if applicable) | | |
| **1.3.0** | **Drives** | | |
| 1.3.1 | Crane Traveling | | |
| a) | No. of motors | | |
| b) | Rating per motor: fast & precision | kW | |
| c) | Duty cycle: fast & precision | % | |
| d) | Type of enclosure (IEC designation) | | |

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| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| 1.3.2 | Crab Transversal | | |
| a) | No. of motors | kW | |
| b) | Rating per motor: fast & precision | kW | |
| c) | Duty cycle: fast & precision | % | |
| d) | Type of enclosure (IEC designation) | | |
| **1.4.0** | **Hoisting** | | |
| a) | No. of motors | | |
| b) | Rating per motor: fast & precision | kW | |
| c) | Duty cycle: fast & precision | | |
| d) | Type of enclosure (IEC designation) | | |
| **1.5.0** | **Auxiliary Hoist** | | |
| a) | Rating per motor: fast & precision | kW | |
| b) | Duty cycle: fast & precision | % | |
| c) | Type of enclosure (IEC designation) | | |
| **1.6.0** | **Weights** | | |
| 1.6.1 | Gantry crane bridge with traveling gear | kg | |
| 1.6.2 | Crab with hoisting - and traversing gear | kg | |
| 1.6.3 | Total weight of the complete crane | kg | |
| **2.0.0** | **ELECTRICAL HOIST** | | |
| **2.1.0** | **General** | | |
| 2.1.1 | Manufacturer | | |
| 2.1.2 | Design according to standard | | |
| 2.1.3 | Stress class | | |
| 2.1.4 | capacity | T | |
| 2.1.5 | Crab traversing speed: fast & precision | m/min | |
| 2.1.6 | Hoisting speed: fast & precision | m/min | |
| 2.1.7 | No of motor | nos. | |
| 2.1.8 | Crab traversing motor rating | kW | |
| 2.1.9 | Hoist motor rating | kW | |

## 1.8.0 COMPRESSED AIR SYSTEM

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| 1.0.0 | **General** | | |
| 1.2.0 | Maximum total compressed air requirement for the whole plant | $Nm^3/hr.$ | |
| 1.3.0 | Max. instrument air requirement for entire plant | $Nm^3/hr.$ | |
| 1.4.0 | Compressed Air system Pressure | $kg/cm^2(g)$ | |
| 2.0.0 | **Compressor** | | |
| 2.1.0 | Number of compressors | - | |
| 2.2.0 | Make, Model No. and Type | - | |
| 2.3.0 | Design code | - | |
| 2.4.0 | Capacity of the each compressor | $Nm^3/hr.$ | |
| 2.8.0 | **Material of construction** | - | |
| 2.8.1 | Casing (Compressor chamber) | - | |
| 2.8.2 | Male / Female rotor of LP stage | - | |
| 2.8.3 | Male / Female rotor of HP stage | - | |
| 2.8.4 | Total cooling water quantity required | $m^3$ / sec | |
| 2.8.5 | Cooling water inlet temperature & temperature rise | $^OC$ | |
| 2.8.6 | Noise level at 1m distance | - | |
| 3.0.0 | **Driving motor** | | |
| 3.2.0 | Speed | rpm | |
| 3.3.0 | Rating | kW | |
| 4.0.0 | **Oil pump** | | |
| 4.1.0 | Rate of delivery | $m^3/h$ | |
| 4.2.0 | Rating (in case of separate motor) | KW | |
| 5.0.0 | **Intercooler** | | |
| 5.1.0 | Design Code | - | |
| 5.2.0 | Max. air outlet temperature | °C | |
| 5.3.0 | Tube material | - | |
| 6.0.0 | **After cooler** | | |
| 6.1.0 | Design Code | - | |
| 6.2.0 | Maximum air outlet temperature | °C | |
| 6.3.0 | Tube material | - | |

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| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| 7.0.0 | **Air drying plant** | | |
| 7.1.0 | Type | - | |
| 7.2.0 | Number of air dryers | - | |
| 7.3.0 | Make, Model No. | - | |
| 7.4.0 | Maximum capacity at operating condition (FAD) | $Nm^3/hr.$ | |
| 7.5.0 | Air pressure drop across air drying plant at maximum flow | $kg / cm^2$ | |
| 7.6.0 | Air outlet temperature | °C | |
| 7.7.0 | Outlet air dew point at atmospheric pressure | | |
| 7.8.0 | Pressure loss in dryer | kg/cm2(g) | |
| 7.9.0 | Cooling water flow rate | $m^3/hr.$ | |
| 7.10.0 | Cooling water outlet temperature | °C | |
| 7.11.0 | Cooling water pressure drop | $kg/cm^2(g)$ | |
| 8.0.0 | **Air receiver** | | |
| 8.1.0 | Numbers | | |
| 8.2.0 | Make | | |
| 8.3.0 | Design / Fabrication conform to code / Standard | | |
| 8.4.0 | Capacity | $m^3$ | |
| 8.6.0 | Design pressure | $kg/cm^2(g)$ | |
| 8.7.0 | Total height | mm | |
| 8.8.0 | Diameter of receiver | mm | |
| 8.9.0 | Shell thickness | mm | |
| 8.10.0 | Material | | |
| 8.11.0 | Protection against corrosion: | | |
| | (a)Internal | | |
| | (b)External | | |
| 9.0.0 | **Pipe work** | | |
| | Materials and relevant standard of pipe work to be stated in detail | | |

## 1.9.0 HEATING, VENTILATION & AIR CONDITIONING SYSTEM

| Sl. No. | Space | Type of Air conditioning / Ventilation System | Equipment Type | Capacity | Qty |
|---|---|---|---|---|---|
| | | | | | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| 1. | **VENTILATION SYSTEM** | | |
| 2. | **AXIAL FLOW FAN** | | |
| i) | Make and Model No. | | |
| ii) | Type | | |
| iii) | Capacity | Cu.m / hr. | |
| iv) | Static pressure, | mmWc | |
| v) | Speed | RPM | |
| vi) | Power consumption | kW | |
| vii) | Type of drive | | |
| viii) | Material of construction | | |
| | Noise level | dB(A) | |
| 3. | **Fresh Air Filter** | | |
| **i)** | Make | | |
| ii) | Type | | |
| iii) | Capacity | Cu. M /sec | |
| | - Face area | Sq.m | |
| | - Face velocity | M / sec. | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| | - Pressure drop | Pa | |
| iv) | Material | | |
| v) | Filtering efficiency down to 10 microns | % | |
| 4. | **Gravity Louvre** | | |
| i) | Pressure required to open the louver | Pa | |
| ii) | Material and thickness of | | |
| | - - Frame | | |
| | - - Blades | | |
| 5. | **ROOF EXTRACTOR** | | |
| **i)** | Make and model | | |
| ii) | Capacity | Cu m / hr. | |
| iii) | Static pressure | mmWC | |
| iv) | Power consumption | kW | |
| v) | Motor rating | kW | |
| vi) | Speed | RPM | |
| vii) | Material of construction | | |
| viii) | Noise level | dB(A) | |
| 6. | **AIR DISTRIBUTION SYSTEM** | | |
| i) | Ducting | | |
| ii) | a) Material | | |
| iii) | b) GI Coating | Gms/m² | |
| iv) | Supply & Return air diffusers / grilles | | |
| | c) Material & thickness | | |
| | d) Volume control dampers | | |
| | Thermal & Acoustic insulation | | |
| | a) Materials | | |
| | b) Thickness | mm | |
| | Fire dampers | | |
| v) | a) Rating | | |
| | b) Type of actuation | | |
| 7. | **AIR CONDITIONING SYSTEM** | | |

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| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| 8. | **PACKAGE AIR CONDITIONER** | | |
| i) | Make & Model No. | | |
| ii) | Nominal cooling capacity | | |
| iii) | Nominal air quantity | | |
| iv) | Total power consumption | KW | |
| v) | Makeup water requirement | $m^3$/hr. | |
| vi) | Overall dimensions | | |
| | - width | | |
| | - depth | | |
| | - height | | |
| vii) | Intake Filter | | |
| | a) Type | | |
| | b) Face area of each filter | | |
| | c) Total quantity of air handled | | |
| | d) Face velocity | | |
| viii) | Efficiency | | |
| ix) | Pressure drop | | |
| x) | Compressor | | |
| | a) Type | | |
| | b) Make | | |
| | c) Model | | |
| | d) Power consumption | | |
| | e) Type of lubrication | | |
| xi) | No. of compressors (in each packaged AC unit) | | |
| xii) | Condenser | | |
| | a) Type | | |
| | b) Make | | |
| | c) Tube material | | |
| | d) Tube thickness | | |
| | e) Fin spacing | | |
| | Electric heater capacity | kW | |
| | Pan type humidifier capacity | kg/hr. | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| 9. | **AIR DISTRIBUTION SYSTEM** | | |
| i) | Ducting | | |
| ii) | a) Material | | |
| | b) GI Coating | Gms/m² | |
| | Supply & Return air diffusers / grilles | | |
| | c) Material & thickness | | |
| | d) Volume control dampers | | |
| | Thermal & Acoustic insulation | | |
| iii) | a) Materials | | |
| | b) Thickness | mm | |
| | c) Density | Kg/m3 | |
| | Fire dampers | | |
| | a) Rating | | |
| | b) Type of actuation | | |
| 10. | **Safeties, Control and interlock** | | |
| | **Protection Devices** | Yes/No | |
| i) | Single phase protection | | |
| ii) | Overload protection | | |
| iii) | Control & interlock | | |
| iv) | ON /OFF delay timer | | |
| v) | Compressor Interlock with liquid line SOV | | |
| vi) | Compressor Interlock with crankcase heater | | |
| vii) | Compressor Interlock with Evaporator flow switch | | |
| viii) | Compressor interlock with condenser fan | | |

## 1.10.0 FIRE PROTECTION SYSTEM

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| **1.0** | **Pipework** | | |
| 1.1 | **Aboveground pipes** | | |
| 1.1.1 | Manufacturer | | |
| 1.1.2 | Material / Class | | |
| 1.1.3 | Specification | | |
| 1.1.4 | Type of joints | | |
| 1.2 | **Underground pipes** | | |
| 1.2.1 | Manufacturer | | |
| 1.2.2 | Material / Class | | |
| 1.2.3 | Specification | | |
| 1.2.4 | Type of joints | | |
| 1.2.6 | Type of corrosion protection provided | | |
| **2.0** | **Isolating Valves (Gate Valves)** | | |
| 2.1 | Manufacturer | | |
| 2.2 | Type | | |
| 2.5 | Material | | |
| 2.6 | Body | | |
| | Bonnet | | |
| 2.13 | Gasket | | |
| 2.14 | Gland packing | | |
| **3.0** | **Globe Valve** | | |
| 3.1 | Manufacturer | | |
| 3.2 | Type | | |
| 3.5 | Material | | |
| 3.6 | Body | | |
| 3.7 | Bonnet | | |
| 3.13 | Gasket | | |
| 3.14 | Gland packing | | |
| **4.0** | **Non Return Valves, NRV** | | |
| 4.1 | Manufacturer | | |
| 4.2 | Type | | |
| 4.4 | Material | | |
| 4.5 | Body | | |
| **5.0** | **Butterfly Valve** | | |
| 5.1 | Type | | |
| | Material | | |
| 5.2 | Body | | |
| 5.3 | Shaft | | |
| 5.4 | Disc | | |
| **6.0** | **Deluge Valve** | | |
| | a)Manufacturer | | |
| | b)Sizes offered | | |

| | | | |
|---|---|---|---|
| | d)Material | | |
| | e)Body | | |
| | k)Valve seat | | |
| | l)Spring | | |
| **7.0** | **Fire Hydrant Valves (Indoor & Outdoor)** | | |
| | a)Type & Numbers | | |
| | b)Manufacturer | | |
| | c)Material | | |
| | d)Body | | |
| **11.0** | **Hydrant Nozzles** | | |
| | a)Manufacturer | | |
| | b)Material | | |
| | c)Diameter of nozzle | | |
| **12.0** | **Spray Nozzle** | | |
| | a)Manufacturer | | |
| | b)Material of construction | | |
| | c)Nozzle diameter - range offered | | |
| | d)Nozzle spray angle range offered | | |
| **14.0** | **Monitors** | | |
| | a)Make/Type | | |
| | b)Material of construction/code | | |
| **15.0** | **Fixed high-velocity water spray system provided for various areas / equipment as per specifications (Bidder shall furnish data for each system)** | | |
| | Design pressure | bar | |
| | Max. water quantity delivered via automatic deluge valve station(s) for the transformers | L/min. | |
| **16.0** | **Fixed Medium-velocity water spray system for provided for various areas / equipment as per specifications (Bidder shall furnish data for each system)** | | |
| | Design pressure | bar | |
| | Max. Water quantity delivered via automatic deluge valve station(s). | l/min. | |
| | **Fire Detection and Alarm system** | | |
| **19.0** | **Fire alarm Panel** (Bidder shall furnish all the data for each detectors and fire alarm panel) | | |
| | Make / type | | |
| | No. of Detection loops | | |
| | Detector per loop | | |
| | Battery & battery charger Provided? | | |
| | User Interface Provided? | | |

| | | | |
|---|---|---|---|
| | Fire panel Approved / Certified by? | | |
| **20.0** | **Repeater Fire alarm Panel** (Bidder shall furnish all the data for repeater fire alarm panel) | | |
| | Make / type | | |
| | Battery & battery charger Provided? | | |
| | LCD Display Provided ( Y / N)? | | |
| | User Interface Provided? | | |
| | Fire panel Approved / Certified by? | | |
| **21.0** | **Smoke Detector** | | |
| | Make / type / model no./ Approved by | | |
| | Area provide with smoke detection: | | |
| **22.0** | **Heat Detector** | | |
| | Make / type / model no./Approved by | | |
| | Area provide with Heat Detectors detection: | | |
| **23.0** | **Multisensor Detectors** | | |
| | Make / type / model no./ Approved by | | |
| | Area provide with Multisensor detectors: | | |
| **24.0** | **Linear Heat Sensing Cable** | | |
| | Make / type / model no./ Approved by | | |
| | Area provided with Linear heat sensing cable: | | |
| **25.0** | **Gas Detectors** | | |
| | Make / type / model no./ Approved by | | |
| | Area provide with gas detectors: | | |
| **26.0** | **Manual Call Point** | | |
| | Make / type / model no./ Approved by | | |
| | Area provide with manual call point: | | |

## 1.11.0 WORKSHOP AND CHEMICAL LABORATORY

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| 1.0.0 | **Workshop & Laboratory** | | |
| | Equipment provided by Bidder shall be listed below: | | |
| 2.0.0 | **Area provided** | | |
| a) | Workshop | m x m | |
| b) | Chemical Lab | m x m | |

## 2.0.0 TECHNICAL DATA SHEET - ELECTRICAL

### 2.1.0 GENERATOR

| Sl. No | Description | Unit | Data |
|---|---|---|---|
| 1.0. | Make & Country of Manufacturer | | |
| 2.0. | Model No. (Type) | | |
| 3.0. | Applicable standard | | |
| 4.0. | Protection class for enclosure | | |
| 5.0. | Type of Cooling | | |
| | a) Stator Winding | | |
| | b) Stator Core | | |
| | c) Rotor | | |
| 6.0. | Rated Coolant Pressure | Bar (G) | |
| 7.0. | Rated apparent power | MVA | |
| 8.0. | Rated Power factor | | |
| 9.0. | Rated active power | MW | |
| 10.0. | Rated terminal voltage | kV | |
| 11.0. | Rated current | A | |
| 12.0. | Rated frequency | Hz | |
| 13.0. | Number of poles | - | |
| 14.0. | Number of phases | - | |
| 15.0. | Rated speed | rpm | |
| 16.0. | At generator rated output, rated speed and P.F., permissible variation range in: | | |
| | a) Terminal Voltage | % | |
| | b) Frequency | % | |
| | c) Absolute sum of combined voltage & frequency variation | % | |
| 17.0. | Short circuit ratio at rated output | | |
| 18.0. | Permissible tolerance in SCR | % | |
| 19.0. | **Efficiencies at rated voltage frequency and power factor** | | |
| | a) At maximum capability | % | |
| | b) At 75% MCR and rated p.f. | % | |
| | c) At 50% MCR and rated p.f. | % | |
| | d) At 25% MCR and rated p.f. | % | |

| Sl. No | Description | Unit | Data |
|---|---|---|---|
| 20.0. | **Regulation under condition of rated speed, voltage and output** | | |
| | a) At 0.8 p.f lag (guaranteed) | % | |
| | b) At 1.0 p.f | % | |
| | c) At 0.9 p.f lead | % | |
| 21.0. | Voltage rise during sudden rejection of full load at rated power factor | | |
| | a) With AVR | % | |
| | b) Without AVR | % | |
| 22.0. | Generator reactive capability | | |
| | a) Maximum inductive loading (Zero lag) | MVAR | |
| | b) Maximum capacitive loading (Zero lead) | MVAR | |
| | c) Capacitive loading at rated load and voltage | MVAR | |
| 23.0. | Permissible unbalanced loading subject to current not being exceeded the rated current in any phase | | |
| | a) Maximum continuous negative sequence current | % | |
| | b) Maximum value of I*I*t for transient operation under system fault (I in p.u & t in sec) | Sec | |
| 24.0. | Generator asynchronous operation | | |
| | a) Permissible Load | % of F.L. | |
| | b) Duration | Min. | |
| 25.0. | Short circuit withstand : | | |
| | a) 3-phase terminal fault | kA & sec | |
| | b) Stator Ground fault (For core) :- | | |
| | - Current (Steady state) | Amps | |
| | - Duration | Sec | |
| 26.0. | Max. noise level at a distance of 1.0 m | dB (A) | |
| 27.0. | Vibration limits (on shaft rated speed) | - | |
| 28.0. | Maximum permissible short time unbalanced load (load and time) | % & s | |
| 29.0. | Maximum permissible short time asynchronous load (load and time) | % & s | |
| 30.0. | Permissible overload current & time | | |
| 31.0. | Symmetrical short circuit current and duration | kA & s | |
| 32.0. | Stator core ground fault current and duration | kA & s | |

| Sl. No | Description | Unit | Data |
|---|---|---|---|
| 33.0. | Max. continuous generator capability under one cooler out of operation. | | |
| 34.0. | One min PF withstand Voltage | kV(rms) | |
| 35.0. | Basic impulse level | kV(peak) | |
| 36.0. | Generator Losses | | |
| | a. Iron Loss at No load / at Full load | | |
| | b. Stator copper loss | | |
| | c. Rotor copper loss at no load / full load | | |
| | d. Stray load loss | | |
| | e. Friction & windage loss | | |
| | f. Excitation losses | | |
| 37.0. | Total losses for efficiency calculation | | |
| 38.0. | **Reactance** | | |
| | a) Direct axis transient, saturated | % | |
| | b) Direct axis transient, unsaturated | % | |
| | c) Direct axis sub transient, saturated | % | |
| | d) Direct axis subtransient unsaturated | % | |
| | e) Quadrature axis transient, saturated | % | |
| | f) Quadrature axis transient, unsaturated | % | |
| | g) Quadrature axis subtransient, saturated | % | |
| | h) Quadrature axis subtransient, unsaturated | % | |
| | i) Negative sequence reactance | % | |
| | j) Zero sequence reactance | % | |
| | k) Synchoronous reactance | % | |
| 39.0. | Capacitance of generator stator wdg to ground | Farads | |
| 40.0. | Permissible tolerance in all guaranteed reactance values | % | |
| 41.0. | X/R Ratio | | |
| 42.0. | **Time Constants** | | |
| | a) Transient O.C time constant | s | |
| | b) Transient S.C time constant | s | |
| | c) Sub-transient S.C time constant | s | |
| | d) Armature time constant | s | |

| Sl. No | Description | Unit | Data |
|---|---|---|---|
| | | | |
| 43.0. | **Constructional Features** | | |
| | a) Material of Stator shell | - | |
| | b) Thickness of shell | mm | |
| | c) Material of stator lamination | - | |
| | d) Thickness of laminations | mm | |
| | e) Cooling method | - | |
| | f) Maximum Vibration Severity on Generator/Exciter bearings | - | |
| 44.0. | **Stator Winding** | | |
| | a) Flux density | - | |
| | b) Type of winding | - | |
| | c) Armature Conductor material | | |
| | d) Armature Current density at max. capability | A/mm² | |
| | e) Type of stator insulation | - | |
| | f) Class of insulation | - | |
| | g) Temperature rise (by resistance) | Deg C | |
| | h) Temperature rise (by thermometer) | Deg C | |
| | i) Cooling medium | | |
| | j) Maximum outlet temperature of cooling medium | Deg C | |
| 45.0. | **Rotor winding** | | |
| | a) Type of insulation | - | |
| | b) Class of insulation | - | |
| | c) Temperature rise (by res.) | Deg C | |
| | d) Temp. rise (by thermometer) | Deg C | |
| | e) Cooling medium | - | |
| | f) Max. outlet temperature | Deg C | |
| 46.0. | **Excitation systems** | | |
| | a) Type of excitation system | - | |
| | b) Redundant capacity available | | |
| | c) No load exciter current | A | |
| | d) Exciter current | A | |

| Sl. No | Description | Unit | Data |
|---|---|---|---|
| | e) Exciter voltage | V | |
| 46.1 | **Exciter Machine** | | |
| | a) Manufacturer | - | |
| | b) Type | - | |
| | c) Power Output | | |
| | d) Speed | rpm | |
| | e) Ceiling voltage and time | V&s | |
| | f) Maximum current and time | A&s | |
| | g) Response ratio | - | |
| | h) Insulation class | - | |
| | i) Protection class of enclosure | - | |
| | j) Type of cooling | - | |
| 47.0. | **Automatic voltage regulator** | | |
| | Manufacturer | - | |
| | Type | | |
| | Voltage regulator range | | |
| | Accuracy of voltage control | - | |
| | Response time | s | |
| | CO2 System | s | |
| | Make & type | | |
| | Capacity offered. | | |

## 2.2.0 GENERATOR CONTROL AND RELAY PANEL

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| 1.0 | Name of Manufacturer | | |
| 2.0 | Type of Panel | | |
| 3.0 | Overall dimensions / weight of panel | mm / kg | |
| 4.0 | Degree of protection | - | |
| 5.0 | Sheet metal thickness | mm | |
| 7.0 | **Numerical Multifunction Generator Protection Relay** | | |
| | a) Make & model number | | |
| | b) Type | | |
| | c) Operating principle | | |
| | d) List of protection functions covered | | |
| | e) Whether communicating facility provided. | | |

## 2.3.0 BUS DUCTS

| Sl. No | Description | Unit | Data |
|---|---|---|---|
| **A.** | **Segregated Phase Bus duct** | | |
| 1.0 | Make | | |
| 2.0 | Reference Standard | | |
| 3.0 | Voltage Class | V | |
| 4.0 | Rated Voltage | V | |
| 5.0 | Frequency | Hz | |
| 6.0 | Short circuit current level | kA & sec | |
| 7.0 | Degree of protection | | |
| **8.0** | **Insulation Level** | | |
| | a) 1 min power frequency withstand Voltage | kV rms | |
| | b) Basic Impulse Voltage | kV peak | |
| | c) Rated Continuous Current at 50°Cambient temperature | Amps | |
| **9.0** | **Maximum temperature rise over 50°C ambient** | | |
| | a) Bus Conductor | Deg C | |
| | b) Bus Enclosure | Deg C | |
| | c) Bus joint-Plain/tin plated | Deg C | |
| | d) Bus joint- Silver plated | Deg C | |
| **10.0** | **Rated Short Time Current** | | |
| | a) Symmetrical kA for 3 sec | kA | |
| | b) Momentary | kA Peak | |
| **11.0** | **Material & Grade** | | |
| | a) for Conductor | | |
| | b) for Enclosure | | |
| 12.0 | a) Maximum span between bus support insulators | mm | |
| **13.0** | **Enclosure Data** | | |
| | a) Phase Spacing | | |
| | b) Overall Dimensions | | |
| | c) Thickness | | |
| **14.0** | Inter phase Barrier plate material | | |

| Sl. No | Description | Unit | Data |
|---|---|---|---|
| **B.** | **Non-Segregated phase bus duct** | | |
| 1.0 | Make | | |
| 2.0 | Voltage Class | V | |
| 3.0 | Rated Voltage | V | |
| 4.0 | Phase | | |
| 5.0 | Frequency | Hz | |
| 6.0 | System earthing | | |
| 7.0 | Short circuit current level | | |
| 8.0 | Degree of protection | | |
| **9.0** | **Insulation Level** | | |
| | a) 1 min power frequency withstand Voltage | kV rms | |
| | b) Rated Continuous Current at 50°Cambient temperature | Amps | |
| **10.0** | **Maximum temperature rise over 50°C ambient** | | |
| | a) Bus Conductor | Deg C | |
| | b) Bus Enclosure | Deg C | |
| | c) Bus joint-Plain/tinned | Deg C | |
| | d) Bus joint-Silver plated | Deg C | |
| **11.0** | **Rated Short Time Current** | | |
| | a) Symmetrical kA for 1 sec | kA rms | |
| | b) Momentary | kAp | |
| **12.0** | **Material & Grade** | | |
| | a) Conductor | | |
| | b) Enclosure | | |
| 13.0 | a) Maximum span between bus support | mm | |
| **14.0** | **Enclosure Data** | | |
| | a) Phase to phase clearance | | |
| | b) Phase to earth clearance | | |
| | c) Thickness of sheet steel | | |

## 2.4.0 TRANSFORMERS

| Sl.No. | Description | Units | Data | |
|---|---|---|---|---|
| A | **Generator transformer / Station transformer** | | Generator transformer | Station transformer |
| 1.0 | Name & Place of Manufacturer | | | |
| 2.0 | Service | | | |
| 3.0 | Application/Designation | - | | |
| 4.0 | Reference Standards | - | | |
| 5.0 | MVA rating (OFAF/ONAF/ONAN cooling) | MVA | | |
| 6.0 | Rated no load voltage ratio | | | |
| 7.0 | Rated frequency | Hz | | |
| 8.0 | Number of phases | - | | |
| 9.0 | Winding Connections ( HV & LV ) | - | | |
| 10.0 | Vector group | | | |
| 11.0 | Type of Tap Changer | - | | |
| | a) Range | - | | |
| | b) Number of steps | | | |
| | c) Voltage variation effected on (HV/LV) | - | | |
| | d) Type of Voltage variation | - | | |
| 12.0 | Reference ambient temperatures | | | |
| | a) Maximum ambient air temperature | Deg C | | |
| | b) Maximum daily average ambient air temperature | Deg C | | |
| | c) Maximum yearly weighted average ambient temperature | Deg C | | |
| 13.0 | Type of Transformer Neutral earthing for HV | | | |
| 14.0 | Type of Cooling | | | |
| 15.0 | Temperature rise over 50 deg C ambient | | | |
| | a) Top oil by Thermometer method | Deg C | | |
| | b) Windings by Resistance method | Deg C | | |
| 16.0 | Hot spot temperature at weighted reference ambient temperature | Deg C | | |
| 17.0 | Efficiencies at 75 Deg. C at Unity Power factor | | | |
| | a) at full load | % | | |
| | b) at 3/4 of full load | % | | |

| Sl.No. | Description | Units | Data | |
|---|---|---|---|---|
| | c) at 1/2 of full load | % | | |
| 18.0 | Regulation at full load at 75 deg. C | | | |
| | a) at unity power factor | % | | |
| | b) at 0.8 p.f. lagging | % | | |
| 19.0 | Total losses at rated voltage at Principal tapping & at rated frequency including auxiliary loss | kW | | |
| 20.0 | Component losses | | | |
| | a) No load loss at rated voltage on principal tapping & at rated frequency | kW | | |
| | b) Load loss at rated current at principal tapping at 75 Deg. C excluding auxiliary loss | kW | | |
| | c) Auxiliary losses (Cooler loss) | kW | | |
| 21.0 | Impedance voltage at rated current at nominal tap / minimum tap / maximum tap | % | | |
| 22.0 | Reactance at rated current & rated frequency ( HV-LV ) | % | | |
| 23.0 | No load current at rated voltage and rated frequency | % | | |
| 24.0 | Separate source power frequency withstand voltage Insulation level of HV & LV windings | kV rms | | |
| 25.0 | Induced over Voltage withstand level of HV & LV windings | kV rms | | |
| 26.0 | Full wave lightning Impulse withstand voltage of HV & LV windings | kVp | | |
| 27.0 | Switching Impulse withstand voltage of HV & LV windings | kVp | | |
| 28.0 | Short circuit withstand current & Duration | | | |
| 29.0 | No. of radiators/ radiator bank | | | |
| 30.0 | Rating of each radiator bank | % | | |
| 31.0 | Type of Termination for HV & LV | | | |
| 32.0 | HV Terminal arrangement | | | |
| | b) Type | | | |
| | c) Minimum Creepage distance | mm | | |
| | e) Lightening impulse voltage | KVP | | |
| | f) Power frequency withstand voltage | KVrms | | |
| | | | | |
| 33.0 | LV Terminal arrangement | | | |

| Sl.No. | Description | Units | Data | |
|---|---|---|---|---|
| | b) Type | | | |
| | c) Minimum Creepage distance | mm | | |
| | e) Lightening impulse voltage | KVP | | |
| | f) Power frequency withstand voltage | KVrms | | |
| 34.0 | HV Neutral Terminal arrangement | | | |
| | b) Type | | | |
| | c) Minimum Creepage distance | mm | | |
| | e) Lightening impulse voltage | KVP | | |
| | f) Power frequency withstand voltage | KVrms | | |
| 35.0 | Oil quantity required for first filling | Lts. | | |
| 36.0 | Max. flux density in core at tap which corresponds to | | | |
| | a) Rated voltage & frequency | Tesla | | |
| | b) 110% rated voltage & 100% rated frequency | Tesla | | |
| | c) 125% rated voltage & 100% rated frequency | Tesla | | |
| | d) 140% rated voltage & 100% rated frequency | Tesla | | |
| 37.0 | Overfluxing withstand capability of transformer at | | | |
| | a) 110% rated voltage & 100% rated frequency | sec. | | |
| | b) 125% rated voltage & 100% rated frequency | sec. | | |
| | c) 140% rated voltage & 100% rated frequency | sec. | | |
| 38.0 | Resistance per phase at 75 deg C winding temperature of | | | |
| | a) HV windings( principal tap) | ohm | | |
| | b) LV windings | ohm | | |
| 39.0 | Winding Current density for HV & LV | Amps/ sq.mm | | |
| 40.0 | Vacuum withstand capability of tank | | | |
| 41.0 | Thickness of transformer tank ( side / bottom / top plates ) | mm | | |
| 42.0 | Core | | | |
| | a) Material of core laminations | | | |
| | b) Thickness of core laminations | mm | | |

| Sl.No. | Description | Units | Data | |
|---|---|---|---|---|
| | c) Type and thickness of insulation of core laminations | | | |
| 43.0 | Means adopted to prevent displacement of core in tank during | | | |
| | a) Transport from works to site | | | |
| | b) Short circuits | | | |
| | c) Seismic disturbances | | | |
| 47.0 | Cooling Fans for each radiator bank | | | |
| | a) Type | | | |
| | b) No. of working & standby fans | | | |
| | e) Motor rating | kW | | |
| 55.0 | Tap Changer | | | |
| | a) Make | | | |
| | b) Type | | | |
| | c) Voltage variation effected on (HV/LV) | | | |
| | d) Type of Voltage variation | | | |
| | e) Voltage rating | | | |
| | f) Current rating | | | |
| | g) Step voltage | | | |
| | h) No of steps | | | |
| | i) OLTC Motor | | | |
| | • kW rating | | | |
| | • Voltage rating | | | |
| | • Class of insulation | | | |
| | • Degree of protection | | | |
| | • Duty | | | |
| 56.0 | RTCC Panel | | | |
| | a) Make | | | |
| | b) Panel material and thickness | | | |
| | c) Degree of Protection | | | |
| **C)** | **LT transformer ( to be submitted for each rating )** | | | |
| 1.0 | Manufacturer & Place | | | |
| 2.0 | Service | | | |

| Sl.No. | Description | Units | Data | |
|---|---|---|---|---|
| 3.0 | Type | | | |
| 4.0 | Reference standard | | | |
| 5.0 | Quantity | | | |
| 6.0 | Type of cooling | | | |
| 7.0 | Rating | | | |
| 8.0 | Rated kVA | KVA | | |
| 9.0 | Rated voltage HV/LV | kV | | |
| 10.0 | Number of phases | | | |
| 11.0 | Rated Frequency | HZ | | |
| 12.0 | Rated current for HV & LV side | Amps | | |
| 13.0 | HV no load current at rated voltage | Amps | | |
| 14.0 | No load current as a percentage of Rated Full load current | | | |
| 15.0 | Maximum guaranteed Temperature rise above 50° C ambient | | | |
| | a) in oil by thermometer | ° C | | |
| | b) in winding by resistance | ° C | | |
| 16.0 | Connections ( HV & LV windings ) | | | |
| 17.0 | Vector group | | | |
| 18.0 | Winding material | | | |
| 19.0 | Winding insulation category | | | |
| 20.0 | Hot spot temperature in winding at yearly weighted ambient temperature of 32°C | °C | | |
| 21.0 | **Losses** | | | |
| | a) Guaranteed losses | | | |
| | b) No-load loss at rated voltage & frequency (Max.) | kW | | |
| | c) Load loss at rated current at 75 ° C (Max.) | kW | | |
| 22.0 | Impedance | % | | |
| 23.0 | Resistance at 75 deg C | Ohms | | |
| 24.0 | Guaranteed Efficiency at 75 °C winding temperature and at 0.8 p.f. lag | | | |
| | a) At full load | % | | |
| | b) At 3/4 load | % | | |
| | c) At 1/2 load | % | | |

FORMT9-P REV-A (MUM)

| Sl.No. | Description | Units | Data | |
|---|---|---|---|---|
| 25.0 | Maximum short time current rating of transformer | Amps | | |
| 26.0 | Regulation at full load and at 75° C at upf & 0.8 pf lag | % | | |
| 27.0 | Maximum flux density | | | |
| | a) At rated voltage | Wb / m2 | | |
| | b) At 110% rated voltage | Wb / m2 | | |
| 28.0 | Type of oil preservation system | | | |
| 29.0 | Type of Pressure relief device | | | |
| 30.0 | Termination arrangement HV side / LV side / LV neutral side | | | |
| 31.0 | **Details of bushings ( HV, LV & LV neutral )** | | | |
| | a) Type | | | |
| | b) Voltage class | kV | | |
| | c) Power frequency withstand voltage (wet & dry) | kV | | |
| | d) Impulse withstand voltage | kV | | |
| | e) Creepage distance | mm | | |
| 32.0 | HV Cable box | | | |
| | a) Degree of protection | | | |
| | b) Phase to Phase Clearances | mm | | |
| | c) Phase to earth Clearances | Mm | | |
| 33.0 | LV Busduct Adapter box | | | |
| | a) Degree of protection | | | |
| | b) Phase to Phase Clearances | mm | | |
| | c) Phase to earth Clearances | mm | | |
| 34.0 | LV Neutral Bushing Current transformers | | | |
| | a) Type | | | |
| | b) Current ratio | | | |
| | c) Burden and accuracy class | | | |
| | Short time withstand current and duration | kA & sec | | |
| 35.0 | Radiator | | | |
| | a) Type & material | | | |
| | b) No. of radiators / bank | | | |

| Sl.No. | Description | Units | Data | |
|---|---|---|---|---|
| | c) Thickness of steel | mm | | |
| | d) Pressure withstand capacity | Kg / m² | | |
| 36.0 | Vacuum withstand capacity of main tank, radiators & accessories. | mm of Hg | | |
| 37.0 | Tank details | | | |
| | a) Thickness of side plate | Mm | | |
| | b) Thickness of top plate | Mm | | |
| | c) Thickness of bottom plate | Mm | | |
| | d) Pressure withstand capacity | Kg /m² | | |
| | e) Vacuum withstand capacity | mm of Hg | | |
| 38.0 | Minimum clearance height for lifting core and winding from tank | mm | | |
| 39.0 | Dimension/ Weight of transformer | | | |
| | a) Overall dimension L x W x H | mxmxm | | |
| | b) Total weights | Kg | | |
| 40.0 | Oil quantity | Litre | | |
| 41.0 | Marshalling box Degree of protection | | | |

**2.5.0 66KV GIS**

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| 1. | General | | |
| 2. | Name of manufacturer | | |
| 3. | Country of origin | | |
| 4. | Delivery from | | |
| 5. | Type & designation | | |
| 6. | Type tested at | | |
| i) | Name of Laboratory | | |
| ii) | Address of Laboratory | | |
| 7. | Installation (Indoor / Outdoor) | | |
| 8. | Standards applicable | | |
| 9. | No. of Phases | | |
| 10. | Single or Three Phase design | | |
| 11. | **Configuration** | | |
| i) | Number of Feeder bays | | |
| ii) | Number of transformer bays | | |
| iii) | Number of Bus coupler bay | | |
| iv) | GIS to transformer connection | | |
| v) | GIS to Feeder connection | | |
| vi) | Number of VT | | |
| vii) | Number of SA | | |
| viii) | Future extension possibility | | |
| | | | |
| 12. | **Service conditions** | | |
| i) | Ambient Air Temp. in Deg. C | | |
| ii) | Max Temp. in Deg. C | | |
| iii) | Min Temp. in Deg. C | | |
| iv) | Creepage distance, in mm/kV | | |
| v) | Vibration level | | |
| vi) | Noise level | | |
| | | | |
| 13. | **Enclosure** | | |
| i) | Type of manufacturing | | |
| ii) | Design temperature in Deg.C | | |
| iii) | Material | | |
| iv) | Material grade & applicable standard | | |
| v) | Outside diameter in mm | | |
| vi) | Minimum Wall Thickness, in mm | | |
| vii) | Painting Shade & Thickness | | |
| | a) External | | |
| | b) Internal | | |
| viii) | Degree of Protection | | |
| ix) | Inductance in H/mt | | |
| x) | Capacitance in pF/mt | | |
| xi) | Resistance in Ohm/mt | | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| xii) | Expansion Bellow | | |
| | a) Material | | |
| | b) Min allowable adjustable displacement<br>c) Longitudinal<br>d) Transverse | | |
| xiii) | Sealing system | | |
| | a) Type | | |
| xiv) | Estimated life in years | | |
| xv) | Barrier | | |
| | a) Material | | |
| | b) Dielectric strength | | |
| | | | |
| 14. | **Support Structure** | | |
| i) | Material | | |
| ii) | Minimum thickness of galvanizing | | |
| iii) | Foundation channels /Anchor bolts | | |
| | | | |
| 15. | **Grounding** | | |
| i) | Grounding Material | | |
| ii) | Grounding of complete GIS | | |
| iii) | Grounding of individual compartment | | |
| iv) | Grounding at flange joints | | |
| | | | |
| 16. | **System Parameters** | | |
| i) | Rated voltage of System in kV | | |
| ii) | Rated voltage of Equipment in kV | | |
| iii) | | | |
| iv) | Rated Insulation level Phase to Earth and between Phases | | |
| a) | One Min Power Frequency withstand voltage | kVrms | |
| b) | Switching impulse withstand voltage, | kVp | |
| | - Phase to Earth | | |
| | - Between Phases | | |
| c) | Lightning Impulse withstand voltage, | kVp | |
| i) | Rated Frequency | | |
| ii) | Rated current | Amp | |
| iii) | Rated current at 50 °C (equipment) in Amp | | |
| iv) | Rated current at 50 °C (bus bar) in Amp | | |
| v) | Rated short circuit withstand current | kArms | |
| | a. Duration in sec | | |
| | b. Peak, kAp | | |
| vi) | Enclosure withstand time for an internal fault | sec. | |
| vii) | Estimated total energy loss at | | |

FORMT9-P REV-A (MUM)

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| | • 100 % of rated capacity | | |
| | • 75 % of rated capacity | | |
| | • 50 % of rated capacity | | |
| | • 25 % of rated capacity | | |
| viii) | Measures taken to minimize Over Voltage | | |
| ix) | Phase labeling | | |
| | | | |
| 17. | **Bus Bar** | | |
| i) | Configuration (Single / Double) | | |
| ii) | Nos of Phases | | |
| iii) | Material | | |
| iv) | Size | | |
| v) | Rating | | |
| vi) | Current density adopted | | |
| vii) | Short time current withstand rating in kA | | |
| viii) | Duration | | |
| ix) | Resistance per phase | | |
| x) | | | |
| xi) | SF6 immersed insulator | | |
| xii) | Material | | |
| xiii) | Dielectric strength | | |
| xiv) | Maximum Partial Discharges measured at HSV | | |
| 18. | **SF6 Gas** | | |
| i) | Applicable standard | | |
| ii) | Quantity of SF6 Gas of complete GIS at filling pressure, in kg | | |
| iii) | Quantity of SF6 Gas of **largest** compartment | | |
| iv) | GIS at filling pressure, in kg | | |
| v) | Nos of Gas compartments | | |
| vi) | Quantity of SF6 Gas of **individual** compartment | | |
| vii) | GIS at filling pressure, in kg | | |
| | | | |
| | **PRESSURE** | MPa | |
| viii) | Design pressure | | |
| | a) Circuit breaker | | |
| | b) Other compartments | | |
| ix) | Rated filling pressure | | |
| | a) Circuit breaker | | |
| | b) Other compartments | | |
| x) | Type tested pressure. | | |
| | a) Circuit breaker | | |
| | b) Other compartments | | |
| xi) | Routine test pressure | | |
| | a) Circuit breaker | | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| | b) Other compartments | | |
| xii) | Operating pressure of PRD | | |
| | a) Circuit breaker | | |
| | b) Other compartments | | |
| xiii) | Alarm Pressure | | |
| | a) Circuit breaker | | |
| | b) Other compartments | | |
| | c) CB lock out Pressure | | |
| | d) Over pressure signaling | | |
| | Maximum SF6 Gas leakage rate, in % per year | | |
| | | | |
| xiv) | Density Monitor to be provided for each | | |
| xv) | Individual gas compartment. | | |
| xvi) | **GIS to Line connection** | | |
| xvii) | **GIS to Transformer connection** | | |
| | | | |
| 19. | **Circuit Breakers** | | |
| i) | Applicable standards | - | |
| ii) | Rated Voltage | kV | |
| iii) | Type of circuit breaker | - | |
| iv) | Continuous current | - | |
| v) | Rated short-circuit breaking current | kA (rms) | |
| vi) | Rated duration of short circuit | s | |
| vii) | Rated short circuit making current | kA | |
| viii) | Maximum rise of temperature over ambient for continuous current rating | °C | |
| ix) | Rated operating duty | - | |
| x) | Total Interrupting Time | | |
| | • Minimum | ms | |
| | • Maximum | ms | |
| xi) | Closing time | ms | |
| xii) | Rated transient recovery voltage for terminal | kV | |
| xiii) | First pole to clear factor | - | |
| xiv) | Rated transient recovery voltage for short-line faults | kV peak | |
| xv) | No. of breaks in series per pole | - | |
| xvi) | Insulation level of the breaker | | |
| | • One minute power frequency withstand Voltage | kV (rms) | |
| | • Impulse withstand voltage | kV (rms) | |
| | • Switching surge withstand test voltage | kV (rms) | |
| xvii) | Radio interference voltage | | |
| | • Test Voltage | kV | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| | • RI level | Micro Volt | |
| xviii) | Visual discharge voltage for falling power frequency voltage | kV | |
| xix) | Minimum clearance in air parts | mm | |
| xx) | Between live parts and earth | mm | |
| xxi) | Centre to centre distance between phases | mm | |
| xxii) | Type of operating mechanism | | |
| xxiii) | Method of tripping | | |
| | • Normal | - | |
| | • Emergency | - | |
| | • Normal voltage of trip coil | V | |
| xxiv) | Pick-up range | V | |
| xxv) | Power for tripping mechanism | W | |
| xxvi) | Method of closing | | |
| | • Normal voltage of closing coils | V | |
| | • Power for closing mechanism | W | |
| xxvii) | Rated line charging breaking current | A | |
| xxviii) | Rated cable charging breaking current | A | |
| xxix) | Rated (single) capacitor bank breaking current | A | |
| xxx) | Critical current (current giving the longest arc when a break takes place) | | |
| xxxi) | Maximum over voltage to earth of the circuit breaker when breaking currents of : | | |
| | • Unloaded transformers | kV peak | |
| | • Unloaded line | kV peak | |
| | • Capacitor banks | kV peak | |
| | • Cable charging | kV peak | |
| | When switching off a synchronous system: | | |
| | • Maximum current | kA | |
| | • Maximum recovery voltage between contacts of one pole | kA | |
| xxxii) | Number of operations, the circuit breaker is capable of performing without inspection, replacement of contacts or other main parts at | | |
| | • Rated interrupting capacity | - | |
| | • Rated continuous current | - | |
| xxxiii) | Overall dimension of complete 3-phase circuit breaker with structure | Dwg enclosed Yes/No | |
| xxxiv) | Weight of complete 3-phase circuit breakers | kg | |
| xxxv) | Whether all type test reports as per latest relevant standards are enclosed ? | Yes/ No | |
| xxxvi) | Whether literature enclosed giving details of arching chamber, main and arching | Yes/No | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| | contacts. | | |
| xxxvii) | Air compressor | | |
| | • Type | - | |
| | • Make | - | |
| | • Capacity | l/minute | |
| | • Rated pressure | kg/cm² | |
| xxxviii) | Safety valve opens on | | |
| xxxix) | Compressor operations | | |
| | • Start at | kg/cm² | |
| | • Stop at | kg/cm² | |
| xl) | Alarm switch closes on air receiver at | kg/cm² | |
| xli) | Permissible minimum pressure | kg/cm² | |
| xlii) | Lockout switch on air receiver operation, at pressure | | |
| | • for closing | kg/cm² | |
| | • for opening | kg/cm² | |
| | • for autoreclosure duty | kg/cm² | |
| xliii) | Time for air compressor to charge the storage reservoirs | | |
| | • from atmospheric to pressure specified | minutes | |
| xliv) | Number of stored close-open operations | | |
| 20. | **Disconnectors** | | |
| i) | Type of Disconnector | | |
| ii) | Rated Voltage | kV | |
| iii) | Current rating | | |
| | • Continuous at site conditions | A | |
| | • Dynamic | kA | |
| | • One second | kA | |
| iv) | One minute power frequency wet withstand voltage | | |
| | • Across the isolating distance | kV | |
| | • To earth and between poles | kV | |
| | 1.2 x 50 □s impulse withstand voltage (+ polarity) | | |
| | • Across the isolating distance | kV peak | |
| | • To earth and between poles | kV peak | |
| v) | Contacts and material of current carrying parts | - | |
| vi) | Type of main and arcing contacts | - | |
| vii) | Material of contacts ( main & arcing ) | - | |
| viii) | Whether contacts are silver faced | Yes/No | |
| ix) | Operating mechanism Manual/ pneumatic/ motor | | |
| 21. | **Insulator Data** | | |
| i) | Type | - | |
| ii) | Number of units | mm | |
| iii) | Cantilever strength upright | kg | |

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| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| iv) | Creepage distance ( total & protected ) | | |
| 22. | **Current Transformers** | | |
| i) | Application | - | |
| ii) | Nominal system voltage & frequency | kV, Hz | |
| iii) | Highest System voltage | kV | |
| iv) | No. of cores | - | |
| v) | Current transformer ratio | A | |
| vi) | Secondary current | A | |
| vii) | Short time thermal rating | kA | |
| viii) | Class of Insulation | - | |
| ix) | Cantilever strength of CT at the terminal | kgm | |
| x) | Creepage distance total | mm | |
| 23. | **Voltage Transformer** | | |
| i) | Type | | |
| ii) | Application | - | |
| iii) | Nominal/Highest System Voltage | kV | |
| iv) | Power frequency | Hz | |
| v) | Rated primary voltage | kV | |
| vi) | Rated secondary voltage | kV | |
| vii) | No. of secondary windings | - | |
| viii) | Rated burden | VA | |
| ix) | Accuracy class | - | |
| x) | Class of winding insulation | - | |
| xi) | Creepage distance (total) | mm | |
| xii) | 1.2/50 □s impulse voltage withstand | kV peak | |
| xiii) | One minute power frequency voltage withstand | kV | |
| 24. | **Surge Arresters** | | |
| i) | Type of arrester | - | |
| ii) | Nominal System Voltage | kV | |
| iii) | Rating | kA | |
| iv) | Rated Arrester Voltage/ Continuous Operating Voltage | kV | |
| v) | Nominal Discharge current of 8/20 Micro second wave shape | kA | |
| vi) | Impulse current with stand | | |
| | • Low current long duration discharge Class (as per IEC 99) | - | |
| | • High current short duration test value (4/10 □s Wave) | kA | |
| | • Low current long duration test value | kA | |
| | • Virtual duration of rectangular wave | □s | |
| | • Residual voltage corresponding to | - | |
| | • Steep current impulse | kV peak | |
| | • Lightning impulse | kV peak | |
| | • Switching impulse | kV peak | |
| | • Line Discharge class (As per IEC | kV peak | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| | TC37 WG-4 1985) | | |
| vii) | Arrester Housing withstand test voltages | | |
| | • One minute power frequency dry & wet | kV (rms) | |
| | • 1.2/50 micro-second impulse | kV peak | |
| viii) | Creepage Distance | mm | |
| ix) | Minimum Cantilever strength of arrester Assembly | | |
| x) | Pressure Relief Class (As per IEC-99) | - | |
| xi) | Minimum prospective symmetrical fault current | kA | |
| 25. | **Bus Post Insulator for OHL Bushing** | | |
| i) | Make and country of manufacturer | - | |
| ii) | Type | - | |
| iii) | Voltage class | kV | |
| iv) | Total creepage distance | mm | |
| v) | Cantilever strength | kg | |
| vi) | Withstand Voltages | | |
| | • 1 min power frequency (Dry) | kV | |
| | • 1 min power frequency (wet) | kV | |
| | • 1.2/50 micro sec. Impulse (Dry) | kV peak | |
| | • 1.2/50 micro sec. Impulse (wet | kV peak | |
| vii) | Puncture voltage | kV peak | |
| 26. | **Disc Insulator** | | |
| i) | Voltage class | - | |
| ii) | Make and country of manufacturer | - | |
| iii) | Type | - | |
| iv) | Creepage distance | mm | |
| v) | Electromechanical strength | kg | |
| vi) | Withstand voltages | | |
| | • 1 min power frequency (Dry) | kV | |
| | • 1 min power frequency (wet) | kV | |
| | • 1.2/50 micro sec impulse (Dry) | kV peak | |
| | • 1.2/50 micro sec. impulse (wet) | kV peak | |
| vii) | Puncture voltage | kV peak | |
| 27. | **Protection Relays** (Shall be furnished for all relays) | | |
| i) | Make and country of manufacturer | | |
| ii) | Type | | |
| iii) | Relay burden at rated voltage | VA | |
| iv) | Indication provided | | |

## 2.6.0 HT SWITCHGEAR

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| **1.0** | **Switchgear Assembly** | | |
| | a) Make & country of manufacturer | - | |
| | b) Type | - | |
| | c) Reference Standards | - | |
| | d) Voltage (Nom./Max.) | kV | |
| | e) Phase, Frequency | No, Hz | |
| | f) Short Circuit Rating | - | |
| | • Peak withstand | kA peak | |
| | • Short-time withstand for 3s | kA rms | |
| | • Momentary withstand capacity of the entire switchgear | kA | |
| | • Internal Arc classification | | |
| | • Loss of service continuity classification | | |
| | g) Insulation level | | |
| | • Impulse voltage withstand | kV peak | |
| | • One minute power frequency withstand voltage | kV | |
| | h) Degree of protection | - | |
| **2.0** | **Busbar** | | |
| | a) Material & Grade | - | |
| | b) Cross sectional Area/Size | mm²/mm | |
| | c) Continuous Current (at site condition, 50°C ambient and within cubicle) | A | |
| | d) Maximum temperature (absolute) for an ambient of 50°C | °C | |
| **3.0** | **Bus support insulator** | | |
| | a) Type/Material | | |
| | b) Voltage Class | kV | |
| **4.0** | **Circuit Breaker** | | |
| | a) Make | | |
| | b) Type | | |
| | c) Rated voltage | kV | |
| | d) Max. continuous voltage | kV | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| | e) Short-time current for 3s | kA rms | |
| | f) Max. temperature (absolute) for an ambient of 50°C | °C | |
| | g) Rated operating duty | - | |
| **5.0** | **Interrupting capacity at rated voltage and operating duty** | | |
| | a) Symmetrical | kA rms | |
| | b) Asymmetrical KA peak | kA | |
| | c) Maximum DC component | % | |
| **6.0** | **Type & Material of contacts** | | |
| | a) Main | - | |
| | b) Arcing | - | |
| | c) Whether contacts silver plated | - | |
| **7.0** | **Minimum clearance in air** | | |
| | a) Type of arc control device provided | - | |
| | b) Type | - | |
| | c) Operating Mechanism | - | |
| | d) No. of breaker operations stored | - | |
| | e) Spring reserve for one C-O-C-O operation available | Yes/No | |
| | f) Method of closing during power supply failure | - | |
| **8.0** | **Spring charging motor** | | |
| | a) Class of Insulation | - | |
| | b) Time required to charge the spring from fully discharged condition | s | |
| **9.0** | **Number of operations before interrupter maintenance required** | | |
| | a) At rated short circuit current | - | |
| | b) At full load current | - | |
| **12.0** | **Relays ( details to be provided for each relay )** | | |
| | a) Provided with built-in test facilities | (Yes/No) | |
| | b) Type of mounting | - | |
| | a) Make | - | |
| | b) Type | - | |
| | c) Setting range | % | |
| | d) No. of contacts | - | |
| | e) Burden | VA | |

### 2.7.0 LT SWITCHGEAR

(For each PCC/MCC/DB, the datas shall be filled up separately)

| Sl.No. | Description | Unit | Data |
|---|---|---|---|
| **1.0** | **PCC / MCC/DB** | | |
| | a) Make | - | |
| | b) Type | - | |
| | c) Reference Standard | - | |
| | d) Voltage (Nom./Max) | V | |
| | e) Phase/Frequency | No/Hz | |
| | f) Short Circuit Rating | | |
| | • Interrupting Symmetrical | kA rms | |
| | • Short-time for 1 sec | kA rms | |
| | g) Insulation level | kV | |
| | h) Degree of Protection | - | |
| | i) Dimensions of vertical section in mm (L x D x H) | mmxmmxmm | |
| | j) Equipment working height limits from floor level | mm | |
| **2.0** | **Bus conductor** | | |
| | a) Material & Grade | - | |
| | b) Busbar size | $mm^2$ | |
| | c) Current density | $A/mm^2$ | |
| | d) Support spacing | m | |
| | e) Type of insulating sleeve for busbars | - | |
| | f) One second withstand capability | kA (rms) | |
| | g) Temperature rise over 50°C ambient | | |
| | • for rated current | °C | |
| | • for short circuit current | °C | |
| | h) Minimum clearance of busbars and connections | | |
| | • Phase to phase | mm | |
| | • Phase to ground | mm | |
| | i) Bus support insulator | | |
| | • Material | - | |
| | • Min. total creepage distance | mm | |
| **3.0** | **Air Circuit Breaker** | | |
| | a) Make | - | |
| | b) Type | - | |
| | c) Standards applicable | - | |
| | d) Rated voltage | V | |
| | e) Continuous current rating | | |
| | • As per manufacturer's standard | A | |
| | • Under site conditions after derating for ambient and within cubicle | A | |
| | f) Symmetrical and asymmetrical interrupting current | kA rms | |
| | g) Making current (peak) | kA | |

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| Sl.No. | Description | Unit | Data |
|---|---|---|---|
| | h) Total opening time (measured from trip coil energisation) | m s. | |
| | i) Closing time | m s. | |
| **4.0** | **Contactors (Please furnish datas separately for AC & DC contactors)** | | |
| | a) Type | - | |
| | b) Rated making capacity | kA | |
| | c) Rated breaking capacity | kA | |
| | d) Duty category | - | |
| | e) Class of Protection for Motor feeders | - | |
| **8.0** | **Relays** | | |
| | a) Make & type | - | |
| | b) Relays details (Type reference for each application is to be Furnished) | - | |

**2.8.0 DC SYSTEM**

(for each type & rating of battery & chargers)

| Sl.No. | Description | Unit | Data |
|---|---|---|---|
| **1.0** | **Battery** | - | |
| | a) Make & Country | - | |
| | b) Type | | |
| | c) Rated capacity for one hour | Ah | |
| | d) Rated system voltage | V | |
| | e) System voltage limits permitted for one hour capacity | V | |
| | f) Number of cells per battery | - | |
| | g) Material of electrodes | - | |
| | h) Electrolyte | | |
| | i) Nominal voltage per cell | V | |
| | j) End cell voltage | | |
| | k) Type of operation | - | |
| | l) Short circuit current | kA | |
| | m) Mounting type | - | |
| | n) AH efficiency at rated load | % | |
| | o) Watt Hour Efficiency | % | |
| | p) Load cycle curve furnished | Yes/No | |
| **2.0** | **Charger** | | |
| | a) Make & Country | - | |
| | b) Type | - | |
| | c) Rectifiers with thyristors | Yes/No | |
| | d) Number of chargers | - | |
| | e) Rated input AC voltage | V | |
| | f) Frequency | Hz | |
| | g) Rated output DC voltage | V | |
| | h) Output DC current | A | |
| | i) Rectifier Efficiency | | |
| | j) Charging voltage | V | |
| | • Float charging | V/Cell | |
| | • Boost charging | V/Cell | |
| | k) Protection class of cubicles | - | |
| | l) Residual ripple | % | |
| | m) Height x width x depth of cubicles | mm | |
| **3.0** | **Rectifier Transformer** | | |
| | a) Make & Country | - | |
| | b) Type | - | |
| | c) Rating | kVA | |
| | d) Voltage ratio | V/V | |
| | e) Insulation class | - | |

**2.9.0 UPS**

| Sl.No. | Description | Unit | Data |
|---|---|---|---|
| **1.0** | **GENERAL** | | |
| | a) Make & Country | | |
| | b) Type | | |
| | c) UPS Capacity ( at 0.8p.f & upf ) | | |
| | d) Output Voltage and regulation | V, % | |
| | e) Frequency and regulation | Hz, % | |
| | f) Radio interference suppression | Yes/ No | |
| **2.0** | **CHARGER** | | |
| | a) Float Charging voltage & current | | |
| | b) Boost Charging voltage & current | | |
| | c) Nominal Voltage | V | |
| | d) Voltage Regulation for AC Input Variations & Load Variations | % | |
| | e) Ripple | % | |
| | f) Time to recharge the completely discharged battery | s | |
| | g) Protection class of cubicles | - | |
| | h) Over load current limit | % | |
| | i) Type of Rectifier Bridge Circuit | - | |
| | j) Rectifier Efficiency | % | |
| **3.0** | **BATTERIES** | | |
| | a) Nominal System Voltage | V | |
| | b) Nominal Cell Voltage | V | |
| | c) End Cell Voltage | V | |
| | d) Duty cycle of the battery | hour | |
| | e) Battery Capacity | Ah | |
| | f) Ah efficiency at rated load | % | |
| | g) Watthour efficiency | % | |
| **4.0** | **INVERTER SYSTEM** | | |
| | a) Type | - | |
| | b) Type of power switching | - | |
| | c) Input | - | |
| | d) Nominal input DC voltage | V | |
| | e) Input DC voltage range | - | |
| | f) Output AC Voltage | V | |
| | g) Voltage adjustment range | % | |
| | h) Accuracy (Steady State) | - | |
| **5.0** | **Transient voltage regulation for** | | |
| | • 50 % step load change | | |
| | • Sudden input voltage change of + 10 % | | |
| | • Loss and return of input AC power | | |
| **6.0** | **Transient recovery time** | | |
| | • Recovery to 95% | | |
| | • Recovery to nominal value | | |

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| Sl.No. | Description | Unit | Data |
|---|---|---|---|
| | a) Output Frequency | Hz | |
| | b) Frequency regulation | | |
| | c) Hormonic Distortion | | |
| **7.0** | **Guaranteed Efficiency** | | |
| | • At 100 % load | % | |
| | • At 50 % load | % | |
| | a) Power factor range | - | |
| | b) Protection class of cubicles | - | |
| **8.0** | **STATIC TRANSFER SWITCHES** | | |
| | a) Type | - | |
| | b) Voltage | V | |
| | c) Frequency | Hz | |
| | d) Transfer time | ms | |
| **9.0** | **BYPASS/ INVERTER/RECTIFIER TRANSFORMER** | | |
| | a) Type | - | |
| | b) Voltage Ratio | V/V | |
| | c) Frequency | Hz | |
| | d) Type of cooling | - | |
| | e) Winding insulation class | - | |

## 2.10.0 MOTORS & ACTUATORS
## ( for each rating & type )

| Sl.No. | Description | Unit | Data |
|---|---|---|---|
| **A** | **MOTORS (Bidder to fill data for each type and rating of motor)** | | |
| 1.0 | Application | - | |
| 2.0 | Make & Country | - | |
| 3.0 | Applicable standard | - | |
| 4.0 | Type of motor | - | |
| 5.0 | Service | - | |
| 6.0 | Duty cycle/ designation | - | |
| 7.0 | Rated speed | rpm | |
| 8.0 | Rated voltage and Voltage variation range | V | |
| 9.0 | Rated frequency and Frequency variation range | Hz | |
| 10.0 | Full load current | A | |
| 11.0 | No load current | A | |
| 12.0 | Rated power factor | - | |
| **13.0** | **Efficiency at rated voltage and frequency** | | |
| | a) Full load | | |
| | b) Three quarter | | |
| | c) 50% load | % | |
| 14.0 | Method of starting | - | |
| 15.0 | Starting current at rated voltage (as % of full load current) | % | |
| 16.0 | Starting current at 80% of rated voltage (as % of full load current) | % | |
| 17.0 | Starting torque (as % of full load torque) | % | |
| **19.0** | **Locked rotor withstand time** | | |
| | • from cold | s | |
| | • from hot | s | |
| 20.0 | Degree of protection of enclosure | | |
| 21.0 | Method of cooling | - | |
| 22.0 | Insulation class | - | |
| 23.0 | Temperature rise over max. ambient | °C | |
| 24.0 | No. of hot starts | | |
| 25.0 | Winding connection | - | |
| | **Motor Terminal Box** | | |
| | a) Type | - | |
| | b) Fault with-stand current and time | kA, s | |
| **B** | **ACTUATORS (Bidder to fill data for each actuator)** | | |
| 1.0 | Make | - | |
| 2.0 | Type | - | |
| 3.0 | Application | - | |
| 4.0 | Rating | | |

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## 2.11.0 BLACK START CUM EMERGENCY DG SET

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| **1.0** | **General** | | |
| | a) Make | | |
| | b) Model no. | | |
| | c) Type of Engine | | |
| | d) Continuous duty rating | | |
| | e) at design condition | kW | |
| | f) at site condition | kW | |
| | g) Operating speed | rpm | |
| | h) Trip speed | rpm | |
| | i) Design life | Hours | |
| **2.0** | **Engine Details** | | |
| | a) No. of cylinders and arrangement | - | |
| | b) Total piston displacement volume | $m^3$ | |
| | c) Shaft critical speed | rpm | |
| **3.0** | **Fuel Consumption** | | |
| | a) Fuel grade | | |
| | b) Consumption at continuous duty rating | kg/kwhr | |
| | c) Consumption at generator rated output | kg/kwhr | |
| | d) Engine fuel oil tank capacity | l | |
| **4.0** | **Engine Lubrication** | | |
| | a) Oil grade | - | |
| | b) Oil consumption at rated output | kg/kwhr | |
| | c) Engine pump oil capacity | l | |
| | d) Lube oil pump capacity | - | |
| **5.0** | **Fuel oil System** | | |
| | a) Fuel oil storage tank capacity | l | |
| | b) Design standard of tank | - | |
| **6.0** | **Fuel oil transfer pump** | | |
| | a) Type and number | | |
| | b) Capacity | LPM | |
| | c) Drive motor rating | kW | |
| **7.0** | **Engine Cooling** | | |
| | a) Method of cooling provided | - | |
| | b) Details of cooling system provided | Yes/No. | |
| **8.0** | **Others** | | |
| | a) Engine overall dimension | | |
| | b) Weight of engine with base plate | kg | |
| | c) Engine performance curve (load-other parameters) enclosed | Yes/No. | |
| **9.0** | **Generator** | | |
| | a) Make | - | |
| | b) Type | - | |
| | c) Applicable standard | - | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| | d) Protection class | | |
| | e) Rated apparent Power | kVA | |
| | f) Rated power factor | - | |
| | g) Rated active power | kW | |
| | h) Rated current | A | |
| | i) Rated frequency | Hz | |
| | j) Rated speed | rpm | |
| | k) Voltage variation range | % | |
| | l) Short circuit ratio | - | |
| | m) Frequency variation range | % | |
| | n) Max. noise level at a distance of 1.0 m | dB(A) | |
| | o) Temperature rise | °C | |
| **10.0** | **Generator Performances** | | |
| | a) Efficiencies at rated voltage frequency and power factor | | |
| | • At maximum capability | % | |
| | • At 75% MCR and rated p.f | % | |
| | • At 50% MCR and rated p.f | % | |
| | • At 25% MCR and rated p.f | % | |
| | b) Regulation under condition of rated speed, voltage and output | | |
| | • At 0.8 p.f. lag (guaranteed) | % | |
| | • At 1.0 p.f | % | |
| | • At 0.9 p.f lead | % | |
| **11.0** | **Reactance** | | |
| | a) Direct axis transient, saturated | % | |
| | b) Direct axis transient, unsaturated | % | |
| | c) Direct axis subtransient, unsaturated | % | |
| | d) Negative sequence reactance | % | |
| | e) Zero sequence reactance | % | |
| | f) Synchronous reactance | % | |
| | g) Capacitance of generator stator wdg to ground | | |
| | h) Maximum permissible short time unbalanced load (load and time) | % & s | |
| **12.0** | **Time Constants** | | |
| | a) Transient O.C time constant | s | |
| | b) Transient S.C time constant | s | |

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| | c) Armature time constant | s | |
| **13.0** | **Insulation** | | |
| | Type of insulation - Stator winding | | |
| | - Rotor winding | | |
| | Class of insulation - Stator winding | | |
| | - Rotor winding | | |
| **14.0** | Type of excitation system | | |
| **15.0** | **Automatic Voltage Regulator** | | |
| | a) Make | - | |
| | b) Type | - | |
| | c) Voltage Regulator Range | - | |

## 2.12.0 ILLUMINATION SYSTEM

| Sl.No. | Description | Unit | Data |
|---|---|---|---|
| **1.0** | **Lighting fixtures (Data to be furnished for each type of lighting fixtures)** | | |
| | a) Make & Country | - | |
| | b) Operating voltage | V | |
| | c) Type | - | |
| | d) Wattage | W | |
| | e) No. of lamps | - | |
| | f) Lumen output | l | |
| | g) Power factor | - | |
| | h) Igniter type | | |
| | i) Dimension | mmxmmxmm | |
| | j) Weight | kg | |
| **2.0** | **Lighting panel** | | |
| | a) Type | - | |
| | b) Voltage | V | |
| | c) Short circuit rating | kA | |
| | d) Degree of protection | - | |
| **3.0** | **Bus conductor material** | | |
| **4.0** | **Lighting Poles height** | | |
| **5.0** | **Lighting Towers height** | | |

## 2.13.0 COMMUNICATION SYSTEM

| Sl. No. | Description | Unit | Data |
|---|---|---|---|
| **1.0** | **Telephone system** | | |
| | a) Manufacturer | - | |
| | b) Type | - | |
| | c) Maximum distance between the PABX cabinets and attendant desks | m | |
| | d) Main distribution frame plug-in type | Yes/No | |
| | e) Extension of the PABX system with plug-in technique | Yes/No | |
| | f) Bandwidth of the switching network (matrix) | MC | |
| | g) DOT approved | Yes/No | |
| **2.0** | **Page and Party System** | | |
| **2.1** | **Master Station** | | |
| | a) Manufacturer | - | |
| | b) Type | - | |
| **2.2** | **Slave Station** | | |
| | a) Manufacturer | | |
| | b) Type | | |
| | c) Frequency range | MHz | |
| **2.3** | **Loudspeaker** | | |
| | a) Manufacturer | - | |
| | b) Type | - | |
| | c) Capacity of loudspeaker lines (max.) | pcs | |
| **2.4** | **Dynamic microphone** | | |
| | a) Manufacturer | - | |
| | b) Type | - | |
| **3.0** | **Battery** | | |
| | a) Manufacturer | | |
| | b) Type | | |
| | c) Voltage | V | |
| | d) Capacity | mAH | |
| **4.0** | **Charging Unit** | | |
| | a) Manufacturer | - | |
| | b) Type | - | |

## 2.14.0 ELEVATOR

| Sl. No. | Description | Unit | Details by Bidder |
|---|---|---|---|
| **1.0** | **GENERAL** | | |
| | a) Manufacturer | - | |
| | b) Applicable standard | - | |
| | c) Type of Elevator | | |
| | d) Capacity | Kg | |
| | e) Speed of Elevator | M/Min | |
| | f) Number of floors served | | |
| | g) Leveling accuracy | | |
| | h) Travel | Metres | |
| | i) Vibration level | | |
| | j) Door opening speed | M/sec | |
| **2.0** | **ELEVATOR CAR** | | |
| | a) Dimensions | MXMXM | |
| | b) Weight | Kg | |
| | c) Door opening size | MXM | |
| **3.0** | **Hoist Motor** | | |
| | a) Rating | kW | |
| | b) Duty | | |
| | c) Full load speed | rpm | |
| | d) Degree of protection | | |
| **4.0** | **Guide rails material** | | |
| **5.0** | **Buffer** | | |
| | a) Make | | |
| | b) Buffer stroke | | |
| | c) Max load | | |
| | d) Type & grade of oil to be used | | |
| **6.0** | **Suspension Rope** | | |
| | a) Material & Size | | |
| | b) No.of ropes | | |
| | c) Factor of safety | | |
| **7.0** | **Over speed Governor tripping speed** | | |
| **8.0** | **Trailing Cables** | | |
| | a) Type | | |
| | b) Conductor Material | | |
| | c) Insulation | | |
| | d) Sheath material & thickness | mm | |

## 2.15.0 POWER & CONTROL CABLES

| S.No | Description | Unit | Details by Bidder |
|---|---|---|---|
| | **CABLES**<br>The bidder shall indicate the following for each type (11kV, 3.3kV, 400V , control cables & special cables) and size of cables as per the format | | |
| 1.0 | Make & Country | - | |
| | Type | - | |
| | Suitable for system with Service voltage | - | |
| 2.0 | **Maximum conductor temperature** | - | |
| | Continuous | °C | |
| | Short time | °C | |
| 3.0 | **Conductor** | - | |
| | Material | - | |
| 4.0 | **Screening on conductor** | - | |
| | Material | - | |
| | Type | - | |
| 5.0 | **Insulation** | | |
| | Material | - | |
| | Type | - | |
| 6.0 | **FRLS Properties** | | |
| | Oxygen index | | |
| | Smoke density | | |
| | Acid gas emission | | |

## 2.16.0 CCTV

| Sl. No. | DESCRIPTION | UNITS | |
|---|---|---|---|
| **A** | **General** | | |
| 1. | Name & Place of Manufacturer | | |
| 2. | Power Supply | | |
| 3. | Outdoor equipment enclosure degree of protection | | |
| 4. | Indoor equipment enclosure degree of protection | | |
| 5. | Design ambient temperature | | |
| 6. | Main junction box material and thickness | | |
| 7. | Bill of quantity enclosed | Yes/No | |
| 8. | Technical catalogue of bidder's offered items enclosed | Yes/No | |
| **B** | **Camera** | | |
| 1. | Quantity | | |
| 2. | Type/Model No. | | |
| 3. | Image device | | |
| 4. | Picture elements | | |
| 5. | Scanning system | | |
| 6. | sensitivity | | |
| 7. | Signal to noise ratio | | |
| 8. | Lens Iris range | | |
| 9. | Lens focal length | | |
| 10. | Pan range horizontal plane | Deg | |
| 11. | Pan speed | Deg/sec | |
| 12. | Tilt vertical plane | Deg | |
| 13. | Tilt speed vertical plane | Deg/sec | |
| 14. | Ambient temperature | Deg °C | |

| Sl. No. | DESCRIPTION | UNITS | |
|---|---|---|---|
| 15. | Degree of protection for indoor / outdoor camera-IP 65 | Yes/No | |
| 16. | Power supply requirements | | |
| 17. | Color dome, digital CCD camera with auto IRIS motorized lenses, PTZ capabilities with 0.7 lux sensitivity shall be UL/CE certified offered | Yes/No | |
| 18. | Pan, tilt & zoom control units<br>-quantity<br>Pan, tilt and zoom control units<br>-Quantity | Yes/No | |
| 19. | Necessary software for displaying camera imagers with multiplexing facility offered | Yes/No | |
| 20. | Necessary camera poles of 6 meters height with camera mounting platform and mounting brackets offered | Yes/No | |
| 21. | The enclosure for outdoor camera shall be provided with a sum shroud, thermostatically controlled heater and blower | Yes/No | |
| 22. | UL/CE certified multiplexer/video switcher for switching number of cameras images to single offered<br>-Quantity<br>-Manufacturer<br>-Type/model No | Yes/No | |
| 23. | Required video and power cable offered<br>-Quantity<br>-Manufacturer<br>-Type/Model No. | Yes/No | |
| 24. | Other associated accessories for fully functioning of the offered system included | Yes/No | |
| 25. | Does the offered system includes necessary requirements as per specification, for the trouble free functioning of the offered system | Yes/No | |
| 26. | Does the offered system meet specification requirement ? | Yes/No | |
| 27. | Hardware and software configuration provided as per specification? | Yes/No | |
| 28. | Detailed BOQ including all the required accessories, furnished? | Yes/No | |
| 29. | Bidder shall be responsible for the smooth functioning of the offered system till final handling over to the customer | Yes/No | |

| Sl. No. | DESCRIPTION | UNITS | |
|---|---|---|---|
| **C** | **Operator cum recording station server** | | |
| 1. | Make | | |
| 2. | Model number | | |
| 3. | Processor | | |
| 4. | Memory | | |
| 5. | Hard disk | | |
| 6. | Monitor size, resolution and speed etc. | | |
| 7. | HDD controller(RAID controller) | | |
| 8. | Redundant hot swappable power supply | | |
| 9. | Storage capacity | Days | |
| 10. | Removable bulk storage drive | | |
| 11. | Removable bulk storage media for above | 10 Nos. | |
| 12. | Media drive | | |
| 13. | Key board | | |
| 14. | Mouse / other positioning media | | |
| 15. | Network accessories | | |
| 16. | Power supply | | |
| 17. | Quantity | | |
| 18. | Accessories | | |
| 19. | All software required for operating administration and storage function provided | Yes/No | |
| **D** | **Cables** | | |
| 1. | Manufacturer | | |
| 2. | Type and size of cable | | |
| 3. | Standard applicable | | |
| 4. | Voltage grade | | |

| Sl. No. | DESCRIPTION | UNITS | |
|---|---|---|---|
| 5. | Conductor material | | |
| 6. | Conductor cross section area | Sq.mm | |
| 7. | Insulation for both inner and outer sheath | | |
| 8. | Overall dia of the cable | | |
| 9. | Operating and storage temperature | | |
| 10. | Identification of | | |
| 11. | Quantity of cable | | |
| **E** | **Fibre optic cable** | | |
| 1. | Manufacturer | | |
| 2. | Fiber type | | |
| 3. | Core Diameter | | |
| 4. | Cladding diameter | | |
| 5. | Primary coating diameter(UV cured acrylate) | | |
| 6. | Secondary buffer diameter(hard elastomeric) | | |
| 7. | Numerical aperture | | |
| 8. | Proof of text level | | |
| 9. | Impact resistance | | |
| 10. | Crush resistance | | |
| 11. | Tensile strength maximum | | |
| 12. | Tensile strength operating | | |
| 13. | Operating temperature | | |
| 14. | Storage temperature | | |
| 15. | Quantity | M | |
| **F** | **UPS** | | |
| 1. | Make and model number | | |

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| Sl. No. | DESCRIPTION | UNITS | |
|---|---|---|---|
| 2. | Manufacturer | | |
| 3. | Capacity | kVA | |
| 4. | Voltage rating | | |
| 5. | Voltage regulation | % | |
| 6. | Type of battery | | |
| 7. | Battery back up time | | |
| 8. | Catalogue enclosed | Yes/No | |
| **I** | **Control panel** | | |
| 1. | Make and manufacturer | | |
| 2. | Material and size of sheet steel | | |
| 3. | IP protection class | | |
| 4. | Dimensions | | |
| 5. | Painting color | | |
| 6. | Bottom cable entry | Yes/No | |
| 7. | Accessories such as base frame, bolts and nuts, gaskets etc. supplied | Yes/No | |
| 8. | Weight of the panel | | |
| 9. | Heat dissipation | | |
| **J** | **Junction boxes** | | |
| 1. | Make and manufacturer | | |
| 2. | Material and thickness | | |
| 3. | IP protection class | | |
| 4. | Dimensions | | |
| 5. | Painting color | | |
| 6. | Bottom cable entry | | |

| Sl. No. | DESCRIPTION | UNITS | |
|---|---|---|---|
| | | | |
| **K** | **Mounting poles** | | |
| 1. | Material | | |
| 2. | Quantity | Nos. | |
| 3. | Length | | |
| **L** | **Mounting accessories** | | |
| | All the accessories as required for successful implementation of the CCTV system included in bidder's scope | Yes/No | |
| **M** | **Cable tray** | | |
| 1. | Type | | |
| 2. | Manufacturer | | |
| 3. | Size | | |
| 4. | Material | | |
| 5. | Quantity | M | |
| **N** | **Cable conduits(each type)** | | |
| 1. | Type | | |
| 2. | Manufacturer | | |
| 3. | Size | | |
| 4. | Material | | |
| 5. | Quantity | | |
| **O** | **Erection hardware** | | |
| 1. | Support angle type and material and quantity | | |
| 2. | Support channel type and material and quantity | | |

### 3.0.0 TECHNICAL DATA SHEET - CONTROL & INSTRUMENTATION

| Sl. No. | Description | Data |
|---|---|---|
| **1.0** | **DCS** | |
| **i)** | System offered – Model | |
| | Year of launching of the system in the market by the manufacturer / collaborator. | |
| | Is the system offered, the latest available / being marketed in the International market by the collaborator / vendor. Software / Hardware version offered shall be a proven one. | |
| | System with open system architecture to enable integration of third party hardware / software applications to provide plant information and management functions. | |
| | The system shall support direct connectivity to Ethernet based LAN. | |
| | Conformity to open system features like interoperability, portability, scalability, flexibility and upward compatibility. | |
| | Conformity to specification regarding Operating system, (MMI) protocol | |
| | Security features to protect the critical functions like operator, engineering, monitoring and control functions | |
| | Whether the system configuration diagram for DCS is enclosed | |
| | Number of controller and I/O cabinets | |
| | Dimensions (H x W x D) | |
| | Enclosure class | |
| | Number of Peripheral Cabinets | |
| | Dimensions (HxWxD) | |
| | Enclosure class | |
| | No. of operator / Engineer stations offered | |
| | No. of laser printer | |
| | No. of colour laser printer, Dot Matrix Printer | |
| | Panel cable entry | |
| | Power supply voltage for DCS | |
| | Signals exchanged between processors of CLCS and between processors of OLCS can pass over local / cubicle bus which is redundant or back plane but not pass over main data bus. | |
| | Signals exchanged between OLCS and CLCS or any other system which are housed in separate cabinets shall be hardwired. | |
| | Offered system has I/O modules separate from controller modules. | |
| | MMI stations residing directly on plant data bus. | |
| | Sequence control display with step by step critical display | |
| | Automatic / step by step manual sequence control | |

| Sl. No. | Description | Data |
|---|---|---|
| | Provision of criteria bypass, sequencing & Intermediate step operation | |
| | Serial link interface to other control systems | |
| | Remote I/O offered | |
| | Spare I/O modules offered (wired and loose spares) | |
| | Conformity to all the tests requirements as stipulated in the specification for factory acceptance test procedure. | |
| **ii)** | System availability for the DCS, MTBF | |
| **iii)** | Digital controller / processor | |
| | CPU Make & Type | |
| | Control processor : 32 bit with floating point arithmetic capability | |
| | Number of controllers offered for control system | |
| | Number of controllers offered for monitoring system | |
| | List for each controller memory loading Assignment of loop | |
| | No. of I/O per controller | |
| | Word length | ……..bits |
| | Working memory offered | ……Kbs |
| | Expandable to | ……Kbs |
| | Type of memory & capacity | |
| | Memory cycle time | ……msec. |
| | Battery back up of not less than 72 hours | |
| | Machine cycle time | |
| | Input scan rate | |
| | Output update rate | |
| | Tuning, configuring and reconfiguring of the controller through VDU / KBD | |
| | Automatic updation of Controller configuration residing in central device when configuration is changed by the engineer | |
| | Change over time to the back-up controller | |
| | On-line configuration via programmer console | |
| | On-diagnostic minimum as per the specification | |
| | Details of the control algorithm furnished | |
| | Power fail / auto restart feature | |
| | Watchdog timer clock rate | |
| | Type of error checking & error recovery feature. | |
| | Memory protection | |
| | Cache memory | |
| | Interrupt handling time | ……Kbytes |
| | Types of communication bus between controllers | |
| | Maximum numbers of devices on the bus | |
| | Bus transfer rate | |

| Sl. No. | Description | Data |
|---|---|---|
| | The control processor designed to have minimum 40% spare capacity over and above acquired considering hot spare I/O modules. Future I/O modules to be located in spare slots (applicable for MS, OLCS & CLCS processors.) | |
| **iv)** | INPUTS & OUTPUTS | |
| | Status indicating LED for each input and output | |
| | Power supply healthy LED in modules | |
| **a)** | ANALOG Inputs | |
| | Make & Model No | |
| | No. of I/O offered | |
| | No. of channels per IO card | |
| | Per channel isolation | |
| | Isolation type (Galvanic / Optical) | |
| | Scan Rate | |
| | Redundancy | |
| | Accuracy | |
| | Normal mode noise rejection | ……db |
| | Common mode noise rejection | ……db |
| | Features offered as per the specification | |
| **b)** | THERMOCOUPLE Inputs | |
| | Make & Model No | |
| | No. of I/O offered | |
| | No. of channels per IO card | |
| | Per channel isolation | |
| | Isolation type (Galvanic / Optical) | |
| | Scan Rate | |
| | Redundancy | |
| | Accuracy | |
| | Normal mode noise rejection | ……db |
| | Common mode noise rejection | ……db |
| | Features offered as per the specification | |
| **c)** | RTD Inputs | |
| | Make & Model No | |
| | No. of I/O offered | |
| | No. of channels per IO card | |
| | Per channel isolation | |
| | Isolation type (Galvanic / Optical) | |
| | Scan Rate | |
| | Redundancy | |
| | Accuracy | |
| | Normal mode noise rejection | ……db |
| | Common mode noise rejection | ……db |
| | Features offered as per the specification | |

| Sl. No. | Description | Data |
|---|---|---|
| **d)** | ANALOG outputs | |
| | Make & Model No | |
| | No. of I/O offered | |
| | No. of channels per IO card | |
| | Per channel isolation | |
| | Isolation type (Galvanic / Optical) | |
| | Scan Rate | |
| | Redundancy | |
| | Accuracy | |
| | Normal mode noise rejection | ……db |
| | Common mode noise rejection | ……db |
| | Features offered as per the specification | |
| **e)** | DIGITAL Inputs | |
| | Make & Model No | |
| | No. of I/O offered | |
| | No. of channels per IO card | |
| | Per channel isolation | |
| | Isolation type (Galvanic / Optical) | |
| | Scan Rate | |
| | Redundancy | |
| | Accuracy | |
| | Normal mode noise rejection | ……db |
| | Common mode noise rejection | ……db |
| | Contact Interrogation Voltage from each channel | |
| | Contact Bounce Filtering | |
| | Contact monitoring for trip contacts and causes of trip contacts for digital signals | |
| | Features offered as per the specification | |
| **f)** | DIGITAL outputs | |
| | Make & Model No | |
| | No. of I/O offered | |
| | No. of channels per IO card | |
| | Per channel isolation | |
| | Isolation type (Galvanic / Optical) | |
| | Scan Rate | |
| | Redundancy | |
| | Accuracy | |
| | Normal mode noise rejection | ……db |
| | Common mode noise rejection | ……db |
| | Contact Interrogation Voltage from each channel | |
| **h)** | Analog –to-Digital converter | |
| | Type of A/D Convertor | |
| | Number of A/D Convertors offered | |

| Sl. No. | Description | Data |
|---|---|---|
| | Number of points per A/D convertor | |
| | Number of bits / Resolution | |
| | Speed of conversion / sec. | |
| | Operating capacity | |
| | Accuracy | |
| **i)** | Digital-to-Analog convertors | |
| | Type of D/A Convertor | |
| | Number of D/A Convertors offered | |
| | Number of points per D/A convertor | |
| | Number of inputs bits / Resolution | |
| | Speed of conversion / sec. | |
| | Output voltage level | |
| | Accuracy | |
| **v)** | VDU IN THE MAIN PLANT CCR(LED) | |
| | Make | |
| | Model / Type | |
| | Quantity | |
| | Screen Size | |
| | Resolution | |
| | Number of colours (excluding black) | |
| | Refresh Rate | |
| | VDU processor configuration | |
| | Keyboard with functional keys/ Mouse | |
| | Capacity of RAM / Hard disk | |
| **vi)** | LARGE VIDEO SCREEN(LED) | |
| | Make | |
| | Model / Type | |
| | Quantity | |
| | Screen Size | |
| | Resolution | |
| | Number of colours (excluding black) | |
| | Refresh Rate | |
| | LVS controller unit processor configuration | |
| | Keyboard / Mouse | |
| | Capacity of RAM / Hard disk | |
| **vii)** | HISTORICAL DATA STORAGE DEVICE | |
| | Make & model number | |
| | Configuration offered | |
| | Type of retrieval device offered | |
| | Capacity offered (in-terms of day / Mega bytes) | |
| | Number of controllers | |
| | Dedicated Stations offered (Type / Size) | |
| | Number of Units | |

| Sl. No. | Description | Data |
|---|---|---|
| | Number and type of displays, logs. Reports stored | |
| | Expandable to | |
| | Average Access time | |
| | Data Transfer time | |
| | Error detection and correction in hardware | |
| **viii)** | DATA HIGHWAY | |
| | Make and model no | |
| | Communication protocol | |
| | Type of highway | Fiber optic / co-axial cable |
| | Number of highways | |
| | Maximum number of devices on each highway | ……Nos. |
| | Data transfer rate | ……MBps |
| | Communications protocols employed (furnish details) | |
| | Message format details | |
| | Communication interface with digital controllers | |
| | Method of error checking | |
| | Communication failure auto switching in secs. | |
| | Maximum length of data bus without repeaters. | |
| | On-line expandability of 25% | |
| | On-line diagnostics (furnish details) | |
| **ix)** | Communication processors | |
| | Make and model number | |
| | Word length | |
| | Number of processors provided | |
| | Redundant highway provided | |
| | Hot repair capability | |
| | Controller memory | |
| **x)** | Utility displays | |
| | Group review displays (Nos) | |
| | Individual point display | |
| | Trend display | |
| | Format of group review | |
| | No. of OP-guide displays provided | |
| | Characteristic point display | |
| | No. of graphic displays provided | |
| | No. of bar charts provided | |
| | No. of X-Y plots provided | |
| | Alarm displays provided | |
| | Plant start-up and shut down guidance displays | |
| | Sequence control display with step by step critical display | |
| | Display of sequence status and criteria waiting & monitoring time | |

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| Sl. No. | Description | Data |
|---|---|---|
| | Mimic diagrams (Plant schematics) to be provided(as required) | |
| **xi)** | LOGS | |
| | Pre & Post trip log with 100 points sampled at 10 seconds interval in a cyclic life. | |
| | No. of trend logs | |
| | No. of alarm logs | |
| | No. of logs of distributed & simulated values | |
| | No. of logs of operator action | |
| | No. of logs of scan period | |
| | No. of point out of scan | |
| | No. of maintenance logs | |
| | No. of Hourly logs | |
| | No. of shift logs | |
| | No. of performance calculation logs | |
| | No. of daily logs | |
| | No. of status change log and C&I fault log. | |
| | No. of special logs | |
| | Unit snap shot log report values of 100 analog inputs & 250 digital status printed on demand. | |
| **xii)** | PERFORMANCE CALCULATION SOFTWARE | |
| **xiii)** | System redundancy | |
| | Redundancy in data high-way is provided | |
| | Redundancy in communication controller is provided | |
| | Hot redundancy provided for all controllers | |
| | For open loop drives like motor operated valves, solenoid valves etc. individual drive control module or redundant mult-channel drive module / redundant output module provided | |
| | Power supplies | |
| **xiv)** | Performance requirements | |
| | Scan time for analog signals(critical closed loops) | …….millisec |
| | Scan time for Analog signals(Non critical closed loops) | …….millisec |
| | Scan time for measurement system parameters | …….millisec |
| | Scan time for Digital signals | …….millisec |
| | Scan time for Pulse signal | …….millisec |
| | Speed of communication Bus (plant data highway / controller data highway / IO bus) under worst case loading condition. | …….MBps |
| | Data storage capacity | |
| | Controller loading under worst case loading condition | |
| | Update time of analog parameter in the VDU | |
| | Update time of digital parameter in the VDU | |
| | Closed loop control update time | |
| | Open loop control update time | |

| Sl. No. | Description | Data |
|---|---|---|
| | Time for display in VDU on operator's request as specified. | |
| | Keyboard command to field equipment | …….Sec |
| | Load rate of communication system under worst condition | |
| | Alarm Annunciation offered | |
| **2.0** | **Proprietary system of GTG (PS-GTGU)** | |
| | Make | |
| | Model | |
| | Part of DCS or separate control system | |
| | Processor / Communication / power supply offered in redundant, fail safe and fault tolerant configuration | |
| | Data bus transfer rate | ……MBps |
| | TUV category AK– 5 certification/SIL certification | |
| | Type of redundant communication with plant DCS | |
| | IO and loop scan time | |
| | All signal inputs / outputs have current limiting & short circuit proof | |
| | Will the automatic change-over be without any disturbance in case of failure? | |
| | VDU display update time | |
| | Call-up time for new display | |
| | No. of operator / engineering stations / printers | |
| | Size of the monitor | |
| | No. of cabinets | |
| | Software's offered | |
| | Power supply voltage | |
| | Enclosure class | |
| **3.0** | **Proprietary system of STG (PS-STGU)** | |
| | Make | |
| | Model | |
| | Part of DCS or separate control system | |
| | Processor / Communication / power supply redundancy fail safe and fault tolerant configuration | |
| | Data bus transfer rate | ……MBps |
| | TUV category AK– 5 certification /SIL certification | |
| | Type of redundant communication with plant DCS | |
| | Scanning time for signal inputs | |
| | All signal inputs / outputs have current limiting & short circuit proof | |
| | Will the automatic change-over be without any disturbance in case of failure? | |
| | VDU display update time | |
| | Call-up time for new display | |
| | No. of operator / engineering stations / printers | |
| | Size of the monitor | |

| Sl. No. | Description | Data |
|---|---|---|
| | No. of cabinets / Size | |
| | Software's offered | |
| | Power supply voltage | |
| | Enclosure class | |
| **4.0** | **Programmable Logic Controller (PLC)** | |
| | Make | |
| | Model | |
| | Controller / Communication / Power supply redundancy | |
| | No. of operator station/ Engineer station / printers offered | |
| | Size of the monitor | |
| | Control desk | |
| | Panel mounted indicators, push buttons, alarm facia | |
| | PLC and communication loading details | |
| | Data bus transfer rate | ……MBps |
| | Balance of plant Package systems for which the PLC is offered. | |

Note: Bidder shall furnish all the data's (Mech, Elect and C&I) along with reference technical catalogue.

**SIGNATURE OF BIDDER** _____

**NAME** _____

**DESIGNATION**_____

**COMPANY SEAL**

**DATE** _____

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## SCHEDULE - 2

## SCHEDULE OF PERFORMANCE GUARANTEE

| Sl. No. | Particulars | |
|---|---|---|
| | **Performance Guarantees under Liquidated Damages [L.D]** | |
| 1.0 | Gross Block Power at Site Specific Reference Conditions | _____ kW |
| 2.0 | Gross Block Heat Rate at Site Specific Reference Conditions | _____ kCal/KWh |
| 3.0 | Block Auxiliary Consumption at Site Specific Reference Conditions | _____ kW |
| 4.0 | $NO_x$ emission level at Site Specific Reference Conditions * | _____ ppmvd |
| 5.0 | CO emission level at Site Specific Reference Conditions * | _____ ppmvd |

Note:

1) The lower heating value of Natural gas is as specified in Vol II /Section 1 General technical specification under CL 2.1.0
2) Site Specific Reference Conditions shall be as given in Vol II /Section 1 General technical specification under CL 9.6.3. No deviation is allowed regarding the reference conditions.
3) The Heat and Mass Balance Diagrams Site Specific Reference Conditions as specified in Vol II /Section 7– Schedules to be filled in by the Bidders under 1.0.0 shall be submitted along with this schedule of performance guarantee.
4) **NO DEVIATIONS ALLOWED FOR THE ABOVE PARAMETERS ON THE HIGHER SIDE MARKED " * "**

We hereby confirm that

We are agreeable to the tender evaluation factors and penalty factors indicated in the tender document.

**SIGNATURE OF BIDDER** _____

**NAME** _____

**DESIGNATION** _____

**DATE :** **COMPANY SEAL** _____

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## SCHEDULE - 3

## SCHEDULE OF RECOMMENDED SPARE PARTS

The Bidder shall indicate hereunder the quantity of Recommended Spares for equipment included in his offer.

| Sl. No. | Item Description | Category I | Category II | Category III |
|---|---|---|---|---|
| | | | | |

**Note**: Additional sheets of similar size and format may be used as per Bidder's requirement and shall be annexed to this schedule.

**SIGNATURE OF BIDDER** _____

**NAME** _____

**DESIGNATION** _____

**DATE :** **COMPANY SEAL** _____

FORMT9-P REV-A (MUM)

# VOLUME - IV

# SECTION - 8

# ANNEXURE – 1

# SUGGESTED VENDOR LIST

### 1.1.0 LIST OF APPROVED SUB-VENDORS

| Sl. No. | Description | Data |
|---|---|---|
| **A** | **MECHANICAL** | |
| 1 | GTG | BHEL / GE / Alsthom / Siemens |
| 2 | HRSG | Thermax / BHEL / NEM / Hi-TECH Engineering corp India pvt Ltd. / |
| 3 | STG | BHEL / Siemens / Alsthom / GE |
| (I) | | |
| 1. | Lube Oil and Gas Fuel Module | |
| | a. Main and Auxiliary lube oil pumps | MHI-KOSAKA Laboratory, Japan / Buffalo, USA/ GE, USA / Kirloskar Ebara / Sulzer / KSB |
| | b. Main and Auxiliary hydraulic pumps | MHI-KOSAKA Laboratory, Japan / Hartman Controls Inc. USA / GE, USA |
| | c. Emergency Lube oil pump | Buffalo, USA / MHI / GE, USA /GMBH & Co., Germany |
| | d. Filters | MHI / Hilliard, USA |
| | e. DC Motor | GE, USA or equivalent / MHI Melco / BHEL / Kirloskar electric |
| 2. | Load coupling | Renk Tacke, Germany / Koplex, USA / Ameridrivs, USA / MHI |
| 3. | Load Gear Box and turning gear | Renk Tacke, Germany / Flender Graffenstanden, France / MAAG, Switzerland TG-/ Sumitomo heavy Industries, Japan/ Aux. gear-MHI-NIIGATA convertor, Japan |
| 4. | Ventilation fan | Industrial Fan / C-Doctor / Duvent / Kruger / Flakt / Alstom |
| 5. | Enclosure for Gas Turbine and other modules | Indira Industries / Lloyd insulation / GB Engineering/ |
| 6. | Inlet ducting | GB Engineering / Indira Industries PVK Engineers |
| 7. | Air processing unit | Indcon / Ingersolrand / AMIS / MHI |
| 8. | Mist Eliminator | Multitex / Dollinger |
| 9. | Inlet air filter | Donaldson / Anfilco / Camfil / Kirloskar AAF |

| Sl. No. | Description | Data |
|---|---|---|
| **A** | **MECHANICAL** | |
| 10. | Compressor water wash skid | Technostrength / AMIS / Pump-Ebara pump corporation, Japan |
| 11. | Cooling tower | Paharpur / Gactel-Gammon / Hammon shriram cottrel |
| 12. | Plate heat exchanger | ALFA Laval / APV CANADA INC / API Schmidt / IDMC / GEA |
| 13. | Boiler feed water pumps | WEIR / Sulzer / KSB / Kirloskar Ebara |
| 14. | EOT Crane | WMI / RECKMAN / Safex / Demag / Unique / Anupam |
| 15. | Fire fighting and protection system | Agnice / Vijay fire protection / Tyco / Extinct |
| 16. | Valves and Specialities | **IBR** – BHEL / Audco / Fisher / Mesoline (France) / KSB / Xomoxo Sunmar<br>**Non IBR** – KSB / Audco / BDK-Weir / Kirlosker/ Fouress |
| 17. | Condensate Extraction Pumps | WEIR / FLOWAY, USA / Sulzer Pumps / Kirloskar Ebara / KSB |
| 18. | Water treatment plant | Ion Exchange / Thermax / Aquatech / Wipro |
| 19. | CW pumps and ACW pumps | WEIR / Sulzar / Kirloskar / Mather and Platt |
| 20. | General service pump | Sulzer Pump / WEIR / IR / ITT / Johnston pumps / Goulds / Kirloskar / Flowmore |
| 21. | Air compressors | Ingersoll Rand / Atlas Copco / Elgi |
| 22. | Tanks / Vessels | BHEL / R.D. Engineers/ S. V. Engineering, Mumbai |
| 23. | Pipes – Carbon Steel | Sumitomo / Koba steel / Maharashtra Steel Tubes / Jindal / SAIL (WTP -Duplex imported) |
| 24. | ETP, Waste Water | Ion Exchange / Thermax / Doshion |
| 25. | Inst. Air drying plant | Indcon / Dhir-Pneumatic / Mellcon |
| 26. | $CO_2$ Fire Protection | Agnice / Vijay fire protection / Tyco / Extinct |
| 27. | Ventilation Fan | Industrial Fan / C-Doctor |
| 28. | Inlet ducting | Indira Industries / Lloyds Insulation / GB engineering |
| 29. | Fuel gas area on / off valves | Automax |
| 30. | Travelling water screen | US filter / General Mechanical Works, India / Macmet India Limited ,India / Brackett green, USA |

| Sl. No. | Description | Data |
|---|---|---|
| **A** | **MECHANICAL** | |
| 31. | Stop blog | US filter |
| 32. | Bar screen | US filter |
| 33. | Spray wash pump | Sterling / Sulzer / Flowserve |
| 34. | CW hydraulic system pump | Shydro |
| 35. | Hydraulic oil accumulator | Berndsen |
| 36. | CW system discharge Valve & Actuator | KSB / AMRI |
| 37. | Gas conditioning system | Petromar / Sulzer / Multitex / Nirmal / Chemtrol |
| 38. | Gas heaters | Petromar |
| 39. | Gas area valves | Fisher / Audco / Virgo / Mesoline |
| 40. | Gas Conditioning Staion Filter | Ravi Techno Systems |
| 41. | Gas inlet duct silencer | GB Engg. / Indira |
| 42. | Steam drums (HP,IP,LP) | Foster wheeler, Canada / Thermax |
| 43. | HRSG area chemical feed system | Johnson march inc./ Milton Roy / ENPRO engineers , Pune |
| 44. | Automatic recirculation valve & Back pressure regulator | Schroedahl, Germany |
| 45. | Steam conditioning valves | Fisher / Nippon fisher / Valtech / Valvtechnologies |
| 46. | HRSG area motor operated valves | Rotark / AUMA / Limitorque / Matheson |
| 47. | Safety relief valves | BHEl / Tyco sanmar / Crossby |
| 48. | Chemical (LP) Dosing System | • Tecno Consultants, Mumbai<br>• Manoj Sales Corporation, Delhi<br>• ENPRO Engineers, Pune<br>• Milton Roy Asia Ltd |
| 49. | Stack Expansion joint | Korema / KE Bergman, Denmark/ Stenflex, Germany |
| 50. | Colour port gauge | Yarway / Keystone |
| 51. | BFP Oil re circulation system | Engineering & general equipment Ltd |

| Sl. No. | Description | Data |
|---|---|---|
| **A** | **MECHANICAL** | |
| 52. | BFP Main lubricating oil pump | Weir IMO/ Sulzer |
| 53. | BFP oil Cooler | Thermax |
| 54. | BFP Lube oil filter | Airpel |
| 55. | LPEC re circulation pump | Kirloskar Ebara Pumps Ltd |
| 56. | Flash Drum & Blow down Drum | R.D.Engineers/ BHEL/ S. V. Engineering, Mumbai |
| 57. | Blow down sump pump | Goulds Pumps Inc., USA/ KBL / Aqua/ |
| 58. | HRSG chemical dosing pumps | Pulsafeeder, USA / VK Pumps / Techno Consultant |
| 59. | Condenser | Foster wheeler, Canada / BGR/ TEMA India Ltd, Mumbai./ Larsen & Tubro(L&T) |
| 60. | Condensate storage tank | L&T / Smith India Ltd |
| 61. | Condensate make up pump | Goulds/ KBL |
| 62. | Chemical feed tank | Neptune Bypass Feeders |
| 63. | Vacuum pump | Nash Engineering Edward / PPI / Tsurumi / Zebo / Everest Blower |
| 64. | ADR & TDR | R.D. Engineers/ peerless/ forbes marshal |
| 65. | LP Steam moisture separator | R.D. Engineers/ peerless/ forbes marshal |
| 66. | Deaerator | Kansas City Deaerator / Thermax / IJT / TKII |
| 67. | Condenser | Kansas City Deaerator / L&T / TEMA(India) Ltd., Mumbai |
| 68. | Closed cooling water pump | Goulds / Kirloskar / WPIL |
| 69. | Auxiliary cooling water pump | Goulds / Kirloskar / WPIL |
| 70. | Expansion tank | BHEL / R.D. Engineers/ S. V. Engineering, Mumbai |
| 71. | Water box priming pump | Nash Engineering , USA |
| 72. | Steam water Separator | Burgess Manning/ peerless/ forbes marshal |
| 73. | Vacuum Receiver | Augusta fiberglass |
| 74. | Air / Vacuum relief valves (Vacuum breaker) | GA Valves |
| 75. | High pressure vessels | BHEL / GB Engg. / Cethar vessels |
| 76. | Low pressure vessels | BHEL / R.D. Engineers/ S. V. Engineering, Mumbai |

| Sl. No. | Description | Data |
|---|---|---|
| **A** | **MECHANICAL** | |
| 77. | Reflex level gauge | Chemtrol |
| 78. | Oil water separation | Hudson industries / Victor Industries (Mumbai) |
| 79. | Emergency DG set | Simpson power products / Powerica / Kirlosker |
| 80. | HVAC | Aerovent / Bluestar / Advance / Voltas / Roots cooling / C-Doctor |
| 81. | Package units | Voltas / Blue star / Carrier / Hitachi / Toshiba |
| 82. | Deluge valves | HD Fire / Kidde |
| 83. | Cranes & hoists | Recman / Indef / Safex / Associated hoists / WH Brady |
| 84. | Air dryer unit | GEM equipment / PSA,Nitrogen / Chicago pneumatics |
| 85. | Nitrogen Manifold | Nirmal Inds, Mumbai/ATLAS COPCO |
| 86. | Compressed air drier | Xebec Ind/MELLCON/ ATLAS COPCO/ INDCON/ TRIDENT DELLAR/ GEM |
| 87. | $CO_2$ fire suppression& foam protection | Vijay fire protection / Grinnel fire protection / Chemtron fire systems |
| 88. | Eyewash / safety shower | Guardian |
| 89. | Fire system Y-strainers | SSI |
| 90. | Deluge system | HD fire protection systems |
| 91. | WTP butterfly valves | Bray / KBL / BDK / NSSL / VAG / CRANE |
| 92. | WTP pipelines | Duplex steel (Imported) |
| 93. | WTP diaphragm check valves | Plasto-matic |
| 94. | WTP ball valves | Chemtrol / BDK / KBL / NSSL / L&T Audco |
| 95. | WTP 2 piece full / reduced bore floating ball valves | Brooksbank / L&T Audco / KBL / NSSL / BDK / Intervalve |
| 96. | WTP manual globe valves | Blackhall / L&T Audco / KBL / NSSL / BDK / Intervalve |
| 97. | WTP Hand operated diaphragm valves | ITT / BDK / Flowway / Crane / Alfa Level |
| 98. | WTP centrifugal pumps | Kirloskar Brothers / KSB / Sulzer / Mather & Platt (M & P) |
| 99. | WTP RO flushing & RO clean-up pumps | KSB / Johnson / Sulzer / M & P |

| Sl. No. | Description | Data |
|---|---|---|
| **A** | **MECHANICAL** | |
| 100. | MB feed pump& DM transfer pump | KSB / Grundfos / Johnson / Sulzer / M & P |
| 101. | Potable water transfer pump | KSB / Grundfos / Johnson / Sulzer / M & P |
| 102. | WTP Mixers/Static mixers | Lightnin / Komax / Penberthy |
| 103. | WTP Blower Twin Lobe | Everest / Kay International / SWAM |
| 104. | WTP Hydraulic turbo charger | PEI |
| 105. | WTP Metering pumps | Prominent / Asia LMI / Positive Metering |
| 106. | WTP Multi function valves | Prominent |
| 107. | Rubber lined swing check valve | APCO |
| 108. | Micron filter | Parker filtration |
| 109. | Ultra filtration | KOCH |
| 110. | Potable service water pump | Goulds / KSB / Grundfos |
| 111. | Potable water pump | Kirloskar Brothers Ltd. / Grundfos |
| 112. | STP lift pump | SMD pump & Engineering Ind. |
| 113. | Waste water pump | Goulds (Submersible), Gusher (Monoblock) |
| 114. | Dewatering/ Submersible pumps | Kirlosker / SMD / KSB |
| 115. | Steam Trap and Strainers | Greaves Cotton / Otokiln / Forbes Marshall |
| 116. | Mechanical Seals | Sealol Hindustan / Dura Metallic (I) Ltd / Eagle poonawala |
| 117. | Expansion Joints | Keld Ellentoft /Bachman Industries Ltd./ Metallic Bellows/ Ke Bergmann, |
| 118. | Lube Oil Pumps (Horizontal – Centrifugal) | KSB, Pune / Sulzer, Mumbai / Kirloskar Ebara, Pune |
| 119. | Oil Vapour Extraction Fans | Radiant Engg., Mumbai / Ventura Fabrication, Mumbai / Siemens / C.Doctor, Ahmedabad |
| 120. | Turbine oil Purification Equipment | Alfa laval / West Falia / Penn Watt |
| 121. | Quick Closing Extraction Non Return Valves | Hopkinsons, UK, / BHEL, Trichy |
| 122. | Gear Box (Turbine) | Renk Tacke Reheine, Germany / Lufkin Industries, USA / MAGG Gear Co. Ltd., Switzerland / Flender Graffen Staden, France. |
| 123. | Couplings (Multi Membrane) | Kop-Flex, USA, / Flexibox, England, / Zurn Indutries inc., USA. |
| 124. | Lube Oil Pumps & Emergency Oil Pumps (Vertical-Centrifugal) | Sihi Halberg Machinenbau GMBH & Co., Germmany / Kirloskar Ebara, Pune (through SIEBURG, Secunderabad) |
| 125. | Jacking Oil Pump | Delta Corporation Ltd., Mumbai / Hagllunds dension Ltd., Hyderabad / Dynamitcs Hydraulic Ltd., Bangalore |
| 126. | Elevator | OTIS / Thyssenkrupp / KONE / Hitachi / Schindler |

| Sl. No. | Description | Data |
|---|---|---|
| **B** | **ELECTRICAL** | |
| 1. | Alternator | BHEL / TDPS / Siemens / Alstom / Brush electrical / GE Energy. |
| 2. | 66kV GIS | ABB / Siemens / Alstom / Hoysung corporation, Korea |
| 3. | AVR | BHEL / ABB /BASLER |
| 4. | **66kV OHL components** | |
| 4.1 | Aluminium alloy steel reinforced Conductors | J-power corporation, Japan, 3M USA or equivalent |
| 4.2 | Clamps and Connectors | Klemmens / Tyco / Framatome/ Rashtriya Udyog |
| 4.3 | Structures | Richardson and Gudas / Utkal / Baroda Structurals / Triveni / Kalpatru / Techno Engg / MV Engg. / Metallite |
| 4.4 | Insulator Hardware | Rashtriya Udyog / International Transmission Products / Modern Melleables / Tyco / EMC |
| 4.5 | Substation Automation System / SCADA, | ABB / Honeywell / Alstom |
| 4.6 | Control & Relay Panels, Relays | ABB / Siemens / Alstom / GE |
| 4.7 | Tariff Metering | Siemens / ABB / SEMS / L&T (ABT meter Make & Type shall be GETCO approved only) |
| 5. | Generator Transformers | BHEL / CGL / ABB / Alstom / Siemens |
| 6. | Station Transformers | BHEL / CGL / ABB / Alstom / Siemens |
| 7. | Auxiliary Transformers | Emco / Alstom / Voltamp / Bharat Bijlee / CGL |
| 8. | MV Switchgear | ABB / Siemens / Schneider |
| 9. | LV Switchgear | L&T / Siemens / GE / ABB / Schneider |
| 10. | HT Busducts | BHEL / Controls & Switchgear (C&S) / Spaceage / Busbar systems |
| 11. | LT Busducts | Controls & Switchgear (C&S) / Star Drive / Interlec / Elpro / Spaceage |
| 12. | DG Set (Alternator) | Kirloskar / Jyoti / Stamford / Jackson / Tractor India Ltd. |

| Sl. No. | Description | Data |
|---|---|---|
| **B** | **ELECTRICAL** | |
| 13. | DC Batteries (Ni-Cd) | HBL-nife / AMCO-saft |
| 14. | Battery Chargers | Chhabi / HBL-nife / Amarraja / Caldyne |
| 15. | HT Motors | BHEL / CGL / ABB / Alstom |
| 16. | LT Motors | ABB / Siemens / Alstom / Bharat Bijlee / CGL |
| 17. | Illumination Fittings | Bajaj / CGL / Philips / Baliga (flame proof) |
| 18. | Public Address System | Philips / Industronic / Gaitronics / BOSCH |
| 19. | EPABX | Philips/ Siemens/ BPL/ Tata Telecom/ Ericsson |
| 20. | EHT & HT Power Cables | Universal / Nicco / Torrent / RPG / Fort Gloster |
| 21. | LT Power Cables | Universal / RPG / FGI / Nicco / Torrent / KEI / Poly Cab |
| 22. | Control Cables | Universal / RPG / FGI / Nicco / Torrent / KEI |
| 23. | CTs & PTs | ABB / Siemens / Prayog Electrical / Pragati Electricals / CGL |
| 24. | Dry type Transformers | BHEL / BBL / CGL / Voltamp / Indcoil Transformers |
| 25. | Cable trays | Indiana / Parekh / Vatco / Jamnametal / AV / Sadhna Steelmite Engineering |
| 26. | Generator Protection / Protection Panels | Alstom / ABB / Siemens / GE Multilin / Beckwith (USA) |
| 27. | NGTR / NGR | BHEL / P.S. Electricals / Prayog electricals / Pragti |
| 28. | Transformer Tap Changers - OLTC | MR – Easun, CTR manufacuring |
| 29. | Transformer Tap Changers – OCTC | Paragon / Equivalent |
| 30. | UPS system | Emerson / Hi-rel |
| 31. | Earth Leakage Relay | Datar , HH Elecon, Prayog |
| 32. | Auxiliary Relay | ABB, Jyoti, Alstom, GE |
| 33. | Control Switch | ABB / L & T / CGL / Kaycee / Siemens / GE / BCH |
| 34. | Timer | Siemens/ L &T / Schneider / Minilec / BCH |
| 35. | Instrument & Meter | L & T, Automatic Electric / Alstom / MECO / |

| Sl. No. | Description | Data |
|---|---|---|
| **B** | **ELECTRICAL** | |
| | | IMP / Rishab / Secure |
| 36. | LDB / MLDB / DCDB | ABB / Alstom / MDS / Indo Asian Switchgears / Elecmech Switchgear & Instrumentation / Siemens / Schneider Electric India Ltd. |
| 37. | ELCB / MCB & DB | Indo-Asian / MDS / GE / Siemens / L&T Hager / Schneider Electric India Ltd. |
| 38. | Cable Gland | FCG / Comet / HMI / Power Engg. |
| 39. | Cable Lug | Dowells / Jenson |
| 40. | Metal Clad Plug & Socket (Including Welding Socket) | Bhartia Cutler Hammer / Best & Crompton / Schneider Electric India Ltd / RB (Ryrol Burn) |
| 41. | HRC Fuse / Base | GEC / Alstom / Siemens / L&T / HH Elecon |
| 42. | Indicating Lamp / Fitting | Telemik / Siemens / L&T / RAS Controls |
| 43. | Terminal Block | Elmex / Tousha / Thermoplast / Connect Well |
| 44. | Air Circuit Breaker | L&T/ Siemens / GE / ABB / Schneider |
| 45. | Energy Meter | Automatic Electric / Alstom / IMP / Simco / L & T / GEB |
| 46. | Termination / Jointing Kit | Raychem Engg / M-Seal / Denson / Pidilite |
| 47. | Lightning Arrestor | Elpro International Ltd., / Alstom / Oblum Electrical Industries / Lamco / Atlas |
| 48. | Flameproof equipment | FCG, Baliga, Flexpro electricals |

| Sl. No. | Description | Data |
|---|---|---|
| **C** | **CONTROL AND INSTRUMENTATION** | |
| 1. | DCS | Yokogawa, Honeywell,Siemens/ ABB/BHEL Metso DNA / Emerson (Ovation) |
| 2. | PLC | Allen Bradley / Siemens / Modicon / GE FANUC |
| 3. | SWAS and Analysers | ABB/ Yokogawa/ Emerson/ Forbes Marshall/ |
| 4. | SWAS components:<br>a) Sample cooler, pressure reducing element, thermal shutoff valve, back pressure regulator<br>ii)filter/tube/ isolation valves/fittings | Sentry<br>Swagelok / Parker / Sandvik / Astec |
| 5. | Flue Gas Analysers | ABB/ Yokogawa/ Forbes Marshall/ Emerson/ Chemtrol |
| 6. | Pressure Gauges | Pyro electric / General instruments/ Altop / Precision Instrument / Waaree / WIKA |
| 7. | Temperature Gauges | WIKA/GIC / Pyroelectric / Waaree / H GURU Instruments/ ASHCROFT / AN Instruments |
| 8. | Differential pressure gauge | Switzer/ A.N. Instruments / Premier Instruments / Chemtrol / Altop / General Instrument |
| 9. | Pressure Switches ,Diff Pressure Switch, Temperature switch | SOR/ Switzer/ General instruments/ Waaree/ Indfoss India Limited/ Ashcroft/ Delta control |
| 10. | Level Switches | Magnetrol / Levcon / Vega/ E + H/ Siemens |
| 11. | PRESSURE SWITCHES (EXPLOSION PROOF) | SOR/ ITT NEODYN/ ASCHCROFT/ YOKOGAWA/ DELTA CONTROLS/ e-PRODUCTIONS SOLUTION/ DANFOSS/ DAG PROCESS |
| 12. | Drum level gauges / Drum level switches | BHEL/ Hydrastep/ Yarway / Tyco/ Emerson |
| 13. | Thermocouples , RTDs | General instruments/ Altop industries/ Toshniwal/ Pyro Electric/ Waaree Instruments/Detriv Instrumentation |
| 14. | Smart Transmitter (P, L, F, DP) | Rosemount/ Yokogawa/ E & H/ ABB/ Honeywell/ SIEMENS/ BAILEY CONTROL/ USA. |
| 15. | Level Transmitters (Displacer Type) | Magnetrol / E&H / Masonelin / Chemtrol |

| Sl. No. | Description | Data |
|---|---|---|
| **C** | **CONTROL AND INSTRUMENTATION** | |
| 16. | Remote Electronic Drum Level Hydrastep Indicator | Hydrastep (Solatron) / Keyston-Yarway / Levelstate |
| 17. | Float & board type level indicator | Microprecision/ S.B. Electromechanicals/ Levcon Instruments (P) Ltd.,/ V. Automat & Control Pvt. Ltd., New Delhi/ Pune Techtrol |
| 18. | Turbovisory Instruments (Vibration / Speed Axial Shift etc.) | Bently Nevada/ Shinkawa |
| 19. | Mass flow meter (Coriolis Principle) | Emerson / E&H / Yokogawa / ABB, / KROHNE MESSTECHNIK, GERMANY |
| 20. | Rotameters | Waaree Instruments/ Eureka/ Scientific Devices / KROHNE MARSHALL LTD. |
| 21. | Vortex flow meter | Yokogawa/ Rosemount/ Endress + Hauser / FOXBORO/ KROHNE MARSHALL |
| 22. | Positive displacement meters | Moorco/ Toshniwal / Smith Meter/ FOXBORO/ Emerson |
| 23. | AVERAGING PITOT TUB | • STAR MECH CONTROLS (INDIA) PVT. LTD.,<br>• EMERSON PROCESS MGT<br>• MIDWEST<br>• THERMO BRANDT INSTRUMENTS, USA,<br>• TORBAR FLOWMETERS LTD. UK.<br>• VERIS INC. USA.INSTRUMENT, USA. |
| 24. | Turbine flow meters | Rosemount / Moorco / Scientific Devices / DANIEL MEASUREMENT & CONTROLS ASIA PACIFIC / TYCO SANMAR |
| 25. | Ultrasonic flow meter | Emerson / Sickmaihak / Krohne, Daniel / ABB / E&H |
| 26. | Flow Switch | • Magnetrol<br>• Tokyo Keiso<br>• Yokogawa India Limited<br>• Barton Instrument System Limited / LINK |

| Sl. No. | Description | Data |
|---|---|---|
| **C** | **CONTROL AND INSTRUMENTATION** | |
| 27. | Magnetic Flow Meters | • Yokogawa, Japan<br>• Yokogawa India Ltd.<br>• Endress-Hauser<br>• Krohne-Marshall, Pune<br>• Emerson Process Management (India) Pvt Ltd |
| 28. | Hydrostatic level transmitter /Radar level transmitter | Emerson / E&H / SBEM |
| 29. | Electronic Indicators / Controllers / Microprocessor Based Recorders /Receiver Indicator | Yokogawa / CHINO / Honeywell / ABB / Laxsons |
| 30. | pH /Conductivity Analysers | Rosemount/ ABB/ Yokogawa/ E&H/ HACH |
| 31. | Silica analyser | HACH/ Emerson |
| 32. | Vibration Monitoring Equipment | Bentley Nevada / Shinkawa / Vibrometer / Rockwell (Entek) |
| 33. | Control Valves | Instrumentation Ltd / Dresser, MIL, Fisher |
| 34. | E/P Converters | Moore Controls / H&B (ABB) / Emerson / Watson / Smith (MTL) / Siemens |
| 35. | Air Filter Regulator | Shavo Norgren/ Placka/ Parker/ ABB/ Legris France |
| 36. | Pressure Reducing and Desuperheating Stations | Spirax Marshall / Sulzer / Keystone / Yarway / Fisher Sanmar / Dresser |
| 37. | Flow Elements | Microprecision / IL-Palghat / Hydropneumatics / General Instruments |
| 38. | GPS(Master/ Slave Clock ) | SERTEL/ Masibus |
| 39. | Solenoid Valves | Asco / Rotex / Herion / Avcon / FESTO / Jefferson |
| 40. | On/Off Valves (Ball / Butterfly Valves) | Fisher / MIL / IL /<br>Virgo Engineers Pvt. Ltd./<br>Elomatic Pvt. Ltd. /<br>Dresser Itallia, Italy |

| Sl. No. | Description | Data |
|---|---|---|
| **C** | **CONTROL AND INSTRUMENTATION** | |
| 41. | Pressure Safety Valve/Relief Valve | • Tyco Sanmar, Trichy,<br>• BHEL, Trichy,<br>• Instrumentation Ltd., Palghat,<br>• Safety Instrument System Ltd,<br>• Audco India Ltd. |
| 42. | Instrument Cables (Including FO cables) | Associated Cables / Delton / Cords / Lapp / Universal / Belden-USA / TCL / Poly Cable Wires Pvt. Ltd, KEI Industries Ltd., Mumbai |
| 43. | Control Panel | Rittal / PROCON / Pyrotech |
| 44. | Mosaic Grids | Sub-KLEW – Germany / Siemens – Germany / Symo - Switzerland |
| 45. | Mosaic Grid Panels | Pyrotech |
| 46. | Annunciation System | IL-Kota / Procon |
| 47. | Interposing Relays | Honeywell / Omron / H&B / OEN |
| 48. | Antisurge Controller | MTL / P&F / Phoenix |
| 49. | Safety Barrier | MTL / P&F/R.STAHL |
| 50. | Surge Absorber | MTL / Weidmuller / P&F |
| 51. | Inst. Calibration Equipment | Yokogawa / Druck / Scandura |
| 52. | Electrical Panel Meter (Ammeter, | Automatic Electric / Meco / ABB |
| 53. | Selector Switches | Kaycee / Siemens / Alstom / L&T |
| 54. | Terminal Blocks | Phoenix / Connectwell / WAGO |
| 55. | AC to DC Covertor | Phoenix / Siemens / Cosel – Germany |
| 56. | Electric Hardware | Microprecision / Wesmec Engg./ MetPress / SMC Pneumatic / Sapag |
| 57. | Impulse and Sample Pipings,fittings | TPS Technitube / Sumitomo – Japan / Technomatic – Italy / Parker / Swagelok / V S Metal |
| 58. | Flame Proof / Weather Proof Cable Glands | Baliga/ Flexpro/ FCC/ Comet |

| Sl. No. | Description | Data |
|---|---|---|
| **C** | **CONTROL AND INSTRUMENTATION** | |
| 59. | Flame Proof / Weather Proof Junction Boxes | Baliga/ Sterling Switch Gears/ Ex-Protecta/ Sumip PUSTRON ( for FRP) |
| 60. | Level Gauges | MAGNETROL / KROHNE / E&H / Levcon / V Automat / SBEM |
| 61. | Pneumatic Header | Excel Hydropneumatics/ Baliga/ Excelsior/ Champ/ Swagelok/ Parker/ V S METAL / Wesmec/ Inventum |
| 62. | Isolation Valves | BDK/ Dewrance Mcneii/ L & T/ Microprecision/ EL O Matic/ Xomox |
| 63. | Temperature Scanners | Radix / Nishko/ Lectrotek/ Bentley Neveda, USA, Rochester Instruments System Ltd. UK |
| 64. | Trip Solenoid Valves | Rotex/ ASCO/ AVCON |
| 65. | Mercury in Steel Dial / Gas filled Thermometers | General Instruments Consortium, Chennai/ Bells Controls Ltd., Chennai/ A.N. Instruments, Chennai/ Waaree Instruments/ Altop |
| 66. | Dissolved Oxygen Analyzer | Rosemount/ ABB/ Yokogawa/ Chemtrol |
| 67. | Pneumatic Cylinder | Festo/ Excel Hydro Pneumatic/ IL/ Keltron |
| 68. | Indicating lamps | Siemens/TEKNIK |
| 69. | Condensate pots | Microprecision/ Excel Hydro Pneumatic |
| 70. | Operator & Engineering Station PC | Dell/ HP |
| 71. | LVS | Barco / Delta |
| 72. | Bulk Power Supply | Phoenix, Cosel, Aplab |
| 73. | Managed Ethernet Switch | CISCO, Allied Tele |
| 74. | Printer (DJP) | HP, Canon, Epson |
| 75. | Dot Matrix Printer | TVSE, Wipro, Epson |
| 76. | DCS Control panels/console | Rittal / Pyrotech |
| 77. | Gas Chromatograph | Daniel / ABB / Siemens / Chemtrol |
| 78. | Flow computer | Daniel / ABB |
| 79. | SMART Positiners/Away mounted positioners/PFT | Fisher / Yokogawa |
| 80. | Pneumatic pr. Switch/ hi-lo pilots (Indicating Dial Type) | e- Productions Solution/ WKM, AXELSON/ PT-PETROTECH/ HALLIBURTON ENERGY/ RUELCO |

| Sl. No. | Description | Data |
|---|---|---|
| **C** | **CONTROL AND INSTRUMENTATION** | |
| 81. | Pneumatic Indicating Controller | • Yokogawa India Ltd,<br>• Emerson Process Management, (earlier Fisher)<br>• Barton Instrument System Limited,<br>• Foxboro,<br>• ABB – KENT,<br>• ABB LIMITED / BRISTOL BABCOCK,<br>• ITT Barton,<br>• Masoneilan india ltd. |
| 82. | GAS & FIRE DETECTION SYSTEM / PORTABLE GAS DETECTOR | • GENERAL MONITORS, UK,<br>• DETECTION INSTRUMENTS (CROWCON),UK.<br>• DETECTOR ELECTRONICS CORPORATION,<br>• DRAGERWERK AG (GERMANY),<br>• OLDHAM (FRANCE),<br>• JOSEPH LESLIE DRAEGGER,<br>• ICARE (FRANCE), M/s GASTECH INC (USA)<br>• INTERNATIONAL SENSOR TECHNOLOGY (USA),<br>• OLIVER IGD LTD. UK,<br>• SEIGER, U.K.,<br>• HONEYWELL AUTOMATION INDIA LTD (HAIL),<br>• YOKOGAWA INDUSTRIAL SAFETY SYSTEM ,<br>• HAVEN AUTOMATION,<br>• DELPHIAN<br>• NOHMI BOSAI,<br>• G.P. ELLIOT<br>• SAFETY SYSTEMS,<br>• ICS,<br>• MSA (INDIA) LTD. |
| 83. | SMOKE/ THERMAL DETECTORS | APOLLO/ THORN / ZELLWEGER |
| 84. | MANUAL CALL POINT (FOR FIRESTATION) | APPOLO/ VIJAY FIRE/ SIMPLEX/ NEW FIRE/ MEDC/ SAFETY SYSTEMS |

| Sl. No. | Description | Data |
|---|---|---|
| **C** | **CONTROL AND INSTRUMENTATION** | |
| 85. | SELF ACTUATED PRESSURE CONTROL VALVES | Fisher Controls / Fisher Sanmar /<br>Dresser Masoneilan/<br>Dresser Valve India Pvt. Ltd./<br>Jordan Valve, |
| 86. | HIGH PRESSURE CONTROL VALVES (HCV) | • DRESSER MASONEILAN / MOKVELD/<br>• FISHER CONTROLS (NOW EMERSON)/<br>• KENT PROCESS CONTROL LTD/<br>• CONTROL COMPONENT INC./<br>• WEIR VALVES & CONTROLS UK LTD./<br>• KOSON PROCESS CONTROLS |
| 87. | ACTUATOR (FOR SHUTDOWN VALVES) | BETTIS / ROTORK / BIFFI / EL-O-MATIC |
| 88. | LIMIT SWITCHES | • BETTIS<br>• HONEYWELL AUTOMATION INDIA LTD. (HAIL) |
| 89. | FRP CABLE TRAYS<br>. | • SUPER REINFORCED PLASTICS ASSOCIATED ENGG. CORP, MUMBAI<br>• GRIP INDIA, MUMBAI<br>• SSB INDUSTRIES, BANGALORE<br>• ERCON COMPOSITES, JODHPUR |
| 90. | FLAME ARRESTORS | • PETROL SERVICE, M/s GROTH EQUIPMENT CORPORATION<br>• GPE CONTROLS<br>• BRAUNSCH WEIGR FLAMMENFILTER,GMBH, WG<br>• WHERSOC, S.A.<br>• SHAND & JURS<br>• MARVAC<br>• SAFETY SYSTEM<br>• PROTEGO EQUIPMENTS PVT.LTD |
| 91. | DEW POINT MONITOR | • PANAMETRICS<br>• SHAW, U.K.<br>• D U PONT.<br>• SOLARTRON TRANSDUCERS |

| Sl. No. | Description | Data |
|---|---|---|
| **C** | **CONTROL AND INSTRUMENTATION** | |
| 92. | B&SW MONITOR/ WATER CUT METER | • EMERSON PROCESS MANAGEMENT<br>• EESIFLO INTERNATIONAL PTE LTD., SINGAPORE<br>• HYDRYL<br>• SOLARTRON TRANSDUCERS<br>• SENTECH |
| 93. | WATER QUALITY ANALYSER | • ABB AUTOMATION LTD<br>• EMERSON PROCESS MANAGEMENT ASIA PACIFIC PTE INDIA<br>• FORBES POLYMETRON PVT LTD.<br>• BRISTOL BABCOCK, AUSTRALIA<br>• SERES, FRANCE<br>• TELEDYNE TEKMAR, USE<br>• IONIC, USA,<br>• THERMONIX LTD. UK<br>• ZELEWEGER SA, FRANCE |
| 94. | CHLORINE ANALYZER | EMERSON PROCESS MANAGEMENT |
| 95. | PROCESS GAS ANALYSER | • ABB AUTOMATION LTD<br>• PANAMETRICS LTD, IRELAND<br>• SERVOMAX PLC, TAIWAN<br>• SICK MAIHAK, GERMANY<br>• MSA (INDIA) LTD. |
| 96. | SPECIFIC GRAVITY ANALYZER | • BOPP & REUTHER MESSTECHNIK GMBH, GERMANY<br>• SOLARTRON MOBREV LTD.,UK<br>• THERMO MEASUREMETN, UK<br>• EMERSON PROCESS, SINGAPORE<br>• ENDRESS-HAUSSER, GERMANY<br>• YOKOGAWA INDIA LIMITED<br>• CHEMTROL ENGINEERING WORKS |

| Sl. No. | Description | Data |
|---|---|---|
| **C** | **CONTROL AND INSTRUMENTATION** | |
| 97. | VISCOSITY ANALYSER | • SOLARTON MOBREY LTD., UK<br>• SERES, FRANCE<br>• ENDRESS-HAUSSER, GERMANY |
| 98. | HYDROGEN ANALYSER | • SIEMENS APPLIED AUTOMATION, USA<br>• AMETEK, USA<br>• FLUID DATA (NOW NAMED THERMO ONIZ LTD.), UK<br>• EMERSON PROCESS MANAGEMENT<br>• MINE SAFETY APPLIANCES, USA<br>• PANAMETRIC LTD., IRELAND |
| 99. | CCTV | • PHILIPS<br>• ECIL,<br>• NELCO LTD<br>• AMERICAN DYNAMICS<br>• PELCO<br>• HONEYWELL<br>• VICON<br>• BOSCH<br>• HERNIS |
| 100. | PORTABLE CALIBRATOR | • FLUKE<br>• DRUCK (NOW GE SENSING)<br>• BEAMAX |
| 101. | AUTO SAMPLER | • JISKOOT LTD, UK,<br>• CLIFF MOCK,<br>• WELKER ENGINEERING COMPANY PTE LTD, SINGAPORE |

| Sl. No. | Description | Data |
|---|---|---|
| **D** | **CIVIL** | |
| 1. | Ceramic tiles for building flooring / skirting / dado | H&R JOHNSON LTD./ SOMANY/ PILKINGTON LTD. / KAJARIA / BELL CERAMIC / SPARTEK |
| 2. | Ceramic / glazed tiles for toilet flooring / dado | H&R JOHNSON LTD./ SOMANY/ PILKINGTON LTD. / KAJARIA / BELL CERAMIC / SPARTEK / NITCO / REGENCY |
| 3. | Antistatic PVC flooring / TILES | ROYAL / ARMSTRONG / KRISHNA / WONDER FLOOR / POLY FLOOR |
| 4. | Kerbing / Pre-finished Cement Tiles | EUROCON / ULTRA |
| 5. | Distemper / ACRYLIC EMULSION Paint / Primer | ICI / BERGER / NEROLAC / JENSON & NIICHOLSAN/ BRITISH PAINTS / ASIAN PAINTS (BUTTERFLY / APCOLITE)/ SHALIMAR / NE PAINT UDYOG, NE PAINT UDYOG LTD. |
| 6. | Waterproofing cement paint | SNOWCEM / INDOCEM / DURACEM/ SUPREME/ SURFACEM |
| 7. | CI Rain water / Soil pipes and CI accessories | NECO OR ISI MARKED AS APPROVED BY THE ENGINEER-IN-CHARGE |
| 8. | MS Pipe / G.I. Pipe | ZENITH/ TATA/ JINDAL / GST |
| 9. | M.S. / G.I. Fittings | TATA / 'R' BRAND |
| 10. | Pre-laminated/Plain particle boards | BHUTAN BOARDS / ECOBOARD / NOVAPEN |
| 11. | Glazing/ Glass | INDO-ASAHI/ HINDUSTAN PILKINGTON./ TRIVENI /ATUL / MODI FLOAT / SAINT GOBAIN |
| 12. | BWP Ply / Plywood/ Common ply/ Flush door | NATIONAL / COREBET/ GREEN PLY / KIT PLY |
| 13. | Sanitary ware (Water closet/ wash basin/ urinal/ flushing Cistern/ WC cover etc.) | HINDUSTAN / PARYWARE / NEYCER/ CERA |
| 14. | C.P. brass fittings | ARK-SOMA/ NOVA-SPECTRUM/ METRO-SUPER/ PARKO/ ESSCO |
| 15. | Flush Valve | ARK-SOMA/ NOVA-SPECTRUM/ METRO-SUPER/ PARKO/ ESSCO |
| 16. | Bib cock / Stop Cock | ARK-SOMA/ NOVA-SPECTRUM/ METRO-SUPER/ PARKO/ ESSCO |
| 17. | Wheel valve/ gate valve (brass) | ORIENT / LEADER |

| Sl. No. | Description | Data |
|---|---|---|
| **D** | **CIVIL** | |
| 18. | Brass float valve with Copper floats | ORIENT / LEADER |
| 19. | Floor Traps / Nahani Traps | I.S. APPROVED |
| 20. | Mirror | MODI / ATUL |
| 21. | PVC Pipe | SUPREME/ FINOLEX / PRINCE/ HYCOUNT |
| 22. | PVC Pipe Fittings | SUPREME/ PRINCE/ STAR |
| 23. | A.C. Sheets | EVEREST/ LOTUS/ CHARMINAR |
| 24. | P.V.C. Tanks | SINTEX/ RENO/ INFRA/ FUSSION/ UNIPLAS/ PATTON |
| 25. | Hydraulic Door closer | PRABHAT / HADWYN / GODREJ |
| 26. | Aluminum section | INDAL/ /JINDAL |
| 27. | Locks | GODREJ / HARRISON |
| 28. | Anodized aluminium hardware fittings | SHALLMAR /GARNISH OR ISI MARKED. |
| 29. | Water proofing Compound | FOSROC/ ROFF/ SIKA MULTIPLAS/ ACCO PROOF. |
| 30. | Floor Hardener | IRONITE/ HARDONITE/ FERROKE |
| 31. | P.V.C handrail | FIXOPAN/ CALIPLAST |
| 32. | Rigid PVC Conduit | Medium Gauge wall thickness ISI & FIA approved & manufactured from virgin material. Precision |
| 33. | Accessories for conduit | Same make as of pipe |
| 34. | Flexible Copper Wires | R.R. KABLE/ HAVELLS/ FINOLEX |
| 35. | Switches | LK ( DENISH RANGE )/MDS / ANCHOR/ LEGRAND |
| 36. | Telephone wires/ CAT 6 wire | RR KABLE/ DELTON/ AT&T AS PER ITD S/WS-113 B. |
| 37. | PVC tape | STEEL GRIP/ ANCHOR |
| 38. | Switch Plate | DECOLAM HYLAM SHEET 3.0 MM THICK. OR SINTEX SMC SHEETS |
| 39. | Button holder/ Angle older/ Ceiling rose | ANCHOR / CPL |
| 40. | M.S. Conduit ISI | BEC/ STEEL CRAFT/ AKG.(14GUAGE) |

| Sl. No. | Description | Data |
|---|---|---|
| **D** | **CIVIL** | |
| 41. | Ceiling Fans, Exhaust Fan | CROMPTON/ ORIENT/ USHA/ BAJAJ/ ALMONARD/ CLIPSAL/ KHAITAN |
| 42. | Steel Doors & Windows | SEN HARVIC/ AGEW / SENTIANAL/ HOPES METAL/ MULTIWYN/ NCL SECCOLOR LTD. |
| 43. | Aluminum Doors, Windows & Wall spans | AJIT INDIA/ ALUMILITE/ INDAL/ JINDAL/ JUPITER WINDOWS |
| 44. | PA System/ Amplifier | MEGA/ SHURE/ PHILIPS |
| 45. | Speaker / Mic | MEGA/SHURE/ PHILIPS |
| 46. | EPABX/Telephone instrument | SEIMENS/ TATA/ ITI/ BPL / MATRIX/ BETEL |
| 47. | Air-conditioners | SAMSUNG/ LG/ CARRIER/ VOLTAS/ ELECTOLUX/ BLUE STAR/ GE/ NATIONAL/ HITACHI |
| 48. | Television | SONY/SAMSUNG/ LG / PHILIPS/ VIDEOCON |
| 49. | DVD Player | SONY/SAMSUNG/ LG / PHILIPS/ VIDEOCON |
| 50. | Water Cooler | VOLTAS/ USHA/ CARRIER / BLUE STAR |
| 51. | R.O. Plant | EUREKA FORBES |
| 52. | Furniture (Modular) | GODREJ / FEATHERLIGHT |
| 53. | P.C. | IBM / HP/ HCL/ COMPAQ |
| 54. | Printer | HP/ SAMSUNG/ EPSON |

# VOLUME - IV

# SECTION - 8

# ANNEXURE – 2

# LIST OF MANDATORY SPARES

## ANNEX – 2

## LIST OF MANDATORY SPARES

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| 1.0.0 | MECHANICAL EQUIPMENT | |
| 1.1.0 | Gas Turbine and Auxiliaries | |
| a) | Combustor: All the listed components/parts shall also include assembly materials, shims, supports, support arrangements, fasteners as applicable /Combustor: All the listed components/parts shall also include assembly materials, shims, supports, support arrangements, fasteners as applicable (Hard ware Consumables for assembly) | |
| b)<br>i) | Set of packing rings for tile inserts of different rows/Combustor Baskets/Liners Hardware | 2 sets |
| ii) | full set of combustor liners with fixing materials /for cannular design-Set of Combustor Baskets with hardware /consumable for assembly | 2 sets |
| c) | Mixing chamber/Transition pieces including Cross flame tube assembly (for silo/annular design) including fixing material for/Combustor Basket/Transition Pieces with Hardware & Consumables for fixing | 2 sets |
| i. | Tiles of each type and size | 100% of total installed quantity |
| ii. | Set of hoses for fuel nozzles / Set Fuel Nozzle with Hardware for fixing | 2 sets |
| iii. | Set of spark plugs with fixtures/Igniter Assembly | 2 sets |
| iv. | Set of spark power units/Igniter Power Transformer | 2 sets |
| v. | Spark plug cables/The Cable Shall be Class to Withstand the Combustor Area Temp. | 2 sets |
| vi. | Spark plug inserting drives/The Instrument Air operated Igniters free from Moisture | 2 sets |
| vii. | Flame Detector ( Scanner ) | 1set |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| viii. | Set of expansion studs, nuts for combustor of all types & sizes /The Hard-wares for TP, CB and Fuel Nozzle like Bolts Studs, Nuts and 2 Set of gaskets and Consumables like High Temperature Molycote& Compounds | 10% of total quantity |
| d) | Gas Turbine [assembly materials should include all items required to complete nozzles/buckets assembly of that particular stage including diaphragms, fixing rings, seals, pins, fins, insulation locking plate, shims, fasteners. /The Turbine Nozzle (Vanes)& Buckets ( Blades ) all the installed stages with set Seal Strips, Setting Pin, Torque Tubes, locking plate & Wire and Hardware/Consumables as required' | |
| i. | Full set of nozzles & bucket seals as needed for stages 1, 2 & 3 during combustor inspection; hot gas path inspection; and major overhaul | 2set |
| ii. | Set of expansion studs, nuts for inner casing & outer casing of all types /'Set of expansion studs, nuts for inner casing & outer casing of all types(Turbine Casing & Blade Rings' | 10% of total installed quantity |
| iii. | Keys + pins for inner casing of all stationary stages | 2 sets |
| iv. | Following spares as needed for Gas turbine during combustor inspection; hot gas path inspection; and major overhaul: | |
| v. | Heat shield segments/shroud ring segments for stationary row including inlet & guide segments for stage 1&2and fixing/assembly materials /"Ring Segments and hardware for all stage assembly" | 100% of all sizes & types installed |
| vi. | Rotor heat shield segments with fixing/assembly material /"Torque Tube Parts /Heat shield with Hard ware & Consumables " | 25% of all sizes and types installed |
| vii. | Gas turbine set bearings | |
| f) | Main shaft bearings assembly with Oil seals to be considered | 2 sets |
| i. | Thrust bearing pads complete with thermocouples, locking plates, counter sunk screws, pressure screws, adaptor thrust ring with Oil seals to be considered | 2 sets |
| g) | Gas turbine auxiliaries | |
| ii. | AOP/EOP/MOP/TOP and any other pumps spares like bearings, keys, shaft, coupling, seals, fasteners | each 1set |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| iii. | Vapour Extractor/ Ventilation system Spares like bearings, fan, keys, shaft, coupling, seals, fasteners | each 1set |
| iv. | Centrifuge spares- all seals, brake liners, keys, shaft, bearings, filter elements etc | each 1set |
| v. | GT related valves/ servo system spares | each 1set |
| vi. | Gas turbine – Shaft/ blade cooling system spares | each 1set |
| vii. | Gas turbine – Shaft/Casing - All Seals | each 1set |
| viii. | Piping gaskets and fasteners | 0.2 |
| ix. | Starting system spares | each 1set |
| x. | GT casing Insulation and piping insulation- pads, preformed pipe sections | 0.2 |
| xi. | GT - Casing nuts and bolts | 0.3 |
| xii. | Blade wash system spares | each 1set |
| h) | Filters (for gas turbine unit) | 2 sets |
| | a. Main oil tank filters | 2 sets |
| | b. Online lube oil filters | 2 sets |
| | c. Online control oil filters | 2 sets |
| | d. GT/GTG cooling water filters as needed | 2 sets |
| | e. Air intake static filters /Separator, coalescer pads, filters spares | 2 sets |
| I) | Coolers | |
| | a. Complete set of seals/gaskets for GT generating, Gas Turbine, Generator and Other Auxiliaries | 2 sets |
| J) | Fuel gas system | |
| i) | Gas filter separator elements | 4 sets |
| ii) | Full set of gaskets, 'O' rings and gland seals for all isolation, control and bypass valve of the system | 4 sets |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| iii) | Gas filter separator element at GT inlet | 4 sets |
| k) | Gas heater related spares | 1 set |
| l) | One Set Of Valves for each category | each 1set |
| m) | Valve &actuator spares, gaskets, seals repair kit and trim repair kit | each 1set |
| O) | Condensate system spares, Pump spares, seals, fasteners` | each 1set |
| i. | Fuel quick stop valve spares consisting of stem, valve trim, packing, O-ring/Gasket/Glands /Seals | 2 sets |
| ii. | One full Valve ESV assembly | |
| iii. | Spares for fuel quick stop valve servomotor consisting of seals, gaskets, washers, O-rings, springs. | 2 sets |
| iv. | ESV Servomotor and consumables Gasket/Glands /Seals | each 1set |
| v. | Oversized coupling, bolts, with nuts, washers for each coupling of GTG, GT. | 2 sets |
| vi. | Balancing weights of different type & stages for GT, GTG & other rotating devices, as required. | 2 sets |
| vii. | In-situ balancing kit | 1 set |
| p) | COMPRESSOR | |
| i) | Inlet Guide Vanes with all hardware materials | 2 sets |
| i) | IGV actuator & Valve Unit spares | 1 set |
| iii) | IGV Greasing Nipples | 1 set |
| iv) | Rotor Seals including all hardware like caulking wire, spring sealing strip. | 2 sets |
| v) | Spindle Bolts related Spares | 1 set |
| vi) | The Compressor Diaphrams | 1 set |
| vii) | Bleed Valves Spares | each 1set |
| viii) | Compressor Washing Chemical | For Two complete wash. |
| ix) | Compressor Casing & Blade Rings Fasteners | 0.3 |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| x) | Compressor Diaphrams Critical Stages adjacent to Bleed Valves Early Stages | each 1set |
| xi) | All GT Turning systems related Spares | each 1set |
| xii) | GT Auxiliaries spares- Equipment spares, repair kit, seals, fasteners | each 1set |
| xiii) | Starting System/ SFC related Spares | each 1set |
| 1.2.0 | **Steam Turbine Auxiliaries** | |
| a) | DC emergency lube oil pump /set consisting of shaft rotor bearings, seals, gland packing, shaft sleeves for complete replacement in one pump) | One number of each type/size |
| b) | Turning Gear motor | One number of each type/size |
| c) | Shaft driven MOP assembly /set consisting of shaft rotor bearings, seals, gland packing, shaft sleeves for complete replacement in one pump) | One number of each type/size |
| d) | Filters –online lube oil and control oil filters | Two sets each of each type/size |
| e) | Shaft Glands and Gland sealing – Metallic labyrinths with seal glands and springs for each stage/ fasteners | One set of each type/size |
| f) | Interstage diaphragm springs, glands and packing for each stage All Dummy ring, Thermal shield, all seals, springs, diaphram liners, fasteners, Blade seals kit | One set of each type/size |
| g) | Combined Thrust and Journal bearings with oil seals | One set of each type/size |
| h) | Governor – Electrical speed measuring device and Emergency governor | One set of each type/size |
| i) | Steam Turbine control and Stop valve of each type and size:- stem, Seal, valve plug, valve bushings, valve gasket, steam strainers | One set of each type/size |
| j) | Servo motor of each size and type – piston, piston ring, set of seals, set of bearing | One set of each type/size |
| k) | Safety diaphragm of LP turbine casing | One set of each type/size |
| l) | ST- Full Hardware for casing & internals | 0.3 |
| m) | Piping - Steam/ Oil - Gaskets, packings, 'O'rings | each 1set |
| n) | ST -STG Coupling bolts, washers | each 1set |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| o) | FCNR (Quick closing NRVs)- spares repair kit and trim kit | each 1set |
| p) | AOP/ TOP spares-spares like bearings, keys, shaft, coupling, seals, fasteners | each 1set |
| q) | Centrifuge spares- all seals, brake liners, keys, shaft, bearings, filter elements etc | each 1set |
| r) | Oil cooler spares seals, fasteners | each 1set |
| s) | Oil cooler spare plates | 0.1 |
| t) | Turbine casing/piping insulation -pads, preformed pipe sections | 0.2 |
| u) | OST spares- repair kit, seals, fasteners | each 1set |
| v) | Atemperation nozzles, Steam traps- spares | each 1set |
| w) | Duplex filters- spare elements, seals, hasteners | each 1set |
| X | All system valves, valve actuator spares, Gaskets, seals like repair kit, tirm kit | each 1set |
| y) | One full Valve assembly | each 1set |
| z) | Gland sealing system spares | each 1set |
| 1.3.0 | **Deaerator** | |
| a) | Spray nozzles with gaskets | 20% of the total number |
| 1.4.0 | **Surface Condenser Spares** | |
| a) | Steam Traps full assembly | each 1no. |
| b) | Spares for ball circulating pump (set consisting of shaft rotor bearings, seals, gland packing, shaft sleeves for complete replacement in one pump) | One set of each type/size |
| c) | Expansion joints on CW line to condenser (set consisting of bellow, SS mesh, fasteners for complete replacement in one condenser) | One set of each type/size |
| d) | Vacuum breaker and valve spares- seals repair kit and valve repair kit | each 1set |
| 1.5.0 | **Vacuum Pump** | |
| a) | Complete set of bearings for pump | One set of each type/size |
| b) | Set of Glands, seals and gaskets | One set of each type/size |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| c) | Full set of wearing rings of one pump | One set of each type/size |
| d) | Vacuum pump ~~PHE~~ spares-seals | each 1set |
| e) | Wafer type valves if any- spares- seals repair kit, trim repair kit | each 1set |
| f) | Wafer type valves if any-full valve | each 1set |
| 1.6.0 | **Condensate Extraction Pump** | |
| a) | Wearing rings | 2 Sets |
| b) | Bushing | 2 Sets |
| c) | Seal assembly | 4 Sets |
| d) | Gasket, housing seals, Labyrinth ring and “O” rings | 2 Sets |
| e) | Thrust bearings | 2 Sets |
| f) | Pump bearings | 4 Sets |
| g) | Shaft sleeves | 2 Sets |
| h) | One fully assembled pump | 1 set |
| i) | Suction strainer element | 1 set |
| j) | Shaft coupling | 2 Sets |
| 1.7.0 | **Boiler Feed Pumps (applicable for HP/ ~~IP~~/ LP / Booster pump)** | |
| a) | Mech. seals | 2 Sets |
| b) | Set of wearing rings | 2 Sets |
| d) | Shaft sleeves | 2 Sets |
| e) | Pump Bearings including thrust bearing of one pump with hydraulic coupling with oil seals for the bearing | 2 Sets |
| f) | Bushes for one pump | 2 Sets |
| g) | Gasket, housing seals, Labyrinth ring and “O” rings | 2 Sets |
| h) | Suction strainer element | 1 Sets |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| i) | Lube oil system spares-MOP/AOP-Spares, Relief valve spares, Check valve spares, Spare Strainers, Bellows, Oil cooler seals etc. | each 1set |
| 1.8.0 | **HRSG AND ITS AUXILIARIES** | |
| 1.8.1 | **Boiler Drums** | |
| a) | Man hole gaskets | 100% of total manholes of one Station |
| b) | Casing manhole Fasteners | 0.3 |
| c) | Drum Internal demister packs/Py/Sy scrubbers, cyclones etc. | each 1set |
| d) | Colour port / Level gauge glass spares | each 1set |
| 1.8.2 | **Safety Valves** | |
| a) | Safety valves for HP and LP drums,and other Boiler circuit safety and relief valves. | |
| b) | Upper adjusting rings for type and size | 2 Numbers each |
| c) | Lower adjusting rings for type and size | 2 Number each |
| d) | Valve Disc for each type and size | 4 Numbers each |
| e) | Valve Stem for each type and size | 2 Number each |
| f) | Gagging tool kit | each 1set |
| g) | Springs for the valves | each 1set |
| h) | Seat ring/ Nozzles for the valves | each 1set |
| i) | Seals/Gaskets/Fasteners for safety valves | each 2set |
| j) | Electro magnetic safety relief valve spares | each 1set |
| k) | Fasteners for safety valves | each 1set |
| 1.8.2.1 | **Expansion joint between GT and HRSG** | 4 Nos. for each HRSG |
| a) | HRSG Module Casing manhole gaskets | 2 |
| 1.8.3 | **Superheater Spray Control Valves** | |
| a) | Body seat rings | 4 Numbers each type and size |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| b) | Stem | 2 Numbers. each type and size |
| c) | Spray Nozzles with seals ( Repair Kit) | each 1set |
| 1.8.3.1 | **Superheater spray control valves** | 2 Numbers for each HRSG |
| a) | PCV.TCV, FCVs - spares ( seals repair kit, trim repair kit) for all these valves to be covered | each 1set |
| 1.8.4 | **Main steam stop valve including integral by-pass valve** | |
| a) | Stems of main stop valve and of its integral by-pass valve | 1 Number of each type and size |
| b) | Discs, Seat rings, Gland packings, Body seal of main stop valve and of its integral by-pass valve | 2 Numbers of each type and size |
| 1.8.5 | **Boiler Feed Check Valves for HP and LP Steam Circuits** | |
| a) | Flaps and seals | 4 Sets of each type and size |
| b) | Packing and fasteners | 2 Sets of each type and size |
| 1.8.6 | Start up Vent Valves for HP and LP Steam Circuits – Set of stems, disc, body seal ring, gland packing and fasteners | 1 Set of each type and size per HRSG, sealing ring (4) sets |
| 1.8.7 | Economiser Recirculation Valve for HP and LP Steam Circuits - Set of stems, disc, body seal ring, gland packing and fasteners | 1 Set of each type and size per HRSG sealing ring (4) sets |
| a) | Back pressure regulator spares- Seals repair kit, trim repair kit | each 1set |
| b) | HRSG - Pipe penetrations Non metallic expansion joint spare and fasteners for the same. | each 1set |
| c) | HRSG Chemical dosing system pump and valve spares | each 1set |
| d) | SWAS system valve spares, spare valves | each 1set |
| 1.9.0 | **HP / LP Superheater tubes, LP Evap tubes, CPH Tubes** | 50 meters for each HRSG |
| a) | Spare- return/riser bends for all HP/~~IP~~/LP modules LP Evaporator tube and Bends shall be SA 213-T22 material | 0.2 |
| 1.10.0 | **EOT Cranes (Mandatory spares for EOT Cranes of each type and size)** | |
| a) | Set of Bearings for long travel wheel of each crane | 1 Set /Station |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| b) | Set of bearings for cross travel wheel of each crane | 1 Set /Station |
| c) | Set of bearings for gear boxes (Main hoist, auxiliary hoist, CT and LT) of each crane | 1 Set /Station |
| d) | Set of brake lining with rivets of each crane | 1 Set /Station |
| e) | For both Main and Auxiliary hoist (Both EM and EM thrustor) | 1 Set/Station |
| f) | Cross travel | 1 Complete Set/Station |
| g) | Long travel | 1 Complete Set/Station |
| h) | Oil seals sets for gear boxes of each cranes | |
| i) | Main hoist | 1 Set/Station |
| j) | Auxiliary hoist | 1 Set/Station |
| k) | Cross travel | 1 Set/Station |
| l) | Long travel | 1 Set/Station |
| m) | Brake springs for main hoist, auxiliary hoist CT and LT of each crane | |
| n) | Thrust Brake Assembly Complete | 1 Set/Station |
| o) | EM thrustor brake | 1 Set/Station |
| p) | Carbon brushes and brush holder of each motor of each crane | One Set/Station |
| q) | Solenoid coil for EM brakes of each motor (Main Hoist, A.H., C.T. and L.T.) of each crane | One Set/Station |
| r) | Complete set of fuse links required for each crane | One Set/Station |
| s) | Over load relays for all motors of each crane | 1 Set/Station |
| t) | Limit switches of all motors of each crane | 1 Set/Station |
| u) | Spare motor for | |
| v) | Main hoist | 1 Number/Station |
| w) | Auxiliary hoist | 1 Number/Station |
| x) | LT | 1 Number/Station |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| 1.11.0 | **Water Treatment Plant** | |
| 1.11.1 | Centrifugal Pumps for each type and capacity | |
| a) | Shaft sleeve | 1 |
| b) | Wearing rings (Impeller & Casing) | 2 |
| c) | Pump bearing | 1 |
| d) | Seal for pumps | 1 |
| e) | Motor bearing | 1 |
| f) | Motor coupling | 1 |
| g) | Pump & Drive coupling, bushes, pins with all fasteners & coupling guards | 1 |
| h) | Gland, Packing & Gland Assembly | 1 |
| 1.11.2 | **Agitators for each type and capacity** | |
| a) | Gear box unit complete | 1 |
| b) | Bearings for gear box unit | 1 |
| c) | Motor gear box Coupling | 1 |
| d) | Gearbox agitator coupling | 1 |
| f) | Agitator | 1 |
| g) | Oil seals | 4 |
| 1.11.3 | Mixed Bed unit | |
| a) | Cation resin | 1Fill |
| b) | Anion resin | 1Fill |
| c) | Resin traps | One full set |
| d) | Strainers for Mixed bed unit | 10% of total quantity |
| e) | Acid / Alkali ejectors | 10% of total quantity |
| f) | Fume absorber | 1 |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| g) | $CO_2$ absorber | 1 |
| h) | Gaskets | 10% of each size |
| i) | Hardware | 10% of each size and type |
| k) | Ejectors | 2nos |
| 1.11.4 | Centrifugal blower | |
| b) | Shaft sleeve | 1 |
| c) | Gland sleeve | 1 |
| d) | Bearings | 1 |
| e) | Seals | 1 |
| f) | Belts | each 1set |
| 1.11.5 | Valves | |
| a) | Pressure vacuum relief valve | 1 no. of each type & rating |
| b) | Pressure vacuum relief valves springs | 1 no. of each type & rating |
| c) | SS solenoid valve | 1 no. of each type & rating |
| d) | Plug Valve | 1 no. of each type & rating |
| e) | Check valve/ Non return valve | 1 no. of each type & rating |
| f) | Ball valve | 1 no. of each type & rating |
| g) | Globe valve | 1 no. of each type & rating |
| h) | Diaphragm valve | 1 no. of each type & rating |
| i) | Butterfly valve | 1 no. of each type & rating |
| j) | All Control valve spares in Desalination plant ( seals repair kit, trim repair kit, fasteners) | 1 no. of each type & rating |
| k) | Victaulic coupling with seals and fasteners of different sizes | 30% of full qty |
| l) | Repair Kit for all valves each one set ( stem.plug/disc, seat, all gaskets, O rings, seals etc) | each 1set |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| 1.12.0 | **POWER CYCLE PIPING AND LOW PRESSURE PIPING** | |
| 1.12.1 | Low Pressure (LP) Piping | |
| a) | Valves including control valves | 5% of the total population or minimum 2 nos. of each type material size and class whichever is more |
| | Note : Complete valve along-with actuator and all other accessories which are the part of original supply shall be also be supplied | |
| b) | Repair Kit for all valves each one set (stem.plug/disc, seat, all gaskets, O rings, seals etc) | each 1set |
| 1.12.2 | Power Cycle Piping (PCP) | |
| a) | Repair Kit for all valves eacch one set (stem.Plug/disc, seat, all gaskets, O rings, seals etc) | each 1set |
| b) | Spare gaskets for all the gate valve for sizes 15mm NB to 500mm NB | 100% of each type, size, material and class for one CC Module. |
| c) | Spare sets of gland packings of all the gate valves for all sizes | 100% of each type, size, material and class for one CC Module. |
| d) | Spare gaskets for all the globe valves for sizes 15mm NB to 500mm NB | 100% of each type, size, material and class for one CC Module. |
| e) | Spare sets of gland packings for the Globe valves for all sizes | 100% of each type, size, material and class for one CC Module. |
| f) | Spare gaskets for NRV for all the valves | 100% of each type, size, material and class for one CC Module. |
| g) | Spare set of Gaskets for safety relief valves for all sizes | 100% of each type, size, material and class for one CC Module. |
| h) | Complete gate valves assembly. up to the size of 50 NB | 100% of each type, size, material and class for one CC Module. |
| i) | Complete angle valves only upto the size of 50NB | 100% of each type, size, material and class for one CC Module. |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| j) | Complete Globe valves upto the size of 50 NB | 100% of each type, size, material and class for one CC Module. |
| k) | Complete NRV's assembly upto the size of 50NB | 100% of each type, size, material and class for one CC Module. |
| l) | Complete needle valves upto the size of 50 NB | 100% of each type, size, material and class for one CC Module. |
| m) | Spring hangers (Variable spring ) | 10% of total population of one (1) unit for each type and stiffness or minimum one number |
| n) | Gasket for each flanged connection on high pressure steam and feed line | 2 numbers |
| o) | Steam traps and Y-Strainers | |
| p) | All internals required for complete | 10% of total population of one unit for each size, type, material and rating, or min. one number |
| q) | Other Valves including Control Valves | |
| r) | Each type, size, material and class for 100mm and below but above 50NB | 1 number |
| s) | Each type, size, material and class | 20% or 2 numbers, above 100 mm whichever is more |
| t) | CC Module : Combined Cycle Module | |
| u) | Note : Wherever valves are specified as mandatory spares, complete valve along with actuator and all other accessories which are the part of original supply shall also be supplied. | |
| 1. 13.0 | **ALL MISCELLANEOUS WATER PUMPS** | |
| a) | (Covered under Auxiliary Water System, GT Wash System, CCW Makeup System, HRSG Makeup, Blowdown, Condensate transfer system and WTP pumps) | |
| 1.13.1 | All Horizontal Pumps | |
| a) | One fully assembled pp | 1set |
| b) | Shaft Sleeve | 2 Sets of each type and size |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| c) | Casing Wear ring | 2 Sets of each type and size |
| d) | All pump Bearings | 2 Sets of each type and size |
| e) | Gland Packing | 2 Sets of each type and size |
| f) | Fasteners | 1 Set of each type and size |
| g) | Complete Coupling (Pump and Motors) | 1 Set of each type and size |
| h) | Mechanical Seal | 1 Set of each type and size |
| 1.13.2 | All Vertical Pumps and Accessories | |
| a) | Shaft sleeves, Bearings, Wear rings, shaft sleeve, packings, mechanical seals, fasteners, couplings, bushes, all gaskets and O rings, rubber expansion joint, impeller nut | 1 set of each type / size/rating |
| b) | One fully assembled pp | 1set |
| 1.14.4 | Auxiliary Cooling Water Pumps and Accessories | 3 Sets of each type and size |
| a) | Shaft sleeves | 2 sets of each type / size / rating |
| b) | Bearing of pumps (all bearings) including thrust bearing as applicable | 2 sets of each type / size / rating |
| c) | Bearing of motor (all bearings including thrust bearing as applicable) | 2 sets of each type / size / rating |
| d) | Wearing rings or equivalent for impeller (if applicable) | 2 sets of each type / size / rating |
| e) | Wearing rings or equivalent for Casing/ Bowl (if applicable) | 2 sets of each type / size / rating |
| f) | and Line shafts with fasteners (as applicable) | 2 sets of each type / size / rating |
| g) | All shaft Couplings with fasteners (as applicable) | 2 sets of each type / size / rating |
| h) | Coupling between pump and motor and coupling Guards | 2 sets of each type / size / rating |
| i) | Bushes for the all Couplings as applicable | 2 sets of each type / size / rating |
| j) | Mechanical seal or gland packing as applicable for the pumps | 2 sets of each type / size / rating |
| k) | Thrust bearing pads (if applicable) | 2 sets of each type / size / rating |
| l) | All Gaskets | 2 sets of each type / size / rating |
| m) | impeller nut | 2 sets of each type / size / rating |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| n) | Rubber Expansion Joint | 2 sets of each type / size / rating |
| 1.15.0 | **COMPRESSED AIR SYSTEM SCREW COMPRESSOR** | |
| 1.15.1 | HP Stages of Compressor (per unit) | |
| a) | HP element | One Set |
| b) | Packing Set | One Set |
| c) | Axial thrust bearing | One Set |
| d) | Labyrinth oil seal or radial seals or double acting seals for drive shaft | One Set |
| e) | Rotor kit one Set | One Set |
| 1.15.2 | LP Stages of Compressor (per unit) | |
| a) | LP element | One Set |
| b) | Graphitic ring shaft seals for compressor chamber or white metal labyrinth seals | One Set |
| c) | Packing kit | One Set |
| d) | Axial thrust bearing | One Set |
| e) | Rotor kit one Set | One Set |
| 1.15.3 | Air Drying Plant (per unit) | |
| a) | Inlet and Outlet valve for Dryer | One Set |
| b) | Valves and air drying plant | One Set |
| c) | Dryer element compound | 2 fill |
| 1.16.0 | **AIR CONDITIONING and VENTILATION SYSTEM** | |
| 1.16.1 | Centrifugal fan | |
| a) | V-belt | 1 set |
| b) | Bearings | 1 set |
| c) | Shaft sleevs | 1 set |
| d) | Gaskets | 1 set |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| e) | Stuffing box | 1 set |
| f) | Impeller wear ring | 1 set |
| g) | Filters | 1 set |
| 1.16.2 | Tube axial fan | |
| a) | Bearings | 1 set |
| b) | Filters | 1 set |
| c) | motor bearing | 1 set |
| 1.16.3 | Control (For each model/capacities) | |
| a) | HP/LP cut out | 2 Numbers |
| b) | Thermostatic expansion valve | 1 Number |
| c) | Humid stat, Thermostat | 1 Number |
| d) | Dual pressure stat | 1 Number |
| e) | Anti freeze thermo stat | 1 Number |
| f) | Modulating thermo stat (each type) | 1 Number each type |
| g) | Heater coil for temp. stabilisation | 2 sets |
| h) | Rotor kit one Set | One Each |
| 1.17.0 | **INDUCED DRAUGHT COOLING TOWERS** | |
| a) | couplings with all the fasteners | 10% or 1 number of each type and size |
| b) | Bearings Complete | 20% or 2 sets of each type and size |
| c) | Complete fan and hub assembly matched and balanced | 10% or 1 set of each type and size |
| d) | Complete gear box | 10% or 1 no. of each type and size |
| e) | Bearings for gear box | 20% or 2 sets of each type and size |
| f) | Oil seals, 'O' rings and Gaskets for gear box | 10% or 2 sets of each type and size |
| g) | All Couplings (Fan end, Gearbox end and motor end) along with all fasteners) | 10% or 1 set of each type and size |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| h) | Cell Isolation Valve | 10% or 1 number of each type and size |
| i) | Tower Internals - Water spray nozzle | 10% of total population of one tower |
| j) | Towers Internals-Film Type Fills Packs | 10% of total population of one tower |
| k) | Towers Internals - Drift eliminator | 10% of total population of one tower |
| 1.18.0 | **FIRE PROTECTION SYSTEM** | |
| 1.18.1 | Fire Hoses with Couplings | |
| a) | 7.5 m long fire hoses with end connectors | 10% of population |
| b) | 15 m long fire hoses with end connectors | 10% of population |
| 1.18.2 | Branch Pipes with Nozzles | |
| a) | Nozzles with branch pipes quick coupling ends | 10% of population |
| b) | Nozzles of water monitors | 10% of population |
| 1.18.3 | Deluge Valve Assemblies | |
| a) | Complete deluge valve assembly along with internals | 10% of population each type |
| b) | Clapper assembly complete (consisting of clapper seat rubber, screws) | 10% of population |
| c) | Solenoid coils | 10% of population each type |
| 1.18.4 | Valves (Gate/Globe/ / Ball / Butterfly/NRV) | |
| a) | Complete Valves | 10% of population of each type and size with minimum 1 number |
| b) | Reduction gear operator (Gate/globe/butterfly) | 10% of population of each type and size with minimum 1 number |
| c) | Flap/Door with pin (NRV) | 10% of population of each type and size with minimum 1 number |
| d) | Disc (butterfly/globe) | 5% of population of each type and size with minimum 1 number |
| e) | Gate (Gate valve) | 5% of population of each type and size with minimum 1 number |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| f) | Stem (all types) | 10% of population of each type and size with minimum 1 number |
| g) | Seal rings (all types) | 10% of population of each type and size with minimum 1 number |
| h) | Flap rings (NRV) | 10% of population of each type and size with minimum 1 number |
| i) | Gaskets | 10% of population of each type and size with minimum 1 number |
| j) | Bearing (butterfly valve) | 10% of population of each type and size with minimum 1 number |
| k) | Yoke bush | 10% of population of each type and size with minimum 1 number |
| 1.18.5 | Y-Type Strainers | |
| a) | Strainers elements with O-rings and stiffeners | 20% of population of each type and size with minimum 1 number |
| 1.18.6 | MVW Spray System | |
| a) | Spray Nozzles | 10% of population |
| b) | QB Detectors | 20% of population |
| 1.18.7 | HVW Spray System | |
| a) | Spray Nozzles | 10% of population |
| b) | QB Detectors | 20% of population |
| c) | Spot/Heat detectors | 20% of population |
| 1.18.8 | Hydrant Valve | |
| a) | Hydrant valve complete (internal) single headed with instantaneous female coupling | 20% of population |
| b) | Hydrant valve complete (external) single headed with instantaneous female coupling | 20% of population |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| c) | Hydrant valve complete (double headed) with instantaneous female coupling | 10% of population |
| d) | Water monitor sets with nozzle, branch pipe | 10% of population |
| e) | Spindle with nuts of Hydrant valve | 20% of population |
| f) | Bonnet, gland nut, rubber assembly of hydrant valve | 25% of population |
| g) | Seat, check nut, washer assembly of hydrant valve | 25% of population |
| h) | Rubber washer for female coupling | 50% of population |
| i) | Instantaneous female coupling assembly complete for hydrant valve | 20% of population |
| j) | Lock pin assy. for hydrant valve | 20% of population |
| 1.18.9 | Smoke/Heat Detectors | |
| a) | Photo-electric type detector (Addressable) | 10% of population |
| b) | Multi sensor type detectors (Addressable) | 10% of population |
| c) | Indicators assembly for smoke detectors provided in false ceiling (Response indicator) | 5% of population |
| d) | Duct Mounted Detectors | 10% of population |
| e) | LHS Cable | 10% of population |
| f) | Spot type heat detectors | 10% of population |
| g) | Gas/ fuel leak detector | 10% of population |
| h) | Any other type of Detector | 10% of population |
| i) | Detector base | 10% of each type |
| j) | Detector head (including ionisation, photoelectric, heat types) | 10% of each type |
| k) | Manual pull stations | 10% of each type |
| 1.18.10 | Portable Extinguishers | |
| a) | Portable extinguishers | 10% of each type and size |
| b) | Water Type | |
| c) | Foam Type | |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| d) | $CO_2$ Type | |
| e) | Dry Chemical Type | |
| f) | Spare hoses for all fire extinguishers, | 30% of each type and size |
| 1.18.11 | Mobile Extinguishers | 10% of each type and size |
| a) | Foam Type | |
| b) | Dry Chemical Type | |
| c) | $CO_2$ Type | |
| 1.18.12 | Control/Annunciation Panels (Addressable) | |
| a) | Control supply transformer | 1 number of each type |
| b) | Relay and timer | 1 number of each type |
| c) | Contactors | 1 number of each type |
| d) | Ammeter | 1 number of each type |
| e) | Voltmeter | 1 number of each type |
| f) | LEDs | 4 numbers. of each type |
| g) | Control Switches | 1 number of each type |
| h) | Push Button complete with | 1 number of each type contact elements |
| i) | Control fuse base with carrier complete set for panel | 2 numbers of each type |
| j) | Bi-metallic overload relays | 1 number of each type |
| k) | Alarm buzzer | 2 numbers of each type |
| 1.18.13 | Field Devices | |
| a) | Pressure gauges | 5 numbers |
| b) | Temperature gauges | 2 numbers |
| c) | Level Indicator | 2 numbers |
| d) | Pressure switches | 5 numbers |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| e) | Flow Switches | 2 numbers |
| f) | Limit Switches for Isolation valves | 20 numbers |
| 1.18.14 | Inert Gas Extinguishing System | |
| a) | Nozzles | 2 numbers of each size/type |
| b) | Automatic and Manual release system | |
| c) | Cylinder valve with safety pressure relief device | 1 number of each size/ type |
| d) | Gas cylinder | 5 numbers of each size/type |
| e) | Flexible hoses (if applicable) | 5 numbers of each size/type |
| f) | Solenoid coils | 2 numbers of each size/type |
| g) | Cylinder Rupture discs | 1 set of each size/ type |
| 1.19.0 | **CONDENSER COOLING WATER PUMPS AND ACCESSORIES** | |
| 1.19.1 | Condenser Cooling Water Pumps | |
| a) | Shaft sleeves | 1 set of each type /size/rating |
| b) | Bearing of pumps (all bearings) including thrust bearing as applicable. | 1 set of each type /size/rating |
| c) | Wearing rings or equivalent for impeller (if applicable) | 1 set of each type /size/rating |
| d) | Wearing rings or equivalent for Casing/ Bowl (if applicable) | 1 set of each type /size/rating |
| e) | All shaft Couplings with fasteners (as applicable) | 1 set of each type /size/rating |
| g) | Coupling between pump and motor and coupling Guards | 1 set of each type /size/rating |
| h) | Bushes for the all Couplings as applicable | 1 set of each type /size/rating |
| i) | Mechanical seal or gland packing as applicable for the pumps | 1 set of each type /size/rating |
| j) | Thrust bearing pads (if applicable) | 1 set of each type /size/rating |
| k) | All Gaskets | 1 set of each type /size/rating |
| l) | impeller nut | 1 set of each type /size/rating |
| m) | Rubber Expansion Joint | 1 set of each type /size/rating |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| n) | Filters / Strainer along with gasket, O rings | One for each type |
| | Note : | |
| 1 | Wherever set is mentioned, one set of the spares of that item shall be for complete replacement of that particular item for one equipment. | |
| 2 | Any fraction of a item shall mean the next higher integer | |
| 1.20.0 | **LP BYPASS CONTROL VALVE** | |
| a) | Spindle complete | 1 number of each type /size/rating |
| b) | Cover sealing | 1 number of each type /size/rating |
| c) | Seat sealing | 1 number of each type /size/rating |
| d) | Packing ring | 4 numbers of each type /size/rating |
| e) | seat | 1 number of each type /size/rating |
| f) | Packing cord | 1 number of each type /size/rating |
| g) | Sealing set for actuator | 1 number of each type /size/rating |
| 1.21.0 | **LP SPRAY WATER CONTROL VALVE** | |
| a) | Set spindle, trim, seat | 1 number of each type /size/rating |
| b) | Packing complete | 1 number of each type /size/rating |
| c) | Cover gasket | 1 number of each type /size/rating |
| d) | Sealing set for actuator | 1 number of each type /size/rating |
| e) | Spray nozzles with seals | 1 set of each type /size/rating |
| 1.22.0 | **LP SPRAY WATER STOP VALVE** | |
| a) | Set spindle, trim, seat | 1 number of each type /size/rating |
| b) | Packing complete | 1 number of each type /size/rating |
| c) | Cover gasket | 1 number of each type /size/rating |
| d) | Sealing set for actuator | 1 number of each type /size/rating |
| e) | Spray nozzles with seals | 1 set of each type /size/rating |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| 1.23.0 | **HP BYPASS CONTROL VALVE** | |
| a) | Spindle complete | 1 number of each type /size/rating |
| b) | Cover sealing | 1 number of each type /size/rating |
| c) | Seat sealing | 1 number of each type /size/rating |
| d) | Packing ring | 4 numbers of each type /size/rating |
| e) | seat | 1 number of each type /size/rating |
| f) | Packing cord | 1 number of each type /size/rating |
| g) | Sealing set for actuator | 1 number of each type /size/rating |
| 1.24.0 | **HP SPRAY WATER CONTROL VALVE** | |
| a) | Set spindle, trim, seat | 1 number of each type /size/rating |
| b) | Packing complete | 1 number of each type /size/rating |
| c) | Cover gasket | 1 number of each type /size/rating |
| d) | Sealing set for actuator | 1 number of each type /size/rating |
| e) | Spray nozzles with seals | 1 set of each type /size/rating |
| 1.25.0 | **HP SPRAY WATER STOP VALVE** | |
| a) | Set spindle, trim, seat | 1 number of each type /size/rating |
| b) | Packing complete | 1 number of each type /size/rating |
| c) | Cover gasket | 1 number of each type /size/rating |
| d) | Sealing set for actuator | 1 number of each type /size/rating |
| e) | Spray nozzles with seals | 1 set of each type /size/rating |
| 1.26.0 | **ALL CONTROL VALVES ISOLATION VALVES** | 5% of total population or min. 1 no. whichever is higher for each type and size |
| a) | Oily water system spares- Pump, Valve- spares & Oil separator elements etc | 1 set of each type /size/rating |
| b) | Lubricants for one year consumption for th entire plant | 1fill for one year operation |

| Sl.No. | Description | Qty / Unit | |
|---|---|---|---|
| d) | All Relief valve spares for all systems ( seals repair kit, trim repair kit) | 1 set of each type /size/rating | |
| 2.0.0 | **ELECTRICAL** | | |
| 2.1.0 | Generator and auxiliaries ( for each generator ) | | |
| 2.1.1 | Gaskets (each set includes all types and size of gaskets for one generator ) | set | 1 |
| 2.1.2 | Insulating materials, washers, bolts, liners, sleeves, rings, packing, bushes, pipes. | % | 10% of each type and size for generator and associated pipes |
| 2.1.3 | Generator bearing | Set | 1 |
| 2.1.4 | Oil guard rings spares for bearing (1 set should consist of sealing strips and caulking material for both ends) | Set | 1 |
| 2.1.5 | Brush holders | Set | 1 |
| 2.1.6 | Carbon brushes | Sets | 1 |
| 2.1.7 | Stator winding bars ( each set includes 20% of upper, lower and end connection for one generator ) | Sets | 1 |
| 2.1.8 | Slot wedges | % | 10% of one generator |
| 2.1.9 | Terminal bushings ( each rating ) | Nos | 2 |
| 2.1.10 | Diodes | % | 10% of each type and rating |
| 2.1.11 | Fuses | % | 10% of each rating and type |
| 2.1.12 | Excitation system and AVR | | |
| a) | Rectifier bridge assembly consisting of thyristors and fuses of each type | set | 1 |
| b) | Fuse failure device | no. | 1 |
| c) | Thyristor failure device | no. | 1 |
| d) | PCB – each type | no. | 1 |
| e) | Exciter field suppression resistors | set | 1 |
| f) | Each type of control and selector switch | no. | 1 |

| Sl.No. | Description | Qty / Unit | |
|---|---|---|---|
| g) | Current transformer, Potential transformers and auxiliary transformers (for each type) | No. | 1 |
| h) | Relays of each type | No | 1 |
| 2.1.13 | Generator control panel for GTG and STG each | | |
| a) | Breaker control switch | no. | 10% of total requirement |
| b) | Voltmeter selector switch | no. | 10% of total requirement |
| c) | Ammeter selector switch | no. | 10% of total requirement |
| d) | Push button | no. of each | 10% of total requirement |
| e) | Semaphore indicator | no. | 10% of total requirement |
| f) | Auxiliary relay | no. of each | 10% of total requirement |
| g) | Indicating, annunciation and tripping lamps/LEDs | Nos. | 30% of total requirement |
| 2.2.0 | Generator Relay panel | | |
| 2.2.1 | Generator protection relays ( for each type) | No. | 1 |
| 2.2.2 | Lock out relay ( for each type) | No. | 1 |
| 2.2.3 | PT fuse failure relay | No. | 1 |
| 2.2.4 | Any other protection relay which are not indicated above but used in the protection scheme ( for each type ) | No. | 1 |
| 2.2.5 | Indication lamps ( each type) | % | 20% |
| 2.2.6 | Control fuses of each type and rating being used for above protections schemes. | % | 20% |
| 2.3.0 | Bus ducts | | |
| 2.3.1 | Bus bar support insulators ( each type and voltage class ) | % | 20% |
| 2.3.2 | Bus bar flexible expansion joint ( each type and rating) | % | 20% |
| 2.3.3 | Rubber bellow ( each type) | No. | 1 |
| 2.3.4 | Current Transformer of each type and rating ( for Isolated phase bus duct or if | No. | 1 |

| Sl.No. | Description | Qty / Unit | |
|---|---|---|---|
| | same are mounted in GCB compartment ) | | |
| 2.3.5 | Seal of Bushings ( for each type and ratings ) | Nos | 20% |
| 2.3.6 | Potential transformers of each type and rating ( for SPVT cubicle or if same are mounted in GCB compartment ) | No. | 1 |
| 2.3.7 | Neutral grounding resistor of each rating | No. | 1 |
| 2.4.0 | 66kV GIS | | |
| 2.4.1 | Spare GIS module for Circuit breaker | set | 1 |
| 2.4.2 | Spare GIS module for Current transformer | set | 1 |
| 2.4.3 | Spare GIS module for Lightning arrester | set | 1 |
| 2.4.4 | Spare GIS module for Isolator | No. | 1 |
| 2.4.5 | Bidder shall submit the list and supply of following spares | | |
| 2.4.6 | Maintenance spares | set | 1 |
| 2.4.7 | Special tools & tackles and spanners required during commissioning, operation & maintenance. | set | 1 |
| 2.4.8 | 66kV Control & relay panel | | |
| 2.4.9 | Generator transformer differential protection relay | No. | 1 |
| 2.4.10 | Overall differential protection relay | No. | 1 |
| 2.4.11 | Generator transformer restricted earth fault relay | No. | 1 |
| 2.4.12 | Generator transformer back up earth fault relay | No. | 1 |
| 2.4.13 | Generator transformer over current relay | No. | 1 |
| 2.4.14 | ST over current relay | No. | 1 |
| 2.4.15 | ST restricted earth fault relay | No | 1 |
| 2.4.16 | ST back up earth fault relay | No | 1 |
| 2.4.17 | ST differential protection relay | No. | 1 |
| 2.4.18 | Other multifunction relay | No. | 1 |

| Sl.No. | Description | Qty / Unit | |
|---|---|---|---|
| 2.4.19 | Push button of each type | nos. | min. 10% of installed quantity or 2 nos whichever is greater |
| 2.4.20 | Local/Remote selector switch | nos. | min. 10% of installed quantity or 2 nos whichever is greater |
| 2.4.21 | Breaker control switch | nos. | min. 10% of installed quantity or 2 nos whichever is greater |
| 2.4.22 | Voltmeter selection switch of each type | nos. | 1 |
| 2.4.23 | Indicating lamp of each type | nos. | min. 30% of installed quantity or 2 nos whichever is greater |
| 2.4.24 | Ammeters of each range | no. | 1 |
| 2.4.25 | Voltmeters | no. | 1 |
| 2.4.26 | Multifunction meter | no. | 1 |
| 2.4.27 | Timers | no. | 1 |
| 2.4.28 | Fuses of each rating | nos. | 10 |
| 2.4.29 | Multifunction relay of each type | No. | 1 |
| 2.4.30 | | | |
| 2.4.31 | Lock out relay | nos. | min. 10% of installed quantity or 2 nos whichever is greater |
| 2.4.32 | Trip coil supervision relay | nos. | min. 10% of installed quantity or 2 nos whichever is greater |
| 2.4.33 | Auxiliary relays of each type | nos. | min. 20% of installed quantity or 2 nos whichever is greater |
| 2.4.34 | Test terminal Blocks for meters | nos. | 2 |
| 2.4.35 | Test terminal Blocks for relays | nos. | 2 |
| 2.5.0 | Transformers( for each type ) | | |
| 2.5.1 | Bucholtz relay | no. | 1 |

| Sl.No. | Description | Qty / Unit | |
|---|---|---|---|
| 2.5.2 | Explosion vent diaphragm | set | 1 |
| 2.5.3 | Winding temperature indicator | no. | 1 |
| 2.5.3.1 | Oil temperature indicator | no. | 1 |
| 2.5.4 | Magnetic oil level guage | no. | 1 |
| 2.5.5 | Dial type thermometer | no. | 1 |
| 2.5.6 | Dial type oil temperature indicator | no. | 1 |
| 2.5.7 | Gasket for each fittings. | no. | 1 |
| 2.5.8 | One valve of each type | no. | 1 |
| 2.5.9 | HV bushing of each rating and type | no. | 1 |
| 2.5.10 | LV bushing of each rating and type | no. | 1 |
| 2.5.11 | Neutral bushing | set | 1 |
| 2.5.12 | Bushing CT of each rating and type | no. | 1 |
| 2.5.13 | Transformer oil in sealed drums | % | 20% of total quantity supplied |
| 2.5.14 | Cooling fans of each rating | No. | 1 |
| 2.5.15 | OLTC mechanism and RTCC panel | | |
| a) | Control switches of each type | No. | 1 |
| b) | Indication lamps of each type | Nos | 30% of total quantity supplied |
| c) | Selector switch of each type | No. | 1 |
| 2.5.16 | Cooling pump-motor set for each GTs | No. | 1 |
| 2.6.0 | Control Panel | | |
| 2.6.1 | Synchroscope | No.. | 1 |
| 2.6.2 | Double voltmeter of each range | No.. | 1 |
| 2.6.3 | Double frequency mater | No.. | 1 |
| 2.6.4 | Control switches of each type | % | 20% |

| Sl.No. | Description | Qty / Unit | |
|---|---|---|---|
| 2.6.5 | Selector switch of each type | no. | 1 |
| 2.6.6 | Synchronizing lamp | no. | 1 |
| 2.6.7 | Check Synchronizing relay | no. | 1 |
| 2.6.8 | Indicating meters of each type and range | no. | 1 |
| 2.6.9 | Indication lamps and annunciation window lamps/LEDs of each type | nos. | 30% of installed quantity |
| 2.6.10 | Semaphore indicator | no. | 1 |
| 2.6.11 | Potential transformer each type | Set | 1 |
| 2.7.0 | 11kV SWITCHGEAR | | |
| 2.7.1 | Bus bar support insulator of each type | nos. | 10 |
| 2.7.2 | Bus seal-off bushing of each type | nos. | 10 |
| 2.7.3 | P.T. fuse for H.T side of each type | nos. | 4 |
| 2.7.4 | Push button of each type | nos. | min. 10% of installed quantity or 2 nos. whichever is greater |
| 2.7.5 | Local/Remote selector switch | nos. | min. 10% of installed quantity or 2 nos whichever is greater |
| 2.7.5 | Breaker control switch | nos. | min. 10% of installed quantity or 2 nos whichever is greater |
| 2.7.6 | Voltmeter selection switch of each type | nos. | 1 |
| 2.7.7 | Indicating lamp of each type | nos. | min. 30% of installed quantity or 2 nos whichever is greater |
| 2.7.8 | Ammeters of each range | no. | 1 |
| 2.7.9 | Voltmeters | no. | 1 |
| 2.7.10 | Multifunction meter | no. | 1 |
| 2.7.11 | Timers | no. | 1 |
| 2.7.12 | CTs of each rating | no. | 1 |

| Sl.No. | Description | Qty / Unit | |
|---|---|---|---|
| 2.7.13 | Cable boxes of each type | no. | 1 |
| 2.7.14 | Fuses of each rating | nos. | 10 |
| 2.7.15 | Breaker closing coil | nos. | min. 10% of installed quantity or 2 nos whichever is greater |
| 2.7.16 | Breaker tripping coil | nos. | min. 10% of installed quantity or 2 nos whichever is greater |
| 2.7.17 | Breaker fixed contact assembly | nos. | min. 10% of installed quantity or 2 nos whichever is greater |
| 2.7.18 | Spring charging motors complete with closing and tripping springs and spring charge/discharge limit switches | nos. | min. 10% of installed quantity or 2 nos whichever is greater |
| 2.7.19 | Spring Charge/ discharge limit switches of each type | nos. | min. 10% of installed quantity |
| 2.7.20 | Auxiliary contact assembly | nos. | min. 10% of installed quantity or 2 nos whichever is greater |
| 2.7.21 | Multifunction relay of each type | No. | 1 |
| 2.7.22 | Under voltage relay | nos. | 2 |
| 2.7.23 | Motor protection relay | nos. | min. 20% of installed quantity or 4 nos. whichever is greater |
| 2.7.24 | Lock out relay | nos. | min. 10% of installed quantity or 2 nos. whichever is greater |
| 2.7.25 | Anti pumping relay | nos. | min. 10% of installed quantity or 2 nos. whichever is greater |
| 2.7.26 | Trip coil supervision relay | nos. | min. 10% of installed quantity or 2 nos. whichever is greater |
| 2.7.27 | Auxiliary relays of each type | nos. | min. 20% of installed quantity or 2 nos. whichever is greater |
| 2.7.28 | Test terminal Blocks for meters | nos. | 4 |

| Sl.No. | Description | Qty / Unit | |
|---|---|---|---|
| 2.7.29 | Test terminal Blocks for relays | nos. | 4 |
| 2.7.30 | Fuses for vacuum Breakers (if applicable) | nos. | min. 10% of installed quantity or 3 nos. whichever is greater |
| 2.7.31 | Surge arrestors/protectors for 11 kV motors feeders(if applicable) | nos. | min. 10% of installed quantity or 3 nos. whichever is greater |
| 2.7.32 | Complete 11kV Breaker of each type | no. | 1 |
| 2.8.0 | L.T. SWITCHGEAR | | |
| 2.8.1 | Push buttons of each type | nos. | min. 10% of installed quantity or 2 nos. whichever is greater |
| 2.8.2 | Selector switches of each type | nos. | min. 10% of installed quantity or 2 nos. whichever is greater |
| 2.8.3 | Indication lamps of each type | nos. | min. 30% of installed quantity or 10 nos. whichever is greater |
| 2.8.4 | Lens covers of all colours | nos. | min. 10% of installed quantity or 2 nos. whichever is greater |
| 2.8.5 | Ammeters of each range | no. | 1 |
| 2.8.6 | Voltmeters | no. | 1 |
| 2.8.7 | Switch fuse unit of each rating | nos. | min. 10% of installed quantity or 2 nos. whichever is greater |
| 2.8.8 | Fuses of each rating and type | nos. | min. 30% of installed quantity or 10 nos. whichever is greater |
| 2.8.9 | Contactors of each rating and type | nos. | min. 10% of installed quantity or 4 nos. whichever is greater |
| 2.8.10 | Total no. of bimetal thermal overload relays of each range | nos. | min. 10% of installed quantity or 2 nos. whichever is greater |

| Sl.No. | Description | Qty / Unit | |
|---|---|---|---|
| 2.8.11 | Lock out relay | nos. | min. 10% of installed quantity or 2 nos. whichever is greater |
| 2.8.12 | Anti-pumping relay | nos. | min. 10% of installed quantity or 2 nos. whichever is greater |
| 2.8.13 | Trip coil supervision relay | nos. | min. 10% of installed quantity or 2 nos. whichever is greater |
| 2.8.14 | Auxiliary relays of each type | nos. | min. 20% of installed quantity or 2 nos. whichever is greater |
| 2.8.15 | Multifunction relay of each type | nos. | 1 |
| 2.8.16 | Multifunction meter | nos. | 1 |
| 2.8.17 | Main Power contacts(Moving) for each rating | nos. | Min 10% |
| 2.8.18 | Arc. chutes (of each type) | nos. | 10% (atleast2 each) |
| 2.8.19 | Arcing contacts fixed (of each type) | nos. | 10% (atleast2 each) |
| 2.8.20 | Arcing contacts moving (of each type) | nos. | 10% (atleast2 each) |
| 2.8.21 | Bus support insulators (of each type) | nos. | 10% (atleast4 each) |
| 2.8.22 | IDMTL over current relay | nos. | min. 10% each |
| 2.8.23 | IDMTL earth fault relay | nos. | min. 10% each |
| 2.8.24 | Instantaneous under voltage relay | nos. | min. 10% each |
| 2.8.25 | Definite time relay | nos. | min. 10% each |
| 2.8.26 | Restricted earth fault relay for transformer incomer | No. | 1 |
| 2.8.27 | Back up earth fault relay for transformer incomer | No. | 1 |
| 2.8.28 | Motor protection relay | Nos | min. 10% of installed quantity or 4 nos. whichever is greater |
| 2.8.29 | Spring charge motors | Nos | 2 per switchgear |
| 2.8.30 | Control transformers | Nos | 10% |
| 2.8.31 | Fuse bases of each size | Nos | min. 10% of installed quantity |

| Sl.No. | Description | Qty / Unit | |
|---|---|---|---|
| | | | or 1 set of each whichever is greater |
| 2.8.32 | Rows of terminal Blocks of each type | Nos. | 10% |
| 2.8.33 | D.C resistance elements | nos. | 4 |
| 2.8.34 | Local push button stations of each type | nos. | 10% of total requirement |
| 2.8.35 | DC starters | nos. | 10% of total requirement |
| 2.8.36 | LT Incomer Switchgear (complete unit) of each type | no. | 1 |
| 2.8.39 | Check Synchronising Relay each type | no. | 1 |
| 2.8.40 | Service/ test position limit switches each type | nos. | min. 10% of installed quantity or 1 no whichever is greater |
| 2.8.41 | Spring Charging Limit switches each type | No. | 2 or 10% whichever greater |
| 2.9.9 | Clamps of each type and size | Nos. | min. 10% of installed quantity |
| 2.9.10 | SCADA system | | |
| a) | Ethernet Switches of each type | Nos. | min. 10% of installed quantity |
| b) | Printer of each type | Nos. | 1 |
| c) | HMI monitor | Nos. | 1 |
| 2.10.0 | BATTERY CHARGER ( for each charger ) | | |
| 2.10.1 | Controller cards of each type used | Set | 1 |
| 2.10.2 | SCR, diodes, capacitors, resistors of each type | Set | 3 |
| 2.10.3 | A.C fuse links each type | Nos. | 2 |
| 2.10.4 | D.C fuse links each type | Nos. | 2 |
| 2.10.5 | Contactors, contactor coil and contact kit of each type | set | 1 |
| 2.10.6 | Toggle switches, push buttons ( each type) | Nos. | 2 |
| 2.10.7 | Potentiometer | Nos. | 3 |
| 2.10.8 | Indication lamps of each type | Nos. | 5 |

| Sl.No. | Description | Qty / Unit | |
|---|---|---|---|
| 2.10.9 | Transducer (Voltage, Current) of each type | nos | min. 10% of installed quantity |
| 2.10.10 | Digital display card of each type | Nos. | 1 |
| 2.10.11 | Annunciator complete unit | Nos. | 1 |
| 2.11.0 | Battery( for each Battery) | | |
| 2.11.1 | Containers with covers | Nos. | min. 10% of installed quantity |
| 2.11.2 | Inter cell and inter row connectors | Nos. | min. 10% of installed quantity |
| 2.11.3 | Cell insulators | Nos. | min. 10% of installed quantity |
| 2.11.4 | Battery rack/stand insulators | Nos. | min. 10% of installed quantity |
| 2.11.5 | Nuts, bolts, washers | Nos. | min. 10% of installed quantity |
| 2.12.0 | UPS | | |
| 2.12.1 | Control cards of each type | Nos. | 2 |
| 2.12.2 | Thyristor and diode of each rating | Nos. | 3 |
| 2.12.3 | Static bypass switch thyrister | Nos. | 2 |
| 2.12.4 | Fuses each type | set | 1 |
| 2.12.5 | Transducer of each type | Nos. | min. 10% of installed quantity or 1 nos whichever is greater |
| 2.12.6 | Digital display unit of each type | set | 1 |
| 2.13.0 | Motors ( each for 11kV, 415v including MOVs and 110V DC motors) | | |
| 2.13.1 | Motor of each frame size(rating) and type | Nos. | Min. 1no up to 05 nos of installed quantities or 02 nos for more than 05 |
| 2.13.2 | Bearings of each motor type and rating | set | min. 10% of installed quantity |
| 2.13.3 | Termination kits for 11kV motor | No. | 1 no. of each size |
| 2.13.4 | Carbon brushes for DC motors | set | 5 sets of each size |
| 2.13.5 | Brush assemblies for DC motors | set | 2 sets of each size |

| Sl.No. | Description | Qty / Unit | |
|---|---|---|---|
| 2.13.6 | Cooling fans | Nos. | min. 10% of installed quantity or 1 no. whichever is greater |
| 2.13.7 | Dust seals | Nos. | min. 10% of installed quantity or 4 no. whichever is greater |
| 2.14.0 | Illumination system | | |
| 2.14.1 | Lamp fixtures of each type | Nos. | min. 10% of installed quantity |
| 2.14.2 | Lamps of each rating and type | Nos. | min. 10% of installed quantity |
| 2.15.0 | Communication system | | |
| a) | Handset instrument of each type | Nos. | min. 10% of installed quantity |
| b) | Speaker of each type | Nos. | min. 10% of installed quantity |
| c) | Communication socket | Nos. | min. 10% of installed quantity |
| d) | Junction boxes | Nos. | min. 10% of installed quantity |
| e) | Telephone set of each type | Nos. | min. 10% of installed quantity |
| 2.16.0 | DC SYSTEM | | |
| a) | DC Distribution Board each type | Set | 1 |
| b) | MCB each type/range | Nos. | 10% of installed quantity or 2 no. whichever is greater |
| c) | Transducer(Voltage & Current) each type | Nos. | 10% of installed quantity or 1 no. whichever is greater |
| 2.17.0 | ACTUATORS | | |
| a) | Actuator complete unit each type | Nos. | 10% of installed quantity or 1 no. whichever is greater |
| b) | Power Supply cards each type | Nos. | 10% of installed quantity or 1 no. whichever is greater |
| e) | Limit switch assembly | Nos. | 10% of installed quantity or 1 no. whichever is greater |

| Sl.No. | Description | Qty / Unit | |
|---|---|---|---|
| f) | Position transmitter assembly each type | set | 10% of installed quantity or 2 no. whichever is greater |
| g) | Motors for actuator each type | Nos. | 10% of installed quantity or 1 no. whichever is greater |
| 2.18.0 | Emer. DG set | | |
| a) | Control cards each type | Nos. | 10% of installed quantity or 1 no. whichever is greater |
| b) | Control / Aux relays each type | Nos. | 10% of installed quantity or 2 no. whichever is greater |
| c) | Control selector switches each type | Nos. | 10% of installed quantity or 1 no. whichever is greater |
| d) | Analog indicating Instruments (Ammeter, Voltmeter, Wattmeter, Power factor meter, frequency meter etc.) each type | Nos. | 10% of installed quantity or 1 no. whichever is greater |
| e) | Control selector switches each type | Nos. | 10% of installed quantity or 1 no. whichever is greater |
| f) | Protective Relay each type | Nos. | 10% of installed quantity or 1 no. whichever is greater |
| g) | Current Transformers each type | Nos. | 10% of installed quantity or 1 no. whichever is greater |
| h) | Fuses & indicating lamps each type | Nos. | 3 or 10% |
| i) | Transducers (Voltage, Current, MWh, Frequency, power factor etc.) each type | No. | 1 |
| j) | Display /Annunciator each type | Set | 1 |

NOTE:

(1) when supply quantity of mandatory spare falls less than 1(one) no for 10% of total installed quantity or requirement as mentioned in above list then minimum one (1) no quantity shall be suppliedas mandatory spares

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| **3.0.0** | **CONTROL AND INSTRUMENTATION** | |
| 3.1.0 | Local gauges (pressure, temperature, level, flow) | 10% for each type and range subject to minimum 2 nos. |
| 3.2.0 | Solenoid | 10% for each type and range subject to minimum 2 nos. |
| 3.3.0 | Flow meters | Accessories (as recommended by the manufacturer) - minimum 2 nos. in each type and size. |
| 3.4.0 | Transmitters (Pressure, temperature, Flow, level) | 10% for each type and range subject to minimum 2 nos. |
| 3.5.0 | Field switches | 10% for each type and range subject to minimum 2 nos. |
| 3.6.0 | Temperature elements and thermo wells | 10% for each type and range subject to minimum 2 nos. |
| 3.7.0 | SMART positioner | 10% for each type and range subject to minimum 2 nos. and Accessories as per manufacturer recommendation |
| 3.8.0 | Air Filter regulator | 10% for each type and range subject to minimum 2 nos. |
| 3.9.0 | Limit switches/Torque switches | 10% for each type and range subject to minimum 2 nos. |
| 3.10.0 | Gaskets/Washers / O-Rings (for each size and type) | 10% for each type and range subject to minimum 2 nos. |
| 3.11.0 | Conductivity probes, Gaskets for probes, Fuses for Conductivity Type drum level monitor | 10% for each type and range subject to minimum 2 nos. |
| 3.12.0 | Indicators and Electrical metering instruments | 10% for each type and range subject to minimum 2 nos. |
| 3.13.0 | Junction boxes (Terminal Blocks, cable glands, lug) | 10% for each type and range subject to minimum 2 nos. |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| 3.14.0 | Terminal Blocks, fuses, MCB's for control panel | 10% for each type and range subject to minimum 2 nos. |
| 3.15.0 | Distributed control System / Programmable logic controller / GTG, STG control system. | 10% for each type subject to minimum 2 nos. except for Input /Output cards which shall be 20% in each type, subject to minimum 2 nos. |
| a) | Input /Output cards. | |
| b) | Processor module | |
| c) | Communication / Network interface module. | |
| d) | Power supply module | |
| e) | Any other electronic module | |
| f) | Auxiliary/interposing relays. | |
| g) | Terminal Blocks. | |
| h) | Redundant I/O Link equipment. | |
| i) | Data bus cable. | |
| j) | Printer cartridges / DVD / CD/HDD/Printer spares | |
| k) | Network switches, Hubs and other network components | |
| 3.16.0 | Vibration monitoring instrumentation | 10% for each type subject to minimum 2 nos. |
| p) | Turbivisory sensor/Drivers/extension cables | |
| q) | Turbovisory I/O card | |
| r) | Turbovisory system chassis | |
| s) | Power supply modules | |
| t) | Relay/Output modules | |
| 3.17.0 | Hardwired alarm system (Lamps / LED module, cards, blank alarm facia) | 10% for each type and range subject to minimum 2 nos. |
| 3.18.0 | Control valve critical parts (stem packing, O-Rings, Gaskets, lubricants, valve trims, position transmitter and actuator parts) | 10% for each type and range subject to minimum 2 nos. |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| 3.19.0 | Master clock system (As per manufactures recommendation) | |
| 3.209.0 | SEMS (Stack emission monitoring system) | |
| a) | Analyser Electronic modules /RTU | 10% for each type and range subject to minimum 2 nos. |
| b) | purging unit and air filters | |
| 3.21.0 | Steam And Water Analyzers (SWAS) | |
| a) | Conductivity cell | 10% for each type and range subject to minimum 2 nos. |
| b) | Resin | |
| c) | Resin column | |
| d) | Ph Electrodes and temperature compensators (each type) | |
| e) | Ph cell housing | |
| f) | DO analyzer Sensor | |
| g) | Fuses | |
| h) | Analyser PCB | |
| i) | O-rings/gaskets | |
| j) | Chemical reagents for all analysers | |
| k) | Temperature gauge | |
| l) | Pressure gauge | |
| m) | Temperature switch | |
| n) | Solenoid valve | |
| o) | Flow meter | |
| p) | Valve packing | |
| q) | All analysers sensors with cable | |
| r) | All analysers electronics cards | |
| s) | Erection hardware | 10% for each type and range subject to minimum 2 nos. |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| 3.22.0 | Any other as recommended by the Bidder. | |
| 3.23.0 | Co2 flooding system/ Foam protection system | |
| a) | Power supply module | 10% for each type and range subject to minimum 2 nos. |
| b) | Monitor Module | |
| c) | I/O module | |
| d) | Connected field Instruments | |
| 3.24.0 | Spares for SAS | |
| a) | All modules in SAS | 10% for each type and range subject to minimum 2 nos. |
| b) | All computers and peripherals in SAS | |
| c) | All components in SAS | |
| 3.25.0 | Valve position feedback transmitter | 10% for each type and range subject to minimum 2 nos. |
| 3.26.0 | Valve pneumatic components | 10% for each type and range subject to minimum 2 nos. |
| 3.27.0 | Servo valve | 10% for each type and range subject to minimum 2 nos. |
| 3.28.0 | On-OFF valve actuator seal kit | 10% for each type and range subject to minimum 2 nos. |
| 3.29.0 | Analyzer spares | 10% for each type and range subject to minimum 2 nos. |
| 3.30.0 | GT Flame scanner | 10% for each type and range subject to minimum 2 nos. |
| 3.31.0 | Hydrastep spares (gasket, electrode, elctronics etc.) | 10% for each type and range subject to minimum 2 nos. |
| 3.32.0 | ST EHC spares | 10% for each type and range subject to minimum 2 nos. |

| Sl.No. | Description | Qty / Unit |
|---|---|---|
| | Definition of Set<br>• Whenever the quantity is indicated as a percentage it shall mean percentage of total population of that item in the station (project), unless specified otherwise, and the fraction will be rounded off to the next higher whole number.<br>• Wherever the requirement has been specified as a 'set' it shall include the total requirement of the item for a unit, module or the station as specified.<br>• Where it is not specified, a 'set' would mean the requirement for the single equipment / system as the case may be.<br>• Also one set for the particular equipment would mean the total quantity of the spare part for a single equipment, e.g. 'set' of bearings for a pump would mean all type and number of bearings required for total replacement.<br>• Also the 'set' would include all components required to replace the item; for example, a set of bearings shall include all hardware normally required while replacing the bearings.<br>• Further one set means all the items / sub-items required for assembly / sub-assembly ofeach size / type / range, e.g. assembly material for vanes / buckets. | |

**NOTE: All mandatory spares as per OEM declared critical items shall be included in the list.**

# VOLUME – IV

# SECTION – 8

# ANNEXURE – 3

# COLOUR CODE FOR PIPING AND FIRE EQUIPMENT

Annexure-I

# SYSTEM OF IDENTIFICATION/COLOUR CODING OF PIPINGS AND FIRE EQUIPMENT

The colour coding system for pipings has been formulated basically on Indian standard; that in itself includes the British & the American standard and follow the system of colour coding as well as positive identification.

However, in some cases of our products ( not included in the Indian standard ),colour bands have been specified as per EIL specifications or proposed, either based on the present system at Ankleshwar Asset or Uran/Hazira plant. It has been ensured that the colour bands do not clash with other products/utilities and the base colour is maintained as per the Indian standard.

The system of colour code consists of a base/ground colour and colour bands/strips superimposed on it. Lettered labels/legends, direction of arrows and danger sign shall also be used as superimposed on colour coding system for positive identification of the contents of a piping system.

The colouring scheme of the valves and hazard indication too are prescribed.

## 1.0 Colour Code System

The system of colour coding consists of a base/ground colour and colour Bands / strips superimposed on it. For identification of piping, the colour code as per Table 1 & 2 (placed at the end )shall be used which is for products being processed and utility items being used in ONGC (Based on Indian standard, British standard and the EIL standard).

## 1.1 Base / Ground Colours

The base/ground colour identifies the basic nature of the fluid carried and distinguishes one fluid from another and has been based on IS 2379:1990 reaffirmed 1996.

### 1.1.1. How much and where to paint

a) Base/ ground colour shall be applied throughout the entire length on un-insulated pipelines

b) Ground colour coating shall be applied at places requiring colour bands ,with minimum 2 meters length or adequate length so that it will not be mistaken as colour band for the following kinds of piping. (As per IS 2379:1990 reaffirmed – 1996 para 6.1.1).

i) Insulated pipes at the position of metal cladding.
ii) Un-insulated austenitic stainless steel.
iii) Plastic and/or plastic coated materials.
iv) Pipes of non-ferrous metals like Alluminium, galvanized "piping", etc.

### 1.1.2. Application

Ground colours as given in Table 1 & 2 shall be applied in one of the following ways : (As per IS 2379:1990 reaffirmed – 1996 para 7.1)

a) Through out the entire length of the pipings.

b) As a colour coating of adequate length, (but in no case less than 300 mm) so that it is not mistaken for a colour band.
c) As a colour panel for pipes which are not accessible on all the sides.
d) As label attached to pipes which are very small in diameter.
e) By the use of colour adhesive tapes for pipes with small diameter or which are difficult to access.
f) Where ever the ground colour are not applied throughout the entire length, it shall be applied at all the places in conjunction with other bands and markings as mentioned in applications- (1.1.1.b).

## 1.2 Colour bands/strips

Colour bands/strips ( as given in Table 1 & 2 )are superimposed on the base/ground colour to distinguish one kind or condition of a fluid from another kind or condition of the same fluid, or one fluid from another but belonging to the same group, for example diesel fuel from the furnace fuel.

### 1.2.1. Identification & Size

a) The width of colour band shall confirm to the following table shown below : (As per IS 2379:1990 reaffirmed.– 1996 PARA 7.3.3).

| NOMINAL PIPE SIZE ( mm) | WIDTH: L (mm) |
|---|---|
| 80 NB and below | 25 MM |
| Over 100 NB up to 150 NB | 50 MM |
| Over 200 NB up to 300 NB | 75 MM |
| Over 350 NB | 100 MM |

**NB- Nominal Bore**

b) The relative proportional width of first colour band to the subsequent bands shall be 4:1.

### 1.2.2. Application

a) Colour bands shall be applied at the following location (IS 2379:1990 – reaffirmed 1996 para 7.3)
   i) Battery limit points.
   ii) Intersection point and change of direction points in piping ways.
   iii) Other points such as midway of each piping way, near valves, junction joints of service appliances, walls, on either side of pipe culverts:
   iv) For long stretch yard piping at 50m interval; and
   v) At start and terminating points.

b) Colour bands shall be arranged in the sequence shown in Table 1 & 2 and the sequence follows the direction of flow.

c) All uninsulated pipes having temperatures above $100^0$ C (Heat resistance aluminium painted) need be identified as special case by using Teflon tape.

d ) For insulated pipes, nominal pipe size means the outside diameter of insulation.

TABLE FOR DIMENSIONS OF ARROW

| SN | Outside diameter of pipe (mm) | Size of dimension A,B,C & D (mm) |
|---|---|---|
| 1. | Upto 200 | A=65, B=30, C=95 & D=20 |
| 2. | Above 200 | A=90, B=30, C=95 & D=30 |

4. For pipes with small diameter, if the label with a code indication is attached to the pipe, the direction of flow shall be shown by the pointed end of this label.

**2.3 Hazardous warning**

To indicate that a pipeline carries a hazardous material, a band of diagonal strips of black and golden yellow as (per IS 2379:1990 reaffirmed 1996 para 8 (c)) shall be painted on the ground colour at location stated at 1.2.2 – Application (a) and next to the colour coding identification and lettered label. Further if material is flammable or explosive material, chemically active or toxic materials, etc. may be indicated by lettering.

**2.4 Visibility of Marking**

Attention shall be given to visibility with reference to pipe markings. Where lines are located above or below the normal line of vision, the lettering shall be placed below or above the horizontal centerline of the pipe. (As per IS 2379:1990 reaffirmed – 1996 para 10).

**2.5 Colour of Valves**

The valves shall be painted as per the IS 2379:1990 reaffirmed – 1996 para 7.4 as per the following table.

| Condition | Colour of valve |
|---|---|
| Valves on Fire fighting piping | Red |
| Valves on piping carrying hazardous material | Golden yellow with black strips |
| Valves on water carrying piping (potable or non potable) | French blue |
| All other piping | Same colour as the main piping |

Example below shows the colour code for a pipe carrying sour gas where light grey and dark violet colour bands have sequence numbers C and D.

## 2.0 Positive identification system

Positive identification system includes lettered label/legend, direction of arrows and danger sign and shall be used as superimposed on colour coding system for positive identification of the contents of a piping system (Based on British standard, Indian standard and ANSI standard).

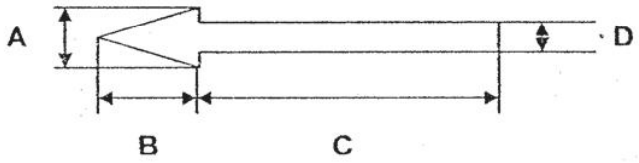
## 2.1 Lettering Label

Positive identification of the contents of piping shall be by lettered label giving the name of the contents in full or the abbreviated form at the locations stated at 1.2.2 Application (a) and next to be colour coding indication.

The lettering shall be as per IS 2379-1990 reaffirmed 1996 para 9.1. The recommended size of letters for pipes of different diameters are given as under :

| Outside diameter of pipe or Covering (mm) | Size of legend ( mm ) |
|---|---|
| 20 to 30 | 10 |
| Above 30 to 50 | 20 |
| Above 50 to 80 | 30 |
| Above 80 to 150 | 40 |
| Above 150 to 250 | 63 |
| Over 250 | 90 |

## 2.2 Direction of flow : Flow Direction




1. Flow direction shall be indicated by arrow in the location stated at 1.2.2 application (a) and next to the colour code indication and lettered label.
2. The colour of arrow shall be black or white and in contrast to the colour on which they are superimposed.
3. The size of arrows shall be as per IS 2379 para 9.2 which is :

# TABLE –1 COLOUR SCHEME FOR PRODUCTS BEING PROCESSED IN ONGC

## A. GASES

| Sl. No. | Description of Products | Colour Code Identification | | Sl. No. | Description of Products | Colour Code Identification | |
|---|---|---|---|---|---|---|---|
| | | Base/ Ground Colour | Colour Bands i)First band ii)Second band | | | Base/Ground Colour | Colour Bands i)First band ii)Second |
| 1. | Sour gas | Canary Yellow | i) Grey ii)Dark violet | 6. | Rich gas | Canary yellow | i)Signal red ii)Smoke grey |
| 2. | Sweet gas | Canary yellow | Grey | 7. | Flare gas | Canary yellow | Aluminium |
| 3. | Fuel gas | Canary yellow | i)Light brown ii) White | 8. | Regenerated gas | Canary yellow | i) White ii)Dark violet |
| 4. | Residue | Canary yellow | i)Oxide red ii) White | 9. | C2-C3 | Canary yellow | i)Brilliant green ii)Signal red |
| 5. | Lean gas | Canary yellow | i) White ii) French blue | 10. | Propane gas | Canary yellow | i) Signal red ii) Black |

## B. LIQUIDS

| Sl. No. | Description of Products | Colour Code Identification | | Sl. No. | Description of Products | Colour Code Identification | |
|---|---|---|---|---|---|---|---|
| | | Base/ Ground Colour | Colour Bands i)First band ii)Second band | | | Base/Ground Colour | Colour Bands i)First ii)Second |
| 1. | Crude oil | Light brown | No band | 12. | Surphuric acid | Dark violet | i)Brilliant green ii)Light orange |
| 2. | LPG (Refrigerated) | Dark admirality grey | i)Brilliant green ii)Dark violet | 13. | Hydrochloric acid | Dark violet | i)Signal red ii)Light orange |
| 3. | Kerosene | Light brown | Brilliant green | 14. | Sodium Hydroxide | Smoky grey | Light orange |
| 4. | Neptha | Dark admirality grey | i)Light brown ii) Black | 15. | Triethylene glycol (TEG) | Dark Admirality grey | i)Sea green ii) Yellow |
| 5. | Light diesel oil/heavy cut | Light brown | i) Brilliant green ii) Black | 16. | DIPA | Dark Admirality grey | i) White ii) Black |
| 6. | High speed diesel | Light brown | i) Brilliant green ii) White | 17. | MDEA | Dark Amirality grey | i) Brilliant green ii) Red |
| 7. | Slope oil | Light brown | Black | 18. | Oily water | Black | No band |
| 8. | Hydrocarbon condensate | Dark Admirality grey | i)Signal red ii) Black | 19. | Dozing chemical | Dark Admirality grey | No band * |
| 9. | Methanol | Dark Admirality grey | i) White ii) Gulf red | 20. | NGL | Dark Admirality grey | i)Brilliant green ii) Black |
| 10. | Mercaptane | Dark Admirality grey | Signal red | 21. | ATF | Dark Admirality grey | i) Black |
| 11. | Chlorine | Dark violet | Signal red | | | | |

## TABLE-2 COLOUR SCHEME FOR UTILITY ITEMS USED IN PROCESS IN ONGC

### A. Water

| Sl. No. | Description of Products | Colour Code Identification | | Sl. No. | Description of Products | Colour Code Identification | |
|---|---|---|---|---|---|---|---|
| | | Base/ Ground Colour | Colour Bands i)First band ii)Second band | | | Base/Ground Colour | Colour Bands i)First band ii)Second |
| 1. | Drinking water | Sea green | i)French blue ii) Signal red | 8. | Wash water | Sea green | Canary yellow |
| 2. | Domestic Hot Water | Sea green | Light grey | 9. | Fire water | Fire red | Crimson red |
| 3. | Cold water service from storage tank | Sea green | i)French blue ii) Canary yellow | 10. | Sea/river untreated water | Sea green | White |
| 4. | De mineralized water | Sea green | Gulf red | 11. | Waste water | Sea green | i) Canary yellow ii) Signal red |
| 5. | Cooling water | Sea green | French blue | 12. | Treated water | Sea green | Light orange |
| 6. | Boiler feed water | Sea green | Gulf blue | 13. | Chilled water | Sea green | i) Black ii) Canary yellow |
| 7. | Condensate water | Sea green | i)Light brown ii) Signal red | | | | |

### B. STEAM

| Sl. No. | Description of Products | Colour Code Identification | | Sl. No. | Description of Products | Colour Code Identification | |
|---|---|---|---|---|---|---|---|
| | | Base/ Ground Colour | Colour Bands i)First ii)Second | | | Base/Ground Colour | Colour Bands i)First ii)Second |
| 1. | Very high pressure (VHP)steam (above40Kg/cm2) | Aluminium | Signal red | 4. | Low pressure steam(SL) (1 kg/cm2 to15 kg/cm2) | Aluminium | Canary yellow |
| 2. | High pressure steam(SH) (25 kg/cm2 to 40 kg/cm2) | Aluminium | French blue | 5. | Purge steam | Aluminium | Grey |
| 3. | Medium pressure steam(SM) (15 kg/cm2 to 25 kg/cm2) | Aluminium | Gulf red | 6. | Steam condensate | Aluminium | i)Sea green ii) Canary yellow |

## C. COMPRESSED AIR

| Sl. No. | Description of Products | Colour Code Identification | | Sl. No. | Description of Products | Colour Code Identification | |
|---|---|---|---|---|---|---|---|
| | | Base/ Ground Colour | Colour Bands i)First band ii)Second | | | Base/ Ground Colour | Colour Bands i)First ii)Second |
| 1. | Compressed air up to 15 kg/cm.sq | Sky blue | --- | 4. | Instrument air | Sky blue | French blue |
| 2. | Compressed air above15 kg/cm.sq | Sky blue | Signal red | 5. | Drainage | Black | -- |
| 3. | Plant air | Sky blue | Silver grey | | | | |

## D. OILS

| Sl. No. | Description of Products | Colour Code Identification | | Sl. No. | Description of Products | Colour Code Identification | |
|---|---|---|---|---|---|---|---|
| | | Base/ Ground Colour | Colour Bands i)First ii)Second | | | Base/Ground Colour | Colour Bands i)First ii)Second |
| 1. | High speed diesel fuel | Light brown | ---- | 3. | Lubricating oil | Light brown | Light grey |
| 2. | Hydraulic power | Light brown | Dark violet | | | | |

## E. GASES

| Sl. No. | Description of Products | Colour Code Identification | | Sl. No. | Description of Products | Colour Code Identification | |
|---|---|---|---|---|---|---|---|
| | | Base/ Ground Colour | Colour Bands i)First ii)Second | | | Base/Ground Colour | Colour Bands i)First ii)Second |
| 1. | Acetelene | Canary yellow | Service brown | 4. | Carbon dioxide | Canary yellow | Light grey |
| 2. | Nitrogen | Canary yellow | Black | 5. | Acid gas | Violate | No band |
| 3. | Oxygen | Canary yellow | White | | | | |

**NOTE : 1.** Any product which is not covered will be governed as per colour code standard IS :2379-1990 / (re affirmed in 1996 )/other standard under reference.

* Name of the dozing chemicals should be written with flow of direction on pipe lines.

## TABLE- 3 FIRE EQUIPMENT, FIRE TENDERS, etc.

| S. N | Item/Application | Standard painting colour | S. N | Item/ Application | Standard painting colour |
|---|---|---|---|---|---|
| 1 | A.Extinguishers : Water based, Foam,DCP, $CO_2$<br><br>B.All fire tenders/ Jeep, Fire engines ( except Foam tank, foam piping & Nitrogen cylinder )<br><br>C. Fire tender water piping/ Wet risers/ Fire hose reel box<br><br>D. Fire tender water pump & engine/ Water pipeline in engine & pump.<br><br>E. DCP tank & DCP piping | Fire red paint ( shade No. 536 of IS-5-AS AMENDED ) | 2 | Foam tank & foam piping/ Nitrogen cylinder | Dark Admiralty grey |
| | | | 3 | Driver compartment & inside of the lockers | Pale cream |
| | | | 4 | Chassis & wheel arches | Black |
| | | | 5 | Fire service insignia & identity nomenclatures | Canary yellow with black border on both sides of the vehicle/equip ment |

**Please click here for colour coding illustration**

# VOLUME – IV

# SECTION – 8

# ANNEXURE – 4

# GEOTECHNICAL INVESTIGATION REPORT - INSIDE AREA

| LARSEN & TOUBRO LIMITED E&C DIVISION | GEOTECHNICAL INVESTIGATION REPORT-INSIDE AREA - RESOLUTION OF EIL COMMENTS ON REV00 | **DOCUMENT NO.** A067-LT-00-CV-04-RP-0004 |
|---|---|---|
| **PROJECT : Additional Gas Processing Facilities (Phase-IV)** | | **REVISION : 01** |
| **CUSTOMER : ONGC,HAZIRA** | | |

**Resolution of EIL Comments dtd. 26.08.2010**

| Sr. No. | COMMENT / OBSERVATION | L&T RESOLUTION |
|---|---|---|
| 1 | **Refer Cl. 7.0 Option 1:**<br>Adapted pile capacity in Compression, uplift and lateral mode is on the higher side. Provide Backup calculation as per IS 2911 relevant parts. | Pile capacities revised as follows:<br>Axial compression: 65T<br>Lateral: 4.5T (fixed head)<br>2.0T (free head)<br>Backup calculations provided in Appendix-I |
| 2 | **Refer Appendix-I:**<br>For pile bearing capacity calculation, Use Nq value given in Fig.1-Ammendment No-1 of IS: 2911 (Part-1/Sec-2)-1979 instead of the Fig. 1 given in page-24 of the same code. And, earth pressure coefficient (k) taken for pile capacity sample calculation of layer-4 is 2.5. But according to IS: 2911 (Part-1/Sec-2)-1979 this value for bored cast in-situ pile ranges between<br>1 and 2. Revise pile capacity as per codal provision. | Calculation has been corrected (ref Appendix I) |
| 3 | Evaluating of pile lateral capacity shall be as per IS Code of relevant parts. | Complied (ref Appendix I) |
| 4 | **Refer Cl. 7.0 Option 2:**<br>The points to be addressed along with the recommendation of lightly loaded structures and equipments.<br>i) For lightly loaded structures and equipments, open foundation with a depth of 2m below FGL is recommended. Ground treatment shall be provided below foundation considering swelling nature of soil.<br>ii) Recommended bearing capacity at 2m depth of footing in both shear and settlement is on the higher side considering poor consistency of soil bearing layer. | i) As per good engineering practice, 300mm granular cushion shall be provided below foundations (section 7, note 1, 5)<br>ii) Bearing capacity has been revised to values provided in Section 7, note 1 |
| 5 | As the soil is of swelling nature, Geotechnical recommendation is required for road & pavement sub grade, culverts, building floors, underground piping etc. with backup calculation and standard practice. | Mitigation measures will be submitted separately. Design ground water table shall be at EL 99.500 (section 7, note 2) |
| 6 | Precaution to counteract the harmful effect of high chloride and sulphate content in soil and ground water is to be recommended. | Clear cover increased to 65mm from 50mm. Requirements governing type of cement and cement content included in Section 7, note 3 |
| 7 | **Refer Cl. 2.2.4 and BVT Test Results:**<br>There is a discrepancy in the block size mentioned at the above mentioned clauses. Clarify the discrepancy. Moreover, Why the block size taken is not according to IS: 5249, 1992. Explain. | Typographical error in Cl. 2.2.4 has been corrected |
| 8 | **Refer Results of Block Vibration Test:**<br>There is some error in calculation of modulus of rigidity and modulus of elasticity value. Verify and correct the same. | Corrected |

| LARSEN & TOUBRO LIMITED E&C DIVISION | GEOTECHNICAL INVESTIGATION REPORT-INSIDE AREA - RESOLUTION OF EIL COMMENTS ON REV00 | **DOCUMENT NO.** A067-LT-00-CV-04-RP-0004 |
|---|---|---|
| **PROJECT : Additional Gas Processing Facilities (Phase-IV)** | | **REVISION : 01** |
| **CUSTOMER : ONGC,HAZIRA** | | |

| | | |
|---|---|---|
| 9. | Concentration of sulphates, expressed as S03 shall be performed for the chemical analysis of water and suitable precaution shall be adopted to counteract the harmful effect of sulphates. | Typographical error in Table 3 has been corrected. $SO_3$ is within limits specified for Class 2 as per IS 456 Table-4 |

| | | | |
|---|---|---|---|
| L&T, E&C DIVISION | Additional Gas Processing Facilities (Phase-IV) | Client: ONGC | OIL AND NATURAL GAS CORPORATION LIMITED |
| | | PMC: ENGINEERS INDIA LIMITED (A Govt. of India Undertaking) | |
| Contractor : Larsen & Toubro Limited, E&C DIVISION, Mumbai | | Doc. No. : A067-LT-00-CV-04-RP-0004<br>Rev. : 01 | |

**TITLE :** GEOTECHNICAL INVESTIGATION REPORT – INSIDE AREA

| | | |
|---|---|---|
| **OWNER** | : | **OIL AND NATURAL GAS CORPORATION LIMITED, HAZIRA, GUJARAT** |
| **PMC** | : | **Engineers India Limited (EIL)** |
| **UNIT** | : | **Additional Gas Processing Facilities (Phase-IV)** |
| **EIL JOB NO** | : | **A067** |
| **L&T JOB NO** | : | **5014** |

| DOC. CATEGORY: (USE TICK MARK) | | EIL Review Code |
|---|---|---|
| A | APPROVAL | Review Code 1 2 3 4 |
| R | REVIEW | Signature & Name _____ |
| I | INFORMATION | Date _____ |
| | | DTN No. _____ |

| Rev. | Date | Description | Prepared By | Reviewed By | Approved By |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| 01 | 09.09.2010 | EIL COMMENTS INCORPORATED AND RE-ISSUED FOR REVIEW | SN | SB | SB |
| 00 | 18.08.2010 | ISSUED FOR REVIEW | SN | SB | SB |

| LARSEN & TOUBRO LIMITED E&C DIVISION | GEOTECHNICAL INVESTIGATION REPORT – INSIDE AREA | DOCUMENT NO. A067-LT-00-CV-04-RP-0004 |
|---|---|---|
| PROJECT : Additional Gas Processing Facilities (Phase-IV) | | REVISION : 01 |
| CUSTOMER : ONGC,HAZIRA | | PAGE : 2 OF 3 |

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| LARSEN & TOUBRO LIMITED E&C DIVISION | GEOTECHNICAL INVESTIGATION REPORT – INSIDE AREA | DOCUMENT NO. A067-LT-00-CV-04-RP-0004 |
|---|---|---|
| PROJECT : Additional Gas Processing Facilities (Phase-IV) | | REVISION : 01 |
| CUSTOMER : ONGC,HAZIRA | | PAGE : 3 OF 3 |

## 1.0 PURPOSE

ONGC has decided to extend their existing plant (Phase IV) under Additional Gas Processing Facilities Project at ONGC-Hazira.

The scope covers the work required for Geotechnical Investigation: field investigations and tests, laboratory tests and analysis and interpretation of data and results and preparation of a detailed geotechnical report including recommendations.

## 2.0 SCOPE

This report covers the area inside the existing plant boundary wall and includes the following units:

A. Dew Point Depression Unit
B. Caustic Wash Unit
C. Off-Site Piperacks

The geotechnical investigation has been performed as per the provisions of:

1. Document No. 6962-00-50-48-SOW-01, Geotechnical Input for Additional Gas Processing Facilities Project at ONGCL Hazira (Ph IV), and
2. Additional points agreed upon at the Engineering Kick-off Meeting at EIL ROV. MoM of the same is attached in Annexure II

## 3.0 INVESTIGATION REPORT

The geotechnical investigation was performed by KCT Consultancy Services of Ahmedabad. The report is attached in Annexure I.

The main recommendations are provided in Section 7.0 of the report.

Calculations and detailed test results are provided in Appendices 1 and 2 of the report.

Compressor foundation shall be designed using the soil parameters obtained from Borehole 5 and the Block Vibration Test performed close to it.

| | | |
|---|---|---|
| LARSEN & TOUBRO LIMITED<br>E&C DIVISION | GEOTECHNICAL INVESTIGATION REPORT – INSIDE AREA | **DOCUMENT NO.**<br>A067-LT-00-CV-04-RP-0004 |
| **PROJECT : Additional Gas Processing Facilities (Phase-IV)** | | **REVISION : 01** |
| **CUSTOMER : ONGC,HAZIRA** | | |

# Annexure I

## *GEOTECHNICAL INVESTIGATION REPORT*

# LARSEN & TOUBRO LIMITED

## TECHNICAL REPORT

## OF

## GEOTECHNICAL INVESTIGATION

## FOR

## PROPOSED STRUCTURES INSIDE PLANT AREA UNDER PROJECT OF ADDITIONAL GAS PROCESSING FACILITES (PHASE 4) FOR ONGC AT HAZIRA, SURAT (INSIDE PLANT AREA)

## BY:

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**August - 2010**

**GEOTECHNICAL INVESTIGATION REPORT FOR PROPOSED STRUCTURES OF ADDITIONAL GAS PROCESSING FACILITES PROECT (PHASE 4 – INSIDE OF PLANT) OF ONGC AT HAjIRA, SURAT**

## 1.0 Introduction

For foundation analysis of the structures of Additional Gas Processing Facilities Project (Phase 4) of ONGC at Hajira, Surat, It is necessary,

1. To determine the subsoil profile of the site and to know physical properties and strength characteristics of soil at various depths.
2. To suggest suitable foundation and to know the safe bearing pressure and probable settlement of foundation.
3. To know any adverse soil conditions to the foundation structures and to take precautionary measures.

For this purpose, the geotechnical investigation was entrusted to us by Larsen and Toubro Limited. Following points were decided,

1. No. Bore holes – 4 nos. in side plant boundary
2. Standard penetration tests are conducted at regular interval.
3. Collection of Undisturbed soil samples at regular interval.
4. Collection of disturbed samples during drilling and from SPT.
5. To find physical properties and strength characteristics of samples as per the testing schedules.
6. To locate ground water table, if any.
7. To conduct block vibration test.
8. To conduct electrical resistivity test.
9. Interpretation of results, Analysis and Recommendations.

Based on the above points the detailed Geotechnical Investigation Program included the following:

**(A) Field Investigation**

1. Drilling of bore hole.
2. Collection of soil samples ( Disturbed and Undisturbed )
3. Conducting Standard Penetration Test.
4. Conducting Block Vibration Test.
5. Conducting Electrical Resistivity Test

**(B) Laboratory Investigation**

1. Bulk Density and moisture content
2. Grain size analysis
3. Consistency limits
4. Shear tests
5. Consolidation tests
6. Chemical analysis of soil and water

**(C) Recommendations**

Based on above investigations, the results are to be obtained. The findings would be based on interpretation of results, analysis and computations as per relevant Indian standards.

## 2.0 Field Investigation

### 2.1 Boring

The exploratory boreholes of 150mm diameter were drilled by rotary drilling method. The depth of the test bore at the proposed location is as under:

| Bore Hole No. | Co-Ordinates | | Reduced Level (m) | Depth Investigated (m) |
|---|---|---|---|---|
| | N | E | | |
| BH – 4 | 365 | 1025 | 98.466 | 20 |
| BH – 5 | 780 | 1100 | 99.423 | 25 |
| BH – 6 | 799 | 1170 | 99.620 | 20 |
| BH – 9 | 1065 | 1750 | 99.232 | 20 |

### 2.2 Sampling

#### 2.2.1 Disturbed samples

Disturbed samples were collected during boring and from the split spoon sampler. The samples recovered were logged, labeled and placed in polyethylene bags and sent to laboratory for testing.

#### 2.2.2 Undisturbed samples

Undisturbed soil samples were collected in thin walled Shelby tubes as per IS 2132 at regular intervals. The samples collected were sealed properly using wax, labeled and transported to the laboratory.

#### 2.2.3 Standard penetration test

The standard penetration tests were conduct in accordance with IS:2131-1981 in test bore at regular intervals. The test gives N – Value, the blow counts of last 30 cm penetration of split spoon sampler with 63.5 kg hammer falling from 76 cm height.

#### 2.2.4 Block Vibration Test

For determining various parameters influencing the design of machine foundation like physical properties of elastic base of the foundation, block vibration test was conducted. For this purpose Oscillator was fixed on the PCC block cast of size 1.00 x 0.75 x 0.75 m at Co ordinates N 789 and E 1087, and vibration was induced. The vibration peak ups were attached, on this block to measure the frequency and amplitude. The test was conducted as per the provisions of IS 5249 – 1969. Various dynamic properties as listed below were calculated for 10sq.mt area.

Cu - Coefficient of elastic uniform compression ( kg / cu.cm )
$C\tau$ - Coefficient of elastic uniform shear ( Kg / cu.cm )
$C\phi$ - Coefficient of elastic non – uniform compression ( Kg / cu.cm )
$C\psi$ – Coefficient of elastic non – uniform shear ( Kg / cu.cm )

The above coefficients are reported for foundation contact area, A of 10.0 sq. m

#### 2.2.5 Electrical Resistivity Test

Geophysical Survey In all geophysical surveys, Electrical Resistivity method is best and reliable to know geological formation of the the area. All geological formations possess properties called electrical resistivity when the current flows through them. Resistivity thus

is defined as the resistance offered by a unit cube of material to direct current flowing through it in a direction perpendicular to two of its opposite faces. The numerical value of the resistivity is expressed in ohm. m in general. Thus the electrical resistivity is principally based on the study of resistance offered by the sub-surface formation to the flow of current. The study in turns helps in evaluation of the characteristic of the sub surface layers in terms of electrical resistivity. Vertical electrical soundings (VES) have been conducted by using resistivity meter of I G I S make direct current in deployed during survey as per IS : 3043. Two metal stakes called current electrodes into the sub surface transmit the current and the potential response is observed by means two copper electrodes called potential electrodes. Apparent resistivity is calculated from the equation:-

$\rho = 2\pi SR$

$K = 2\pi S$ = Geometric factor for electrode spacing (Wenner's configuration)

R = Resistance in Ohms

S = Spacing between adjacent electrodes in (m)

$\rho$ = Resistivity in ohm.m.

Test was conducted at Co ordinates: N 762 E 1087

### 3.0 Laboratory investigation

The laboratory tests were conducted on the samples collected. The following laboratory tests were conducted on undisturbed and disturbed soil samples collected from various depths to find physical properties and strength characteristics.

| Tests | Recom$^{nd}$ procedure | Type Samples |
|---|---|---|
| 1. Sample Preparation | IS 2720 Pt I | DS / UDS |
| 2. Moisture Content | IS 2720 Pt II | DS / UDS |
| 3. Dry Unit Weight | LAMBE | UDS |
| 4. Specific Gravity | IS 2720 Pt III | DS |
| 5. Liquid Limit | IS 2720 | DS |
| 6. Plastic Limit | IS 2720 Pt V | DS |
| 7. Grain Size Analysis | IS 2720 Pt IV | DS |
| 8. Soil Classification | IS 1498 | DS / UDS |
| 9. Consolidation | IS 2720 Pt XV | UDS |
| 10. Triaxial Comp. Test | IS 2720 Pt X | UDS |
| 11. Laboratory permeability | IS 2720 Part XVII | UDS |

### 4.0 Results

1. The location plan of Bore hole is shown in fig no.1
2. The bore log details of Bore hole are shown in fig nos. 2 to 5
3. Results of permeability of Bore hole are given in table no 1
4. The Chemical analysis of soil and water is given in table nos.2 & 3
5. Laboratory test results of Bore hole are appended in table nos. 4 to 7
6. Results of BVT are shown in fig nos. 6 & 7
7. Results of ERT are given in fig no. 8

### 5.0 General stratification

The soil deposits at Hajira are alluvial in nature formed by River Tapti and its interaction with the sea over the geological history. The layers consist of plastic clays from stiff to very stiff consistency at top. The subsequent layer consists of plastic clays and silts from very

soft to stiff consistency, followed by silty sands with density varying from loose to dense and very dense.

## 6.0 Discussion

Two foundation options are suggested:

1. **Pile Foundations** :

For heavy equipment and major structures, pile foundations are recommended. Due to proximity to process areas driven piles are not permitted and bored cast-in-situ piles are recommended. Piles of 500 mm diameter with depth of embedment of 16 m are suitable. Pile calculations are given in Appendix – 1. The lateral capacities are 4.5 t for a fixed headed pile and 2.0 t for a free headed pile. The lateral capacity is also to be confirmed by means of a lateral load test on a test pile. The tests have to be carried out as per IS 2911 / Part 4 – 1985.

2. **Open foundations for lightly loaded structures and equipment** :

The possibility of placing the light to intermediate loaded structures and equipment foundations, open shallow foundations can be explored. The minimum depth of foundation recommended is 2 m from FGL. The permissible settlement is 25mm. The recommended bearing capacity values borehole wise for permissible settlements for 25mm are as given in Section 7 (Conclusion) below and the calculations are appended in Appendix 2.

## 7.0 Conclusions

1) Two foundation options are recommended.

**Option 1 :** For process equipments and heavily loaded structures, Bored cast –in- situ piles, 500 mm diameter, length of embedment of 16 and cutoff level approximately at 2.50 m from NGL having capacities given below may be provided,

| | |
|---|---|
| Axial Compression | 65 T |
| Lateral – Fixed Head | 4.5 T |
| Lateral – Free Head | 2.0 T |
| Uplift | 24 T |

**Option 2:** For light to moderately loaded structures and equipment foundations, open foundations with minimum depth of 2m below FGL is recommended. A 30 cm thick, well compacted coarse sand layer below the bottom of foundation is recommended.

The net safe bearing pressures as tabulated below are recommended.

| **Size of Foundation** | | **Recommended net Safe Bearing Pressure ($T/m^2$)** |
|---|---|---|
| **Depth (m)** | **Width (m)** | |
| 2.0 | 1.0 | 14 |
| 2.0 | 2.0 | 8 |

| | | |
|---|---|---|
| 2.0 | 3.0 | 6 |
| 2.0 | Strip | 5 |
| 2.5 | 1.0 | 15 |
| 2.5 | 2.0 | 10 |
| 2.5 | 3.0 | 7 |
| 2.5 | Strip | 6 |

2) Ground water table is encountered at around 3.50 m from EGL, during investigation, which is likely to rise up to two mt from ground level in monsoon. Design groundwater level shall be at EL 99.500 to account for rain and tidal effects.

3) From results of chemical soil as reported in table 2 & 3, the sub soil is classified in class 2 based on sulphite Content ($SO_3$), as per the table no. 4 under clauses 8.2.2.4 and 9.1.2 of IS: 456, 2000. PPC or PSC with minimum cement content of 330kg/$m^3$ and maximum face water-cement ratio of 0.5 can be used for all RCC in foundation structures. OPC may be used provided the $C_3A$ content is within 5 to 8% as per IS 456, Table 4, Note 6. Alternatively, OPC mixed with fly ash as per the provisions of IS 456 and IS 3812 may be used with validation of concrete characteristics through testing. Minimum cement content in piles shall be 400kg/$m^3$ as per the requirements of IS 2911. As the chloride content is high, clear cover to the reinforcement in foundation systems shall at least be 65 mm.

4) Suitable side slope in excavation and any measures if required and so far as is reasonably practicable shall be provided to prevent dislodgement of earth or any other material forming the side of excavation.

5) Considering the swelling characteristic adequate measures shall be taken to mitigate adverse consequences of swelling and shrinking due to moisture movement. A layer of compacted coarse sand having 300 mm thickness shall be provided under the pile caps and aprons around the structures and in plinths under floor finishes.

7) The comments given in this report and the opinion expressed are based on the ground conditions encountered during site work and on the results of tests made in field and in the laboratory. There may however, special conditions prevailing at the site which have not been disclosed by the investigation and which have not been taken in to account in the report. Any variation in stratification in any of the foundation location shall be studied thoroughly before executing the foundation work

**(K.K.Thaker)** **(Dr. K.C.Thaker)**

# APPENDIX – I

## Calculation of Safe Load on Bored Cast in Situ Pile

## (As per IS: 2911 (Part I / Sec II))

**1) Design Stipulations**

Pile Diameter: 0.50m
Existing GWT level: 0.00m
Pile Cut-Off level: 2.50m from existing ground level.
Pile Termination level: 18.50m from E.G.L
For maximum overburden pressure at Pile tip 15 x diameter of pile length of pile has been taken

**2) Soil Parameters Considered**

| Layer Thickness m | Cohesion Kg / cm$^2$ | Angle of Internal Friction | Field Density gm / cc | SPT N Value |
|---|---|---|---|---|
| 5.10 | 0.39 | 9 | 1.76 | 8 |
| 7.50 | 0.00 | 25 | 1.70 | 10 |
| 12.4 | 0.00 | 34 | 1.90 | 19 |

**3) Ultimate End Bearing Capacity**

Que = Ap (0.5 * D * $\gamma$ * N$\gamma$ + Pd * Nq)
Where,
Ap = Cross sectional Area = 0.196 m$^2$
D = Pile Stem Diameter = 0.50 m
$\gamma$ = Bulk Unit Weight of soil at Pile tip = 0.90 T/m$^3$
N$\gamma$ = Bearing Capacity factor = 41.06
Pd = Effective overburden pressure at pile tip = 5.56 T/m$^2$
Nq = Bearing Capacity factor = 42.80
**Ultimate End Bearing Capacity Que =0.196*(0.5*0.50*0.90*41.06+5.56*42.8) = 48.48 T**

Pd Level for this pile = 7.50 m
Layer No.1 Effective overburden pressure due to this layer = 0.00 x 1.76 +5.10 x (1.76 - 1) = 3.88 T/m$^2$
Layer No.2 Effective overburden pressure due to this layer = 2.40 x (1.70 - 1) =1.68 T/m$^2$
Layer No.3 No contribution from this layer
Total effective overburden pressure up to 7.50m level from EGL= 5.56T/m$^2$.

**4) Ultimate Skin Friction Capacity**

Qsg = $\Sigma$ [K * Pdi * tan ($\delta$) * Asi] for all layers
Where,
K = Earth Pressure Coefficient
Pdi = Effective Overburden pressure for ith layer
$\delta$ = Angle of wall friction for ith layer
Asi = Surface area of pile stem for ith layer

Qsc = $\Sigma$ [$\alpha$ * C * as] for all layers
Where, $\alpha$ = Reduction factor
C = Average Cohesion
Asi = Surface area of pile stem for ith layer

**Layer no. 1:**

K: 1.00 Pd1 : 1.94 T/m$^2$ tan ($\delta$) : 0.16 As1 : 4.08 m$^2$
Qsg = K*Pd1*tan ($\delta$)*As1 =1.00*1.94*0.16*4.08 = 1.25 T
Reduction factor ($\alpha$): 0.40 Average Cohesion(C): 3.90 T/m$^2$.
Qsc = $\alpha$*C*As1 = 0.40*3.90*4.08 = 6.37 T
**Total net skin friction of this layer = 7.62T/m$^2$**

**Layer no. 2:**
K: 1.50 Pd2: 4.72 T/$m^2$. tan ($\delta$) : 0.47 As2 : 11.78 $m^2$.
Qsg = K*Pd2*tan ($\delta$)*As2 =1.50*4.72*0.47*11.78 = 38.82 T
Reduction factor ($\alpha$): 0.40 Average Cohesion(C): 0.00 T/$m^2$.
Qsc = a*C*As2 =0.40*0.00*11.78 = 0.00 T
**Total net skin friction of this layer = 38.82 T/$m^2$.**

**Layer no. 3:**
K: 2.00 Pd3 : 5.56 T/$m^2$. tan ($\delta$) : 0.67 As3 : 9.26 $m^2$.
Qsg = K*Pd3*tan ($\delta$)*As3 =2.00*5.56*0.67*9.26 = 69.38 T
Reduction factor ($\alpha$): 0.30 Average Cohesion(C): 0.00 T/$m^2$.
Qsc = $\alpha$*C*As3 =0.30*0.00*9.26 = 0.00 T
**Total net skin friction of this layer = 69.38T/$m^2$.**

Total Skin Friction Capacity Qus = Qsg + Qsc = 115.82 T
Total Ultimate Pile Capacity Qu = Qus + Que = 164.30 T
**Net Ultimate Pile Capacity Qu/FOS = 65.7 T**

**5) Safe Load in Compression in Ton**

| Pile Diameter in m | Pile Length after cutoff in m | | |
|---|---|---|---|
| | **14.0** | **16.0** | **18.0** |
| **0.45** | 45.1 | 52.8 | 60.5 |
| **0.50** | 56.3 | 65.7 | 75.1 |

Calculating safe load on pile in uplift for various diameters,

**6) Safe Load in Uplift in Ton**

| Pile Diameter in m | Pile Length after cutoff in m | | |
|---|---|---|---|
| | **14.0** | **16.0** | **18.0** |
| **0.45** | 30.9 | 38.6 | 46.2 |
| **0.50** | 36.9 | 46.4 | 55.7 |

**7) Computation of Lateral Capacity**
Lateral capacity is computed based up on the allowable top deflection of 5.0mm. Free Length L1 is 0.00 m and overall nature of soil is clayey.

For a Fixed Head Pile of 500 mm diameter, soil constant K2= 48.8 Kg/$cm^3$ (From IS Code), E = 273861.27 Kg/$cm^2$, I = 306640.63 $cm^4$, R = 203.67, L1/R = 0.00. Depth of Fixity Lf = 443.99 cm = 4.4 m
Total Ultimate Horizontal Load Capacity H [As per IS Code] =12EIY/$(L1+Lf)^3$ = 5.76 T
**Ultimate Horizontal Load Capacity is recommended as 4.50 T**
Moment Reduction Factor m = 0.825(From IS Code)
**Total Ultimate Moment Capacity M [As per IS Code] =mH (L1+Lf)/2 = 8.24 ~ 8.2 Tm**

**Recommended Lateral Capacities For Fixed Head Piles**

| Pile Diameter in m | 0.45 | 0.50 |
|---|---|---|
| Horizontal Load Capacity in T | 4.0 | 4.5 |

For a Free Head Pile of 500 mm diameter, soil constant K2= 48.8 Kg/$cm^3$ (From IS Code), E = 273861.27 Kg/$cm^2$, I = 306640.63 $cm^4$, R = 203.67, L1/R = 0.00. Depth of Fixity Lf = 391.05 cm = 3.9 m

Total Ultimate Horizontal Load Capacity H [As per IS Code] = $3EIY/(L1+Lf)^3$ = 2.1 T
**Ultimate Horizontal Load Capacity is recommended as 2.0 T**
Moment Reduction Factor m = 0.4 (From IS Code)
**Total Ultimate Moment Capacity M [As per IS Code] = mH (L1+Lf) = 3.13 ~3.0 Tm**

**Recommended Lateral Capacities For Free Head Piles**

| Pile Diameter in m | 0.45 | 0.50 |
|---|---|---|
| Horizontal Load Capacity in T | 1.9 | 2.0 |

**8) Notes:**
1) Initial and routine pile load tests shall be carried out on the piles at site to confirm the capacity of pile worked out theoretically.

**(K.K.Thaker)**

# KCT Consultancy Services, Ahmedabad

## APPENDIX - 2 a (Borehole No. 4)

## Calculation of net Safe Bearing Capacity Based on Shear Parameters C - $\phi$

$$qu = 1 / FS [ 2 / 3 C Nc dc Sc ic + \gamma d (Nq - 1) Sq dq iq Wq + 0.5 \gamma B N\gamma S\gamma d\gamma i\gamma W\gamma ]$$

**Project :** Proposed structures of plant of Additional gas processing facilities project (Phase 4 ) of ONGC at Hazira, Surat, L & T Ltd

**For Isolated Square Footing**

| Sr. | Size of Foundation | | Depth of Foundation | Shear Parameter | | Bearing Capacity Factors | | | Shape Factors | | | Depth Factors | | | Inclination Factors | | | Unit Weight | | Water Table Correction | | Safe Bearing Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Length | Width | | C | $\phi$ | Nc | Nq - 1 | N$\gamma$ | Sc | Sq | S$\gamma$ | dc | dq | d$\gamma$ | ic | iq | i$\gamma$ | $\gamma$ | 0.5 $\gamma$ | Wq | W$\gamma$ | |
| No. | m | m | m | Kg/cm$^2$ | degree | | | | | | | | | | | | | gm/cc | | | | t / m$^2$ |
| 1 | 1.00 | 1.00 | 2.00 | 0.39 | 9 | 6.82 | 0.72 | 0.57 | 1.30 | 1.20 | 0.80 | 1.44 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 1.00 | **15** |
| 2 | 2.00 | 2.00 | 2.00 | 0.39 | 9 | 6.82 | 0.72 | 0.57 | 1.30 | 1.20 | 0.80 | 1.22 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.75 | **13** |
| 3 | 3.00 | 3.00 | 2.00 | 0.39 | 9 | 6.82 | 0.72 | 0.57 | 1.30 | 1.20 | 0.80 | 1.15 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.67 | **12** |
| 4 | 4.00 | 4.00 | 2.00 | 0.39 | 9 | 6.82 | 0.72 | 0.57 | 1.30 | 1.20 | 0.80 | 1.11 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.63 | **12** |
| 5 | 1.00 | 1.00 | 2.50 | 0.39 | 9 | 6.82 | 0.72 | 0.57 | 1.30 | 1.20 | 0.80 | 1.56 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.75 | **16** |
| 6 | 2.00 | 2.00 | 2.50 | 0.39 | 9 | 6.82 | 0.72 | 0.57 | 1.30 | 1.20 | 0.80 | 1.28 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.63 | **14** |
| 7 | 3.00 | 3.00 | 2.50 | 0.39 | 9 | 6.82 | 0.72 | 0.57 | 1.30 | 1.20 | 0.80 | 1.19 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.58 | **13** |
| 8 | 4.00 | 4.00 | 2.50 | 0.39 | 9 | 6.82 | 0.72 | 0.57 | 1.30 | 1.20 | 0.80 | 1.14 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.56 | **12** |
| 9 | 1.00 | 1.00 | 3.00 | 0.39 | 9 | 6.82 | 0.72 | 0.57 | 1.30 | 1.20 | 0.80 | 1.67 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.50 | **17** |
| 10 | 2.00 | 2.00 | 3.00 | 0.39 | 9 | 6.82 | 0.72 | 0.57 | 1.30 | 1.20 | 0.80 | 1.33 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.50 | **14** |
| 11 | 3.00 | 3.00 | 3.00 | 0.39 | 9 | 6.82 | 0.72 | 0.57 | 1.30 | 1.20 | 0.80 | 1.22 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.50 | **13** |
| 12 | 4.00 | 4.00 | 3.00 | 0.39 | 9 | 6.82 | 0.72 | 0.57 | 1.30 | 1.20 | 0.80 | 1.17 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.50 | **13** |

**Note :-**

**1) Factor of safety is 2.5**

**2) Depth of foundation shall be from E G L**

# KCT Consultancy Services, Ahmedabad

## APPENDIX - 2 b (Borehole No. 5)

## Calculation of net Safe Bearing Capacity Based on Shear Parameters C - $\phi$

$$qu = 1 / FS [ 2 / 3 C Nc dc Sc ic + \gamma d (Nq - 1) Sq dq iq Wq + 0.5 \gamma B N\gamma S\gamma d\gamma i\gamma W\gamma ]$$

**Project :** Proposed structures of plant of Additional gas processing facilities project (Phase 4 ) of ONGC at Hazira, Surat, L & T Ltd

**For Isolated Square Footing**

| Sr. | Size of Foundation | | Depth of Foundation | Shear Parameter | | Bearing Capacity Factors | | | Shape Factors | | | Depth Factors | | | Inclination Factors | | | Unit Weight | | Water Table Correction | | Safe Bearing Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Length | Width | | C | $\phi$ | Nc | Nq - 1 | N$\gamma$ | Sc | Sq | S$\gamma$ | dc | dq | d$\gamma$ | ic | iq | i$\gamma$ | $\gamma$ | 0.5 $\gamma$ | Wq | W$\gamma$ | |
| No. | m | m | m | Kg/cm$^2$ | degree | | | | | | | | | | | | | gm/cc | | | | t / m$^2$ |
| 1 | 1.00 | 1.00 | 2.00 | 0.46 | 12 | 7.55 | 1.07 | 0.87 | 1.30 | 1.20 | 0.80 | 1.46 | 1.23 | 1.23 | 1.00 | 1.00 | 1.00 | 1.71 | 0.86 | 1.00 | 1.00 | **20** |
| 2 | 2.00 | 2.00 | 2.00 | 0.46 | 12 | 7.55 | 1.07 | 0.87 | 1.30 | 1.20 | 0.80 | 1.23 | 1.12 | 1.12 | 1.00 | 1.00 | 1.00 | 1.71 | 0.86 | 1.00 | 0.75 | **17** |
| 3 | 3.00 | 3.00 | 2.00 | 0.46 | 12 | 7.55 | 1.07 | 0.87 | 1.30 | 1.20 | 0.80 | 1.15 | 1.08 | 1.08 | 1.00 | 1.00 | 1.00 | 1.71 | 0.86 | 1.00 | 0.67 | **16** |
| 4 | 4.00 | 4.00 | 2.00 | 0.46 | 12 | 7.55 | 1.07 | 0.87 | 1.30 | 1.20 | 0.80 | 1.12 | 1.06 | 1.06 | 1.00 | 1.00 | 1.00 | 1.71 | 0.86 | 1.00 | 0.63 | **16** |
| 5 | 1.00 | 1.00 | 2.50 | 0.46 | 12 | 7.55 | 1.07 | 0.87 | 1.30 | 1.20 | 0.80 | 1.58 | 1.29 | 1.29 | 1.00 | 1.00 | 1.00 | 1.71 | 0.86 | 1.00 | 0.75 | **22** |
| 6 | 2.00 | 2.00 | 2.50 | 0.46 | 12 | 7.55 | 1.07 | 0.87 | 1.30 | 1.20 | 0.80 | 1.29 | 1.14 | 1.14 | 1.00 | 1.00 | 1.00 | 1.71 | 0.86 | 1.00 | 0.63 | **18** |
| 7 | 3.00 | 3.00 | 2.50 | 0.46 | 12 | 7.55 | 1.07 | 0.87 | 1.30 | 1.20 | 0.80 | 1.19 | 1.10 | 1.10 | 1.00 | 1.00 | 1.00 | 1.71 | 0.86 | 1.00 | 0.58 | **17** |
| 8 | 4.00 | 4.00 | 2.50 | 0.46 | 12 | 7.55 | 1.07 | 0.87 | 1.30 | 1.20 | 0.80 | 1.14 | 1.07 | 1.07 | 1.00 | 1.00 | 1.00 | 1.71 | 0.86 | 1.00 | 0.56 | **17** |
| 9 | 1.00 | 1.00 | 3.00 | 0.46 | 12 | 7.55 | 1.07 | 0.87 | 1.30 | 1.20 | 0.80 | 1.69 | 1.35 | 1.35 | 1.00 | 1.00 | 1.00 | 1.71 | 0.86 | 1.00 | 0.50 | **24** |
| 10 | 2.00 | 2.00 | 3.00 | 0.46 | 12 | 7.55 | 1.07 | 0.87 | 1.30 | 1.20 | 0.80 | 1.35 | 1.17 | 1.17 | 1.00 | 1.00 | 1.00 | 1.71 | 0.86 | 1.00 | 0.50 | **20** |
| 11 | 3.00 | 3.00 | 3.00 | 0.46 | 12 | 7.55 | 1.07 | 0.87 | 1.30 | 1.20 | 0.80 | 1.23 | 1.12 | 1.12 | 1.00 | 1.00 | 1.00 | 1.71 | 0.86 | 1.00 | 0.50 | **18** |
| 12 | 4.00 | 4.00 | 3.00 | 0.46 | 12 | 7.55 | 1.07 | 0.87 | 1.30 | 1.20 | 0.80 | 1.17 | 1.09 | 1.09 | 1.00 | 1.00 | 1.00 | 1.71 | 0.86 | 1.00 | 0.50 | **18** |

**Note :-**

**1) Factor of safety is 2.5**

**2) Depth of foundation shall be from E G L**

# KCT Consultancy Services, Ahmedabad

## APPENDIX - 2 C (Borehole No. 6)

## Calculation of net Safe Bearing Capacity Based on Shear Parameters C - $\phi$

$$qu = 1 / FS [ 2 / 3 C Nc dc Sc ic + \gamma d (Nq - 1) Sq dq iq Wq + 0.5 \gamma B N\gamma S\gamma d\gamma i\gamma W\gamma ]$$

**Project :** Proposed structures of plant of Additional gas processing facilities project (Phase 4 ) of ONGC at Hazira, Surat, L & T Ltd

**For Isolated Square Footing**

| Sr. | Size of Foundation | | Depth of Foundation | Shear Parameter | | Bearing Capacity Factors | | | Shape Factors | | | Depth Factors | | | Inclination Factors | | | Unit Weight | | Water Table Correction | | Safe Bearing Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Length | Width | | C | $\phi$ | Nc | Nq - 1 | N$\gamma$ | Sc | Sq | S$\gamma$ | dc | dq | d$\gamma$ | ic | iq | i$\gamma$ | $\gamma$ | 0.5 $\gamma$ | Wq | W$\gamma$ | |
| No. | m | m | m | Kg/cm$^2$ | degree | | | | | | | | | | | | | gm/cc | | | | t / m$^2$ |
| 1 | 1.00 | 1.00 | 2.00 | 0.24 | 2 | 5.46 | 0.13 | 0.10 | 1.30 | 1.20 | 0.80 | 1.41 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.70 | 0.85 | 1.00 | 1.00 | **7** |
| 2 | 2.00 | 2.00 | 2.00 | 0.24 | 2 | 5.46 | 0.13 | 0.10 | 1.30 | 1.20 | 0.80 | 1.20 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.70 | 0.85 | 1.00 | 0.75 | **6** |
| 3 | 3.00 | 3.00 | 2.00 | 0.24 | 2 | 5.46 | 0.13 | 0.10 | 1.30 | 1.20 | 0.80 | 1.14 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.70 | 0.85 | 1.00 | 0.67 | **5** |
| 4 | 4.00 | 4.00 | 2.00 | 0.24 | 2 | 5.46 | 0.13 | 0.10 | 1.30 | 1.20 | 0.80 | 1.10 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.70 | 0.85 | 1.00 | 0.63 | **5** |
| 5 | 1.00 | 1.00 | 2.50 | 0.24 | 2 | 5.46 | 0.13 | 0.10 | 1.30 | 1.20 | 0.80 | 1.51 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.70 | 0.85 | 1.00 | 0.75 | **7** |
| 6 | 2.00 | 2.00 | 2.50 | 0.24 | 2 | 5.46 | 0.13 | 0.10 | 1.30 | 1.20 | 0.80 | 1.26 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.70 | 0.85 | 1.00 | 0.63 | **6** |
| 7 | 3.00 | 3.00 | 2.50 | 0.24 | 2 | 5.46 | 0.13 | 0.10 | 1.30 | 1.20 | 0.80 | 1.17 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.70 | 0.85 | 1.00 | 0.58 | **6** |
| 8 | 4.00 | 4.00 | 2.50 | 0.24 | 2 | 5.46 | 0.13 | 0.10 | 1.30 | 1.20 | 0.80 | 1.13 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.70 | 0.85 | 1.00 | 0.56 | **5** |
| 9 | 1.00 | 1.00 | 3.00 | 0.24 | 2 | 5.46 | 0.13 | 0.10 | 1.30 | 1.20 | 0.80 | 1.61 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.70 | 0.85 | 1.00 | 0.50 | **8** |
| 10 | 2.00 | 2.00 | 3.00 | 0.24 | 2 | 5.46 | 0.13 | 0.10 | 1.30 | 1.20 | 0.80 | 1.31 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.70 | 0.85 | 1.00 | 0.50 | **6** |
| 11 | 3.00 | 3.00 | 3.00 | 0.24 | 2 | 5.46 | 0.13 | 0.10 | 1.30 | 1.20 | 0.80 | 1.20 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.70 | 0.85 | 1.00 | 0.50 | **6** |
| 12 | 4.00 | 4.00 | 3.00 | 0.24 | 2 | 5.46 | 0.13 | 0.10 | 1.30 | 1.20 | 0.80 | 1.15 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.70 | 0.85 | 1.00 | 0.50 | **6** |

**Note :-**

**1) Factor of safety is 2.5**

**2) Depth of foundation shall be from E G L**

# KCT Consultancy Services, Ahmedabad

## APPENDIX - 2 d (Borehole No. 9)

## Calculation of net Safe Bearing Capacity Based on Shear Parameters C - $\phi$

$$qu = 1 / FS [ 2 / 3 C Nc dc Sc ic + \gamma d (Nq - 1) Sq dq iq Wq + 0.5 \gamma B N\gamma S\gamma d\gamma i\gamma W\gamma ]$$

**Project :** Proposed structures of plant of Additional gas processing facilities project (Phase 4 ) of ONGC at Hazira, Surat, L & T Ltd

**For Isolated Square Footing**

| Sr. | Size of Foundation | | Depth of Foundation | Shear Parameter | | Bearing Capacity Factors | | | Shape Factors | | | Depth Factors | | | Inclination Factors | | | Unit Weight | | Water Table Correction | | Safe Bearing Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Length | Width | | C | $\phi$ | Nc | Nq - 1 | N$\gamma$ | Sc | Sq | S$\gamma$ | dc | dq | d$\gamma$ | ic | iq | i$\gamma$ | $\gamma$ | 0.5 $\gamma$ | Wq | W$\gamma$ | |
| No. | m | m | m | Kg/cm$^2$ | degree | | | | | | | | | | | | | gm/cc | | | | t / m$^2$ |
| 1 | 1.00 | 1.00 | 2.00 | 0.38 | 13 | 7.82 | 1.20 | 0.99 | 1.30 | 1.20 | 0.80 | 1.47 | 1.23 | 1.23 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 1.00 | **18** |
| 2 | 2.00 | 2.00 | 2.00 | 0.38 | 13 | 7.82 | 1.20 | 0.99 | 1.30 | 1.20 | 0.80 | 1.23 | 1.12 | 1.12 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.75 | **15** |
| 3 | 3.00 | 3.00 | 2.00 | 0.38 | 13 | 7.82 | 1.20 | 0.99 | 1.30 | 1.20 | 0.80 | 1.16 | 1.08 | 1.08 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.67 | **15** |
| 4 | 4.00 | 4.00 | 2.00 | 0.38 | 13 | 7.82 | 1.20 | 0.99 | 1.30 | 1.20 | 0.80 | 1.12 | 1.06 | 1.06 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.63 | **14** |
| 5 | 1.00 | 1.00 | 2.50 | 0.38 | 13 | 7.82 | 1.20 | 0.99 | 1.30 | 1.20 | 0.80 | 1.58 | 1.29 | 1.29 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.75 | **20** |
| 6 | 2.00 | 2.00 | 2.50 | 0.38 | 13 | 7.82 | 1.20 | 0.99 | 1.30 | 1.20 | 0.80 | 1.29 | 1.15 | 1.15 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.63 | **17** |
| 7 | 3.00 | 3.00 | 2.50 | 0.38 | 13 | 7.82 | 1.20 | 0.99 | 1.30 | 1.20 | 0.80 | 1.19 | 1.10 | 1.10 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.58 | **16** |
| 8 | 4.00 | 4.00 | 2.50 | 0.38 | 13 | 7.82 | 1.20 | 0.99 | 1.30 | 1.20 | 0.80 | 1.15 | 1.07 | 1.07 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.56 | **15** |
| 9 | 1.00 | 1.00 | 3.00 | 0.38 | 13 | 7.82 | 1.20 | 0.99 | 1.30 | 1.20 | 0.80 | 1.70 | 1.35 | 1.35 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.50 | **22** |
| 10 | 2.00 | 2.00 | 3.00 | 0.38 | 13 | 7.82 | 1.20 | 0.99 | 1.30 | 1.20 | 0.80 | 1.35 | 1.17 | 1.17 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.50 | **18** |
| 11 | 3.00 | 3.00 | 3.00 | 0.38 | 13 | 7.82 | 1.20 | 0.99 | 1.30 | 1.20 | 0.80 | 1.23 | 1.12 | 1.12 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.50 | **17** |
| 12 | 4.00 | 4.00 | 3.00 | 0.38 | 13 | 7.82 | 1.20 | 0.99 | 1.30 | 1.20 | 0.80 | 1.17 | 1.09 | 1.09 | 1.00 | 1.00 | 1.00 | 1.76 | 0.88 | 1.00 | 0.50 | **16** |

**Note :-**

**1) Factor of safety is 2.5**

**2) Depth of foundation shall be from E G L**

**KCT Consultancy Services, Ahmedabad**

## Calculation of Settlement (BH 4)

**Settlement $S_C = \{ ( C_C H ) / ( 1 + e_0 ) \} \log_{10} \{ ( P_0 + \Delta P ) / P_0 \}$**

**Project:- Proposed structures of plant of Additional gas processing facilities project (Phase 4 ) of ONGC at Hazira, Surat, L & T Ltd**

| Sr. No. | Comp Index Cc | Depth of Footing D m | Width of Footing B m | H m | Voids Ratio $e_0$ | Field Density $\gamma$ gm / cc | d m | $p_0$ T / $m^2$ | SBC T / $m^2$ | $\Delta p$ T / $m^2$ | $(\Delta p+p_0)/p_0$ | $\lambda$ factor related to pore pressure parameter | Correction for depth | Consolidation Settlement Sc mm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.15 | 2.00 | 1.00 | 2.00 | 0.82 | 1.76 | 3.00 | 5.28 | 15 | 3.68 | 1.70 | 0.7 | 0.66 | **17.5** |
| 2 | 0.15 | 2.00 | 2.00 | 3.15 | 0.82 | 1.76 | 3.58 | 6.29 | 13 | 3.98 | 1.63 | 0.7 | 0.73 | **28.2** |
| 3 | 0.15 | 2.00 | 3.00 | 3.15 | 0.82 | 1.76 | 3.58 | 6.29 | 12 | 5.22 | 1.83 | 0.7 | 0.80 | **38.0** |
| 4 | 0.15 | 2.00 | 4.00 | 3.15 | 0.82 | 1.76 | 3.58 | 6.29 | 12 | 6.11 | 1.97 | 0.7 | 0.85 | **45.5** |
| 5 | 0.15 | 2.50 | 1.00 | 2.00 | 0.82 | 1.76 | 3.50 | 6.16 | 16 | 4.00 | 1.65 | 0.7 | 0.65 | **16.2** |
| 6 | 0.15 | 2.50 | 2.00 | 2.65 | 0.82 | 1.76 | 3.83 | 6.73 | 14 | 4.89 | 1.73 | 0.7 | 0.73 | **26.4** |
| 7 | 0.15 | 2.50 | 3.00 | 2.65 | 0.82 | 1.76 | 3.83 | 6.73 | 13 | 6.13 | 1.91 | 0.7 | 0.75 | **32.4** |
| 8 | 0.15 | 2.50 | 4.00 | 2.15 | 0.82 | 1.76 | 3.58 | 6.29 | 12 | 7.70 | 2.22 | 0.7 | 0.81 | **34.8** |
| 9 | 0.15 | 3.00 | 1.00 | 2.00 | 0.82 | 1.76 | 4.00 | 7.04 | 17 | 4.32 | 1.61 | 0.7 | 0.63 | **15.2** |
| 10 | 0.15 | 3.00 | 2.00 | 2.15 | 0.82 | 1.76 | 4.08 | 7.17 | 14 | 6.04 | 1.84 | 0.7 | 0.73 | **24.0** |
| 11 | 0.15 | 3.00 | 3.00 | 2.15 | 0.82 | 1.76 | 4.08 | 7.17 | 13 | 7.23 | 2.01 | 0.7 | 0.73 | **27.4** |
| 12 | 0.15 | 3.00 | 4.00 | 2.15 | 0.82 | 1.76 | 4.08 | 7.17 | 13 | 8.02 | 2.12 | 0.7 | 0.77 | **31.3** |

**KCT Consultancy Services, Ahmedabad**

## Calculation of Settlement (BH 5)

**Settlement $S_C = \{ ( C_C H ) / ( 1 + e_0 ) \} \log_{10} \{ ( P_0 + \Delta P ) / P_0 \}$**

**Project:- Proposed structures of plant of Additional gas processing facilities project (Phase 4 ) of ONGC at Hazira, Surat, L & T Ltd**

| Sr. No. | Comp Index Cc | Depth of Footing D m | Width of Footing B m | H m | Voids Ratio $e_0$ | Field Density $\gamma$ gm / cc | d m | $p_0$ T / $m^2$ | SBC T / $m^2$ | $\Delta p$ T / $m^2$ | $(\Delta p+p_0)/p_0$ | $\lambda$ factor related to pore pressure parameter | Correction for depth | Consolidation Settlement Sc mm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.18 | 2.00 | 1.00 | 2.00 | 0.91 | 1.71 | 3.00 | 5.13 | 20 | 5.01 | 1.98 | 0.7 | 0.66 | **25.8** |
| 2 | 0.18 | 2.00 | 2.00 | 3.15 | 0.91 | 1.71 | 3.58 | 6.11 | 17 | 5.38 | 1.88 | 0.7 | 0.73 | **41.5** |
| 3 | 0.18 | 2.00 | 3.00 | 3.15 | 0.91 | 1.71 | 3.58 | 6.11 | 16 | 7.01 | 2.15 | 0.7 | 0.80 | **54.9** |
| 4 | 0.18 | 2.00 | 4.00 | 3.15 | 0.91 | 1.71 | 3.58 | 6.11 | 16 | 8.19 | 2.34 | 0.7 | 0.85 | **65.2** |
| 5 | 0.18 | 2.50 | 1.00 | 2.00 | 0.91 | 1.71 | 3.50 | 5.99 | 22 | 5.51 | 1.92 | 0.7 | 0.65 | **24.2** |
| 6 | 0.18 | 2.50 | 2.00 | 2.65 | 0.91 | 1.71 | 3.83 | 6.54 | 18 | 6.64 | 2.02 | 0.7 | 0.73 | **38.8** |
| 7 | 0.18 | 2.50 | 3.00 | 2.65 | 0.91 | 1.71 | 3.83 | 6.54 | 17 | 8.28 | 2.27 | 0.7 | 0.75 | **46.9** |
| 8 | 0.18 | 2.50 | 4.00 | 2.15 | 0.91 | 1.71 | 3.58 | 6.11 | 17 | 10.38 | 2.70 | 0.7 | 0.81 | **49.5** |
| 9 | 0.18 | 3.00 | 1.00 | 2.00 | 0.91 | 1.71 | 4.00 | 6.84 | 24 | 6.02 | 1.88 | 0.7 | 0.63 | **23.0** |
| 10 | 0.18 | 3.00 | 2.00 | 2.15 | 0.91 | 1.71 | 4.08 | 6.97 | 20 | 8.28 | 2.19 | 0.7 | 0.73 | **35.2** |
| 11 | 0.18 | 3.00 | 3.00 | 2.15 | 0.91 | 1.71 | 4.08 | 6.97 | 18 | 9.84 | 2.41 | 0.7 | 0.73 | **39.6** |
| 12 | 0.18 | 3.00 | 4.00 | 2.15 | 0.91 | 1.71 | 4.08 | 6.97 | 18 | 10.87 | 2.56 | 0.7 | 0.77 | **44.8** |

**KCT Consultancy Services, Ahmedabad**

## Calculation of Settlement (BH 6)

**Settlement $S_C = \{ ( C_C H ) / ( 1 + e_0 ) \} \log_{10} \{ ( P_0 + \Delta P ) / P_0 \}$**

**Project:- Proposed structures of plant of Additional gas processing facilities project (Phase 4 ) of ONGC at Hazira, Surat, L & T Ltd**

| Sr. No. | Comp Index Cc | Depth of Footing D m | Width of Footing B m | H m | Voids Ratio $e_0$ | Field Density $\gamma$ gm / cc | d m | $p_0$ T / $m^2$ | SBC T / $m^2$ | $\Delta p$ T / $m^2$ | $(\Delta p+p_0)/p_0$ | $\lambda$ factor related to pore pressure parameter | Correction for depth | Consolidation Settlement Sc mm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.29 | 2.00 | 1.00 | 2.00 | 0.92 | 1.7 | 3.00 | 5.10 | 7 | 1.66 | 1.33 | 0.7 | 0.66 | **17.1** |
| 2 | 0.29 | 2.00 | 2.00 | 2.00 | 0.92 | 1.7 | 3.00 | 5.10 | 6 | 2.54 | 1.50 | 0.7 | 0.73 | **27.1** |
| 3 | 0.29 | 2.00 | 3.00 | 2.00 | 0.92 | 1.7 | 3.00 | 5.10 | 5 | 3.05 | 1.60 | 0.7 | 0.80 | **34.2** |
| 4 | 0.29 | 2.00 | 4.00 | 2.00 | 0.92 | 1.7 | 3.00 | 5.10 | 5 | 3.38 | 1.66 | 0.7 | 0.85 | **39.6** |
| 5 | 0.29 | 2.50 | 1.00 | 1.50 | 0.92 | 1.7 | 3.25 | 5.53 | 7 | 2.33 | 1.42 | 0.7 | 0.65 | **15.7** |
| 6 | 0.29 | 2.50 | 2.00 | 1.50 | 0.92 | 1.7 | 3.25 | 5.53 | 6 | 3.17 | 1.57 | 0.7 | 0.73 | **22.8** |
| 7 | 0.29 | 2.50 | 3.00 | 1.50 | 0.92 | 1.7 | 3.25 | 5.53 | 6 | 3.60 | 1.65 | 0.7 | 0.75 | **26.0** |
| 8 | 0.29 | 2.50 | 4.00 | 1.50 | 0.92 | 1.7 | 3.25 | 5.53 | 5 | 3.86 | 1.70 | 0.7 | 0.81 | **29.5** |
| 9 | 0.29 | 3.00 | 1.00 | 1.00 | 0.92 | 1.7 | 3.50 | 5.95 | 8 | 3.40 | 1.57 | 0.7 | 0.63 | **13.2** |
| 10 | 0.29 | 3.00 | 2.00 | 1.00 | 0.92 | 1.7 | 3.50 | 5.95 | 6 | 4.02 | 1.68 | 0.7 | 0.73 | **17.3** |
| 11 | 0.29 | 3.00 | 3.00 | 1.00 | 0.92 | 1.7 | 3.50 | 5.95 | 6 | 4.28 | 1.72 | 0.7 | 0.73 | **18.1** |
| 12 | 0.29 | 3.00 | 4.00 | 1.00 | 0.92 | 1.7 | 3.50 | 5.95 | 6 | 4.43 | 1.74 | 0.7 | 0.77 | **19.7** |

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## Calculation of Settlement (BH 9)

**Settlement $S_C$ = mv H $\Delta$P**

**Project:- Proposed structures of plant of Additional gas processing facilities project (Phase 4 ) of ONGC at Hazira, Surat, L & T Ltd**

| Sr. No. | Depth of Footing D<br>m | Width of Footing B<br>m | mv | H<br>m | $\Delta$p<br>T / $m^2$ | SBC<br>T / $m^2$ | $\lambda$ factor related to pore pressure parameter | Correction for depth | Consolidation Settlement Sc<br>mm |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.00 | 1.00 | 0.12 | 1.50 | 5.88 | 18 | 0.3 | 0.73 | 23.2 |
| 2 | 2.00 | 2.00 | 0.12 | 1.50 | 7.93 | 15 | 0.3 | 0.76 | 32.6 |
| 3 | 2.00 | 3.00 | 0.12 | 1.50 | 9.60 | 15 | 0.3 | 0.80 | 41.3 |
| 4 | 2.00 | 4.00 | 0.12 | 1.50 | 9.93 | 14 | 0.3 | 0.83 | 44.3 |
| 5 | 2.50 | 1.00 | 0.12 | 1.00 | 8.89 | 20 | 0.3 | 0.73 | 23.3 |
| 6 | 2.50 | 2.00 | 0.12 | 1.00 | 10.88 | 17 | 0.3 | 0.73 | 28.6 |
| 7 | 2.50 | 3.00 | 0.12 | 1.00 | 11.76 | 16 | 0.3 | 0.75 | 31.9 |
| 8 | 2.50 | 4.00 | 0.12 | 1.00 | 11.85 | 15 | 0.3 | 0.78 | 33.4 |
| 9 | 3.00 | 1.00 | 0.12 | 0.50 | 14.08 | 22 | 0.3 | 0.73 | 18.5 |
| 10 | 3.00 | 2.00 | 0.12 | 0.50 | 14.22 | 18 | 0.3 | 0.73 | 18.7 |
| 11 | 3.00 | 3.00 | 0.12 | 0.50 | 14.49 | 17 | 0.3 | 0.73 | 19.0 |
| 12 | 3.00 | 4.00 | 0.12 | 0.50 | 14.17 | 16 | 0.3 | 0.75 | 19.1 |

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## Allowable Bearing Pressure for 25 mm Settlement (BH 4)

**Settlement $S_C = \{ ( C_C H ) / ( 1 + e_0 ) \} \log_{10} \{ ( P_0 + \Delta P ) / P_0 \}$**

**Project:- Proposed structures of plant of Additional gas processing facilities project (Phase 4 ) of ONGC at Hazira, Surat, L & T Ltd**

| Sr. No. | Comp Index Cc | Depth of Footing D m | Width of Footing B m | H m | Voids Ratio $e_0$ | Field Density $\gamma$ gm / cc | d m | $p_0$ T / $m^2$ | $\Delta p$ T / $m^2$ | $(\Delta p+p_0)/p_0$ | $\lambda$ factor related to pore pressure parameter | Correction for depth | Consolidation Settlement Sc mm | Allowable Bearing Pressure T / $m^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.15 | 2.00 | 1.00 | 2.00 | 0.82 | 1.76 | 3.00 | 5.28 | 5.94 | 2.13 | 0.7 | 0.66 | 25 | **24** |
| 2 | 0.15 | 2.00 | 2.00 | 3.15 | 0.82 | 1.76 | 3.58 | 6.29 | 3.42 | 1.54 | 0.7 | 0.73 | 25 | **11** |
| 3 | 0.15 | 2.00 | 3.00 | 3.15 | 0.82 | 1.76 | 3.58 | 6.29 | 3.07 | 1.49 | 0.7 | 0.80 | 25 | **7** |
| 4 | 0.15 | 2.00 | 4.00 | 3.15 | 0.82 | 1.76 | 3.58 | 6.29 | 2.84 | 1.45 | 0.7 | 0.85 | 25 | **6** |
| 5 | 0.15 | 2.50 | 1.00 | 2.00 | 0.82 | 1.76 | 3.50 | 6.16 | 7.17 | 2.16 | 0.7 | 0.65 | 25 | **29** |
| 6 | 0.15 | 2.50 | 2.00 | 2.65 | 0.82 | 1.76 | 3.83 | 6.73 | 4.55 | 1.68 | 0.7 | 0.73 | 25 | **13** |
| 7 | 0.15 | 2.50 | 3.00 | 2.65 | 0.82 | 1.76 | 3.83 | 6.73 | 4.36 | 1.65 | 0.7 | 0.75 | 25 | **9** |
| 8 | 0.15 | 2.50 | 4.00 | 2.15 | 0.82 | 1.76 | 3.58 | 6.29 | 4.87 | 1.77 | 0.7 | 0.81 | 25 | **8** |
| 9 | 0.15 | 3.00 | 1.00 | 2.00 | 0.82 | 1.76 | 4.00 | 7.04 | 8.41 | 2.19 | 0.7 | 0.63 | 25 | **34** |
| 10 | 0.15 | 3.00 | 2.00 | 2.15 | 0.82 | 1.76 | 4.08 | 7.17 | 6.38 | 1.89 | 0.7 | 0.73 | 25 | **15** |
| 11 | 0.15 | 3.00 | 3.00 | 2.15 | 0.82 | 1.76 | 4.08 | 7.17 | 6.38 | 1.89 | 0.7 | 0.73 | 25 | **12** |
| 12 | 0.15 | 3.00 | 4.00 | 2.15 | 0.82 | 1.76 | 4.08 | 7.17 | 5.89 | 1.82 | 0.7 | 0.77 | 25 | **9** |

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## Allowable Bearing Pressure for 25 mm Settlement (BH 5)

**Settlement $S_C = \{ ( C_C H ) / ( 1 + e_0 ) \} \log_{10} \{ ( P_0 + \Delta P ) / P_0 \}$**

**Project:- Proposed structures of plant of Additional gas processing facilities project (Phase 4 ) of ONGC at Hazira, Surat, L & T Ltd**

| Sr. No. | Comp Index Cc | Depth of Footing D m | Width of Footing B m | H m | Voids Ratio $e_0$ | Field Density $\gamma$ gm / cc | d m | $p_0$ T / $m^2$ | $\Delta p$ T / $m^2$ | $(\Delta p+p_0)/p_0$ | $\lambda$ factor related to pore pressure parameter | Correction for depth | Consolidation Settlement Sc mm | Allowable Bearing Pressure T / $m^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.18 | 2.00 | 1.00 | 2.00 | 0.91 | 1.71 | 3.00 | 5.13 | 4.79 | 1.93 | 0.7 | 0.66 | 25 | **19** |
| 2 | 0.18 | 2.00 | 2.00 | 3.15 | 0.91 | 1.71 | 3.58 | 6.11 | 2.82 | 1.46 | 0.7 | 0.73 | 25 | **9** |
| 3 | 0.18 | 2.00 | 3.00 | 3.15 | 0.91 | 1.71 | 3.58 | 6.11 | 2.54 | 1.42 | 0.7 | 0.80 | 25 | **6** |
| 4 | 0.18 | 2.00 | 4.00 | 3.15 | 0.91 | 1.71 | 3.58 | 6.11 | 2.36 | 1.39 | 0.7 | 0.85 | 25 | **5** |
| 5 | 0.18 | 2.50 | 1.00 | 2.00 | 0.91 | 1.71 | 3.50 | 5.99 | 5.78 | 1.96 | 0.7 | 0.65 | 25 | **23** |
| 6 | 0.18 | 2.50 | 2.00 | 2.65 | 0.91 | 1.71 | 3.83 | 6.54 | 3.73 | 1.57 | 0.7 | 0.73 | 25 | **10** |
| 7 | 0.18 | 2.50 | 3.00 | 2.65 | 0.91 | 1.71 | 3.83 | 6.54 | 3.58 | 1.55 | 0.7 | 0.75 | 25 | **7** |
| 8 | 0.18 | 2.50 | 4.00 | 2.15 | 0.91 | 1.71 | 3.58 | 6.11 | 3.98 | 1.65 | 0.7 | 0.81 | 25 | **6** |
| 9 | 0.18 | 3.00 | 1.00 | 2.00 | 0.91 | 1.71 | 4.00 | 6.84 | 6.76 | 1.99 | 0.7 | 0.63 | 25 | **27** |
| 10 | 0.18 | 3.00 | 2.00 | 2.15 | 0.91 | 1.71 | 4.08 | 6.97 | 5.19 | 1.74 | 0.7 | 0.73 | 25 | **12** |
| 11 | 0.18 | 3.00 | 3.00 | 2.15 | 0.91 | 1.71 | 4.08 | 6.97 | 5.19 | 1.74 | 0.7 | 0.73 | 25 | **10** |
| 12 | 0.18 | 3.00 | 4.00 | 2.15 | 0.91 | 1.71 | 4.08 | 6.97 | 4.81 | 1.69 | 0.7 | 0.77 | 25 | **8** |

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## Allowable Bearing Pressure for 25 mm Settlement (BH 6)

**Settlement $S_C = \{ ( C_C H ) / ( 1 + e_0 ) \} \log_{10} \{ ( P_0 + \Delta P ) / P_0 \}$**

**Project:- Proposed structures of plant of Additional gas processing facilities project (Phase 4 ) of ONGC at Hazira, Surat, L & T Ltd**

| Sr. No. | Comp Index Cc | Depth of Footing D m | Width of Footing B m | H m | Voids Ratio $e_0$ | Field Density $\gamma$ gm / cc | d m | $p_0$ T / $m^2$ | $\Delta p$ T / $m^2$ | $(\Delta p+p_0)/p_0$ | $\lambda$ factor related to pore pressure parameter | Correction for depth | Consolidation Settlement Sc mm | Allowable Bearing Pressure T / $m^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.29 | 2.00 | 1.00 | 2.00 | 0.92 | 1.70 | 3.00 | 5.10 | 2.60 | 1.51 | 0.7 | 0.66 | 25.0 | **10.4** |
| 2 | 0.29 | 2.00 | 2.00 | 2.00 | 0.92 | 1.70 | 3.00 | 5.10 | 2.31 | 1.45 | 0.7 | 0.73 | 25.0 | **5.2** |
| 3 | 0.29 | 2.00 | 3.00 | 2.00 | 0.92 | 1.70 | 3.00 | 5.10 | 2.08 | 1.41 | 0.7 | 0.80 | 25.0 | **3.7** |
| 4 | 0.29 | 2.00 | 4.00 | 2.00 | 0.92 | 1.70 | 3.00 | 5.10 | 1.93 | 1.38 | 0.7 | 0.85 | 25.0 | **3.0** |
| 5 | 0.29 | 2.50 | 1.00 | 1.50 | 0.92 | 1.70 | 3.25 | 5.53 | 4.18 | 1.76 | 0.7 | 0.65 | 25.0 | **12.8** |
| 6 | 0.29 | 2.50 | 2.00 | 1.50 | 0.92 | 1.70 | 3.25 | 5.53 | 3.57 | 1.65 | 0.7 | 0.73 | 25.0 | **6.8** |
| 7 | 0.29 | 2.50 | 3.00 | 1.50 | 0.92 | 1.70 | 3.25 | 5.53 | 3.42 | 1.62 | 0.7 | 0.75 | 25.0 | **5.3** |
| 8 | 0.29 | 2.50 | 4.00 | 1.50 | 0.92 | 1.70 | 3.25 | 5.53 | 3.14 | 1.57 | 0.7 | 0.81 | 25.0 | **4.4** |
| 9 | 0.29 | 3.00 | 1.00 | 1.00 | 0.92 | 1.70 | 3.50 | 5.95 | 8.10 | 2.36 | 0.7 | 0.63 | 25.0 | **18.2** |
| 10 | 0.29 | 3.00 | 2.00 | 1.00 | 0.92 | 1.70 | 3.50 | 5.95 | 6.62 | 2.11 | 0.7 | 0.73 | 25.0 | **10.3** |
| 11 | 0.29 | 3.00 | 3.00 | 1.00 | 0.92 | 1.70 | 3.50 | 5.95 | 6.62 | 2.11 | 0.7 | 0.73 | 25.0 | **9.0** |
| 12 | 0.29 | 3.00 | 4.00 | 1.00 | 0.92 | 1.70 | 3.50 | 5.95 | 6.09 | 2.02 | 0.7 | 0.77 | 25.0 | **7.7** |

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## Calculation of Settlement (BH 9)

**Settlement $S_C = mv\ H\ \Delta P$**

**Project:- Proposed structures of plant of Additional gas processing facilities project (Phase 4 ) of ONGC at Hazira, Surat, L & T Ltd**

| Sr. No. | Depth of Footing D<br>m | Width of Footing B<br>m | mv | H<br>m | Δp<br>T / $m^2$ | λ factor related to pore pressure parameter | Correction for depth | Settlement Sc<br>mm | Allowable Bearing Pressure<br>T / $m^2$ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.00 | 1.00 | 0.12 | 1.50 | 6.35 | 0.3 | 0.73 | 25.0 | 19 |
| 2 | 2.00 | 2.00 | 0.12 | 1.50 | 6.08 | 0.3 | 0.76 | 25.0 | 11 |
| 3 | 2.00 | 3.00 | 0.12 | 1.50 | 5.81 | 0.3 | 0.80 | 25.0 | 9 |
| 4 | 2.00 | 4.00 | 0.12 | 1.50 | 5.61 | 0.3 | 0.83 | 25.0 | 8 |
| 5 | 2.50 | 1.00 | 0.12 | 1.00 | 9.52 | 0.3 | 0.73 | 25.0 | 21 |
| 6 | 2.50 | 2.00 | 0.12 | 1.00 | 9.52 | 0.3 | 0.73 | 25.0 | 15 |
| 7 | 2.50 | 3.00 | 0.12 | 1.00 | 9.21 | 0.3 | 0.75 | 25.0 | 13 |
| 8 | 2.50 | 4.00 | 0.12 | 1.00 | 8.87 | 0.3 | 0.78 | 25.0 | 11 |
| 9 | 3.00 | 1.00 | 0.12 | 0.50 | 19.04 | 0.3 | 0.73 | 25.0 | 30 |
| 10 | 3.00 | 2.00 | 0.12 | 0.50 | 19.04 | 0.3 | 0.73 | 25.0 | 24 |
| 11 | 3.00 | 3.00 | 0.12 | 0.50 | 19.04 | 0.3 | 0.73 | 25.0 | 22 |
| 12 | 3.00 | 4.00 | 0.12 | 0.50 | 18.53 | 0.3 | 0.75 | 25.0 | 21 |

## NOTATIONS

| | |
|---|---|
| C | Cohesion |
| $\phi$ | Angle of internal friction of soil |
| DS | Disturbed Sample |
| UDS | Undisturbed Sample |
| NMC | Natural Moisture Content |
| NP | Non Plastic Soils |
| G | Specific Gravity |
| G | Gravel Content |
| M | Silt Content |
| S | Sand Content |
| C | Clay Content |
| LL | Liquid Limit |
| PL | Plastic Limit |
| PI | Plasticity Index |
| Cc | Compression Index |
| K | Coefficient of Permeability |
| UCS | Unconfined Compression |
| N | SPT Value |
| BH | Bore Hole |
| Suffix | The Number of Bore Holes |
| Nc,Nq,N$\gamma$ | Bearing Capacity Factor |
| Sc,Sq,S$\gamma$ | Shape Factors |
| D | Depth of foundation |
| FS | Factor of Safety |
| Cv | Coefficient of consolidation |
| UU | Unconsolidated undrained triaxial test |
| CU | Consolidated undrained triaxial test |
| CD | Consolidated drained triaxial test |
| GC | Clayey Gravels |
| GP | Poorely Graded Gravels |
| GW | Well Graded Gravels |
| SC | Clayey Sand |
| SM | Silty Sand |
| SW | Wel Graded Sand |
| SP | Poorly Graded Sand |
| CH | Clays of High Plasticity |
| CI | Clays of Intermediate Plasticity |
| CL | Clays of Low Plasticity |
| MH | Silts of High Plasticity |
| MI | Silts of Intermediate Plasticity |
| ML | Silts of Low Plasticity |

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**TABLE NO. – 1**

RESULTS OF LABORATORY PERMEABILITY

| Sr. No. | Bore Hole No. | Depth (m) | Permeability (mm/s) |
|---|---|---|---|
| 1. | BH – 4 | 2.50 | $0.66 \times 10^{-6}$ |
| 2. | BH – 5 | 2.50 | $0.68 \times 10^{-6}$ |
| 3. | BH – 6 | 2.50 | $0.60 \times 10^{-6}$ |
| 4. | BH – 9 | 5.50 | $0.58 \times 10^{-6}$ |

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**Table No. 2**
**Results of Chemical Analysis of Soil**

| Sr. No. | BH No. | Depth (m) | pH | SO3 in 2:1 Water : Soil Extract (mg/l) | Chlorides |
|---|---|---|---|---|---|
| 1 | BH 4 | 2.50 | 7.45 | 886 | 2013 |
| 2 | BH 5 | 4.50 | 7.63 | 926 | 2003 |
| 3 | BH 6 | 2.50 | 7.72 | 947 | 2014 |
| 4 | BH 9 | 2.50 | 7.75 | 868 | 2045 |

**Table No. 3**
**Results of Chemical Analysis of Ground Water**

| Sr. No. | Location | pH | Total Dissolved Solids | | Sulphate (SO3) (mg/l) | Chloride (mg/l) |
|---|---|---|---|---|---|---|
| | | | Organic | Inorganic | | |
| 1 | BH 4 | 7.65 | Nil | 905 | 1081 | 1036 |
| 2 | BH 5 | 7.72 | Nil | 895 | 1015 | 1028 |
| 3 | BH 6 | 7.53 | Nil | 907 | 1059 | 1053 |
| 4 | BH 9 | 7.63 | Nil | 884 | 1083 | 1026 |

For KCT Consultancy Services

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### RESULTS OF LABORATORY TEST

Project :- Proposed structures of plant of Additional gas processing facilities project (Phase 4 ) of ONGC at Hazira, Surat, L & T Ltd
BH No. :- 4

| Sr No | Depth | Type of Sample | Field Density | Natural Moisture Content | | Grain Size Analysis | | | | Consistancy limits | | | | | | | Shear Parameter | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | gm / cc | % | | % | % | % | % | % | % | % | % | Kg/cm$^2$ | | | C Kg/cm$^2$ | ϕ Degree | | | | | | |
| 1 | 0.00 | DS | - | 10.64 | - | 1 | 3 | 54 | 42 | 55 | 29 | 26 | - | - | - | CH | - | - | - | - | - | - | - | - |
| 2 | 0.50 | SPT | - | - | - | 1 | 10 | 47 | 42 | 54 | 28 | 26 | - | - | - | CH | - | - | - | - | 19 | - | - | - |
| 3 | 1.50 | SPT | - | - | - | 1 | 8 | 44 | 47 | 54 | 25 | 29 | - | - | - | CH | - | - | - | - | 16 | - | - | - |
| 4 | 2.50 | UDS | 1.76 | 21.34 | 2.64 | 2 | 6 | 46 | 46 | 55 | 26 | 29 | 8 | 0.26 | 54.3 | CH | 0.39 | 9 | - | 0.15 | - | - | 0.82 | 45.1 |
| 5 | 3.00 | SPT | - | - | - | 2 | 9 | 43 | 46 | 57 | 31 | 26 | - | - | - | CH | - | - | - | - | 8 | - | - | - |
| 6 | 4.50 | SPT | - | - | - | 2 | 10 | 71 | 17 | 51 | 36 | 15 | - | - | - | MH | - | - | - | - | 2 | - | - | - |
| 7 | 5.50 | UDS | 1.70 | 35.70 | 2.64 | 2 | 79 | 15 | 4 | NP | NP | NP | - | - | - | SM | - | 25 | - | - | - | - | 1.11 | 52.6 |
| 8 | 6.00 | SPT | - | - | - | 1 | 8 | 76 | 15 | 50 | 39 | 11 | - | - | - | MH | - | - | - | - | 10 | - | - | - |
| 9 | 7.50 | SPT | - | - | - | 0 | 9 | 72 | 19 | 55 | 41 | 14 | - | - | - | MH | - | - | - | - | 8 | - | - | - |
| 10 | 8.50 | UDS | 1.76 | 22.06 | 2.66 | 0 | 16 | 79 | 5 | 50 | 42 | 8 | - | - | - | MH | - | 28 | - | - | - | - | 0.84 | 45.7 |
| 11 | 9.00 | SPT | - | - | - | 1 | 83 | 13 | 3 | NP | NP | NP | - | - | - | SM | - | - | - | - | 15 | - | - | - |
| 12 | 10.50 | SPT | - | - | - | 0 | 82 | 14 | 4 | NP | NP | NP | - | - | - | SM | - | - | - | - | 19 | - | - | - |
| 13 | 11.50 | DS | - | - | - | 1 | 82 | 13 | 4 | NP | NP | NP | - | - | - | SM | - | - | - | - | - | - | - | - |
| 14 | 12.00 | SPT | - | - | - | 0 | 83 | 14 | 3 | NP | NP | NP | - | - | - | SM | - | - | - | - | 22 | - | - | - |
| 15 | 13.50 | SPT | - | - | - | 1 | 80 | 15 | 4 | NP | NP | NP | - | - | - | SM | - | - | - | - | 28 | - | - | - |
| 16 | 14.50 | DS | - | - | - | 2 | 79 | 15 | 4 | NP | NP | NP | - | - | - | SM | - | - | - | - | - | - | - | - |
| 17 | 15.00 | SPT | - | - | - | 0 | 82 | 15 | 3 | NP | NP | NP | - | - | - | SM | - | - | - | - | 41 | - | - | - |
| 18 | 16.50 | SPT | - | - | - | 4 | 82 | 12 | 2 | 21 | NP | NP | - | - | - | SM | - | - | - | - | 59 | - | - | - |
| 19 | 17.50 | DS | - | - | - | 4 | 82 | 12 | 2 | 20 | NP | NP | - | - | - | SM | - | - | - | - | - | - | - | - |
| 20 | 18.00 | SPT | - | - | - | 1 | 33 | 34 | 32 | 40 | 29 | 11 | - | - | - | Cl | - | - | - | - | > 100 | - | - | - |
| 21 | 20.00 | SPT | - | - | - | 4 | 78 | 14 | 4 | 24 | NP | NP | - | - | - | SM | - | - | - | - | 94 | - | - | - |

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### RESULTS OF LABORATORY TEST

Project :- Proposed structures of plant of Additional gas processing facilities project (Phase 4 ) of ONGC at Hazira, Surat, L & T Ltd

BH No. :- 5

| Sr No | Depth m | Type of Sample | Field Density gm / cc | Natural Moisture Content % | Specific Gravity | Grain Size Analysis | | | | Consistancy limits | | | | Liquefaction Susceptibility | | Classification of Soil | Shear Parameter | | Unconfined Compressive Strength Kg/cm² | Cohesion Kg/cm² | Standard Penetration Value | Relative Density | Dry Density gm/cc | Porosity % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | Plasticity Index % | Shrinkage Limit % | Liquefaction Susceptibility | Settlement Factor Kg/cm² | | C Kg/cm² | ϕ Degree | | | | | | |
| 1 | 0.00 | DS | - | - | - | Filled up Clay of high plasticity with debris and gravels | | | | | | | | | | | | | | | - | - | | |
| 2 | 1.50 | SPT | - | - | - | 1 | 13 | 42 | 44 | 59 | 30 | 29 | - | - | - | CH | - | - | - | - | 16 | - | - | - |
| 3 | 2.50 | UDS | 1.71 | 23.24 | 2.65 | 0 | 10 | 44 | 46 | 58 | 29 | 29 | 7 | 0.22 | 46.3 | CH | 0.46 | 12 | - | 0.08 | - | - | 0.91 | 47.6 |
| 4 | 3.00 | SPT | - | - | - | 1 | 13 | 43 | 43 | 55 | 26 | 29 | - | - | - | CH | - | - | - | - | 4 | - | - | - |
| 5 | 4.50 | SPT | - | - | - | 0 | 86 | 12 | 2 | NP | NP | NP | - | - | - | SM | - | - | - | - | 6 | - | - | - |
| 6 | 5.50 | UDS | 1.76 | 31.54 | 2.64 | 2 | 84 | 12 | 2 | NP | NP | NP | - | - | - | SM | - | 26 | - | - | - | - | 0.97 | 49.3 |
| 7 | 6.00 | SPT | - | - | - | 0 | 14 | 50 | 36 | 53 | 40 | 13 | - | - | - | MH | - | - | - | - | 9 | - | - | - |
| 8 | 7.50 | SPT | - | - | - | 6 | 79 | 12 | 3 | NP | NP | NP | - | - | - | SM | - | - | - | - | 27 | - | - | - |
| 9 | 8.50 | UDS | 1.95 | 28.43 | 2.65 | 6 | 79 | 12 | 3 | NP | NP | NP | - | - | - | SM | - | 32 | - | - | - | - | 0.75 | 42.7 |
| 10 | 9.00 | SPT | - | - | - | 6 | 77 | 15 | 2 | NP | NP | NP | - | - | - | SM | - | - | - | - | 30 | - | - | - |
| 11 | 10.50 | SPT | - | - | - | 4 | 78 | 15 | 3 | NP | NP | NP | - | - | - | SM | - | - | - | - | 23 | - | - | - |
| 12 | 11.50 | DS | - | - | - | 5 | 78 | 14 | 3 | NP | NP | NP | - | - | - | SM | - | - | - | - | - | - | - | - |
| 13 | 12.00 | SPT | - | - | - | 3 | 81 | 13 | 3 | NP | NP | NP | - | - | - | SM | - | - | - | - | 45 | - | - | - |
| 14 | 13.50 | SPT | - | - | - | 3 | 83 | 12 | 2 | NP | NP | NP | - | - | - | SM | - | - | - | - | 39 | - | - | - |
| 15 | 14.50 | DS | - | - | - | 6 | 80 | 12 | 2 | NP | NP | NP | - | - | - | SM | - | - | - | - | - | - | - | - |
| 16 | 15.00 | SPT | - | - | - | 0 | 56 | 24 | 20 | 24 | 15 | 9 | - | - | - | SC | - | - | - | - | 38 | - | - | - |
| 17 | 16.50 | SPT | - | - | - | 2 | 83 | 12 | 3 | NP | NP | NP | - | - | - | SM | - | - | - | - | 80 | - | - | - |
| 18 | 17.50 | DS | - | - | - | 0 | 85 | 12 | 3 | NP | NP | NP | - | - | - | SM | - | - | - | - | - | - | - | - |
| 19 | 18.00 | SPT | - | - | - | 0 | 83 | 15 | 2 | NP | NP | NP | - | - | - | SM | - | - | - | - | 92 | - | - | - |
| 20 | 19.50 | SPT | - | - | - | 0 | 30 | 38 | 32 | 35 | 30 | 5 | - | - | - | MI | - | - | - | - | 77 | - | - | - |
| 21 | 20.50 | DS | - | - | - | 7 | 76 | 14 | 3 | NP | NP | NP | - | - | - | SM | - | - | - | - | - | - | - | - |
| 22 | 21.00 | SPT | - | - | - | 3 | 28 | 37 | 32 | 36 | 30 | 6 | - | - | - | MI | - | - | - | - | 83 | - | - | - |
| 23 | 22.50 | SPT | - | - | - | 16 | 19 | 32 | 33 | 38 | 32 | 6 | - | - | - | MI | - | - | - | - | 91 | - | - | - |
| 24 | 23.50 | UDS | 2.26 | 23.51 | 2.65 | 12 | 25 | 30 | 33 | 36 | 29 | 7 | - | - | - | MI | 0.10 | 36 | - | - | - | - | 0.45 | 31.0 |
| 25 | 25.00 | SPT | - | - | - | 15 | 25 | 30 | 30 | 36 | 31 | 5 | - | - | - | MI | - | - | - | - | > 100 | - | - | - |

# KCT Consultancy Services, Ahmedabad

## RESULTS OF LABORATORY TEST

Project :- Proposed structures of plant of Additional gas processing facilities project (Phase 4 ) of ONGC at Hazira, Surat, L & T Ltd

BH No. :- 6

| Sr No | Depth m | Type of Sample | Field Density gm / cc | Natural Moisture Content % | Grain Size Analysis | | | | Consistancy limits | | | | Shear Parameter | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | C Kg/cm² | ϕ Degree | | | | | | |
| 1 | 0.00 | DS | - | - | - | Filled up Clay of high plasticity with debris and gravels | | | | | | | | | | | | - | - | - |
| 2 | 1.50 | SPT | - | - | - | 0 | 25 | 39 | 36 | 56 | 27 | 29 | 7 | - | 61.3 | CI | - | - | - | 18 | - | - | - |
| 3 | 2.50 | UDS | 1.70 | 23.40 | 2.65 | 0 | 24 | 37 | 39 | 54 | 26 | 28 | 8 | 0.21 | 52.4 | CH | 0.24 | 2 | - | 0.19 | - | - | 0.92 | 48.0 |
| 4 | 3.00 | SPT | - | - | - | 1 | 19 | 43 | 37 | 51 | 26 | 25 | - | - | - | CH | - | - | - | - | 4 | - | - | - |
| 5 | 4.50 | SPT | - | - | - | 1 | 86 | 10 | 3 | NP | NP | NP | - | - | - | SM | - | - | - | - | 6 | - | - | - |
| 6 | 5.50 | DS | - | - | - | 0 | 16 | 64 | 20 | 52 | 39 | 13 | - | - | - | MH | - | - | - | - | - | - | - | - |
| 7 | 6.00 | SPT | - | - | - | 1 | 18 | 67 | 14 | 54 | 40 | 14 | - | - | - | MH | - | - | - | - | 4 | - | - | - |
| 8 | 7.50 | SPT | - | - | - | 0 | 82 | 14 | 4 | NP | NP | NP | - | - | - | SM | - | - | - | - | 12 | - | - | - |
| 9 | 8.50 | UDS | 1.78 | 29.34 | 2.67 | 1 | 82 | 14 | 3 | NP | NP | NP | - | - | - | SM | - | 28 | - | - | - | - | 0.94 | 48.5 |
| 10 | 9.00 | SPT | - | - | - | 13 | 71 | 12 | 4 | NP | NP | NP | - | - | - | SM | - | - | - | - | 20 | - | - | - |
| 11 | 10.50 | SPT | - | - | - | 12 | 69 | 15 | 4 | NP | NP | NP | - | - | - | SM | - | - | - | - | 33 | - | - | - |
| 12 | 11.50 | DS | - | - | - | 1 | 87 | 10 | 2 | NP | NP | NP | - | - | - | SM | - | - | - | - | - | - | - | - |
| 13 | 12.00 | SPT | - | - | - | 1 | 83 | 13 | 3 | NP | NP | NP | - | - | - | SM | - | - | - | - | 42 | - | - | - |
| 14 | 13.50 | SPT | - | - | - | 2 | 85 | 10 | 3 | NP | NP | NP | - | - | - | SM | - | - | - | - | 44 | - | - | - |
| 15 | 14.50 | DS | - | - | - | 56 | 22 | 16 | 6 | NP | NP | NP | - | - | - | GM | - | - | - | - | - | - | - | - |
| 16 | 15.00 | SPT | - | - | - | 0 | 85 | 12 | 3 | NP | NP | NP | - | - | - | SM | - | - | - | - | 48 | - | - | - |
| 17 | 16.50 | SPT | - | - | - | 1 | 57 | 24 | 18 | 21 | 13 | 8 | - | - | - | SC | - | - | - | - | 52 | - | - | - |
| 18 | 17.50 | UDS | 1.99 | 21.34 | 2.66 | 2 | 21 | 38 | 39 | 55 | 27 | 28 | - | - | - | CH | 0.41 | 18 | - | 0.11 | - | - | 0.62 | 38.3 |
| 19 | 18.00 | SPT | - | - | - | 1 | 26 | 36 | 37 | 51 | 22 | 29 | - | - | - | CH | - | - | - | - | 51 | - | - | - |
| 20 | 20.00 | SPT | - | - | - | 0 | 25 | 39 | 36 | 56 | 28 | 28 | - | - | - | CH | - | - | - | - | 72 | - | - | - |

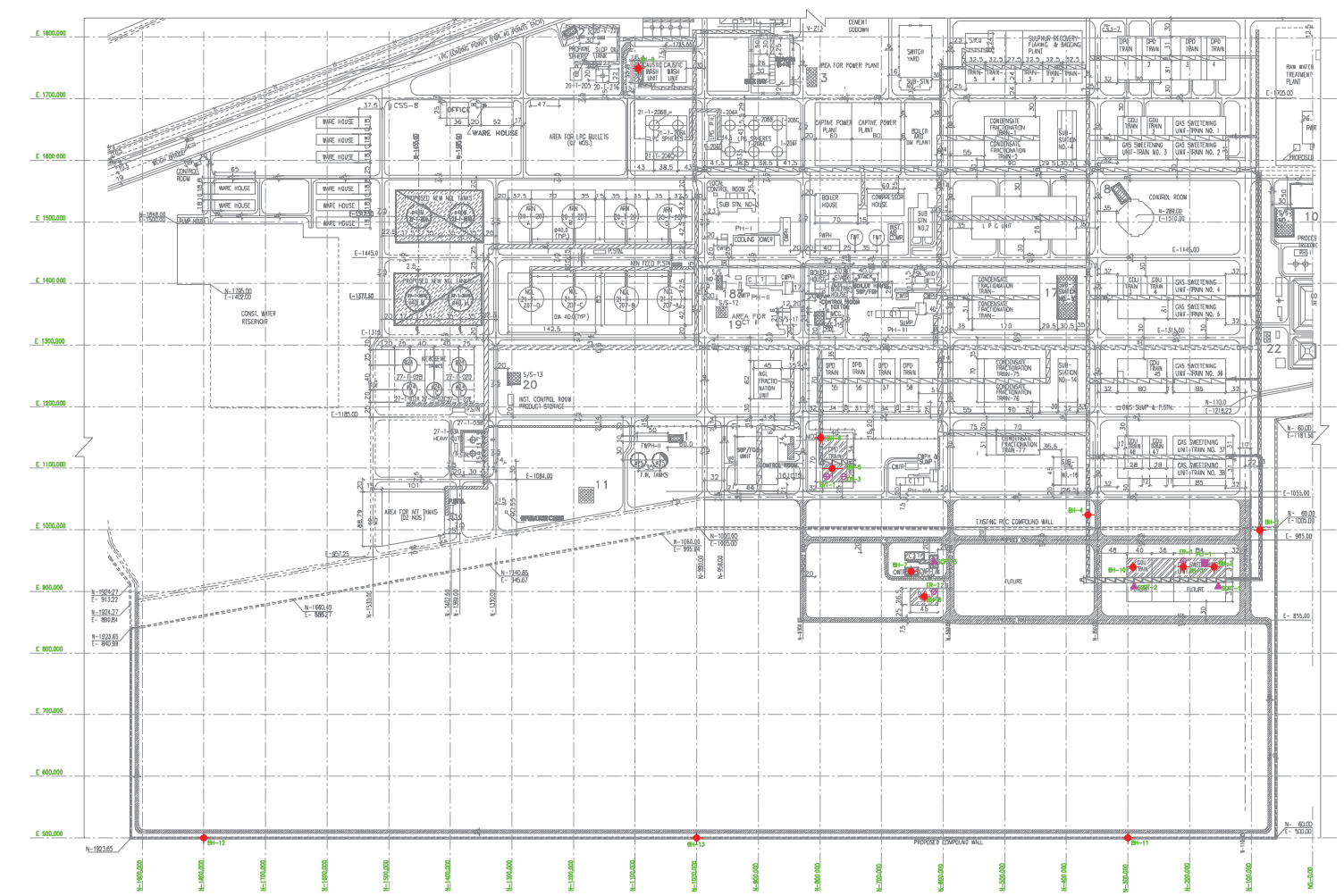
11-06-2012

# KCT Consultancy Services, Ahmedabad

## RESULTS OF LABORATORY TEST

Project :- Proposed structures of plant of Additional gas processing facilities project (Phase 4 ) of ONGC at Hazira, Surat, L & T Ltd
BH No. :- 9

| Sr No | Depth | Type of Sample | Field Density | Natural Moisture Content | | Grain Size Analysis | | | | Consistancy limits | | | | | | | Shear Parameter | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | gm / cc | % | | % | % | % | % | % | % | % | % | Kg/cm² | % | | C Kg/cm² | ϕ Degree | | | | | | |
| 1 | 0.00 | DS | - | - | - | Filled up Clayey Sand with debris and gravels | | | | | | | | | | | | | | | - | | | |
| 2 | 1.50 | SPT | - | - | - | 0 | 22 | 38 | 40 | 57 | 30 | 27 | - | - | - | CI | - | - | - | - | 15 | - | - | - |
| 3 | 2.50 | UDS | 1.76 | 26.57 | 2.64 | 0 | 12 | 48 | 40 | 54 | 27 | 27 | 7 | 0.28 | 53.1 | CH | 0.38 | 13 | - | 0.17 | - | - | 0.90 | 47.3 |
| 4 | 3.00 | SPT | - | - | - | 2 | 15 | 45 | 38 | 58 | 29 | 29 | - | - | - | CH | - | - | - | - | 8 | - | - | - |
| 5 | 4.50 | SPT | - | - | - | 0 | 82 | 15 | 3 | NP | NP | NP | - | - | - | SM | - | - | - | - | 13 | - | - | - |
| 6 | 5.50 | UDS | 1.86 | 31.05 | 2.63 | 2 | 81 | 13 | 4 | NP | NP | NP | - | - | - | SM | - | 29 | - | - | - | - | 0.85 | 46.0 |
| 7 | 6.00 | SPT | - | - | - | 2 | 86 | 10 | 2 | NP | NP | NP | - | - | - | SM | - | - | - | - | 21 | - | - | - |
| 8 | 7.50 | SPT | - | - | - | 2 | 79 | 15 | 4 | NP | NP | NP | - | - | - | SM | - | - | - | - | 24 | - | - | - |
| 9 | 8.50 | UDS | 1.95 | 24.61 | 2.64 | 2 | 82 | 12 | 4 | NP | NP | NP | - | - | - | SM | - | 33 | - | - | - | - | 0.69 | 40.7 |
| 10 | 9.00 | SPT | - | - | - | 2 | 80 | 14 | 4 | NP | NP | NP | - | - | - | SM | - | - | - | - | 28 | - | - | - |
| 11 | 10.50 | SPT | - | - | - | 16 | 67 | 13 | 4 | 21 | NP | NP | - | - | - | SM | - | - | - | - | 32 | - | - | - |
| 12 | 11.50 | DS | - | - | - | 5 | 77 | 14 | 4 | NP | NP | NP | - | - | - | SM | - | - | - | - | - | - | - | - |
| 13 | 12.00 | SPT | - | - | - | 3 | 84 | 10 | 3 | NP | NP | NP | - | - | - | SM | - | - | - | - | 44 | - | - | - |
| 14 | 13.50 | SPT | - | - | - | 5 | 77 | 15 | 3 | NP | NP | NP | - | - | - | SM | - | - | - | - | 43 | - | - | - |
| 15 | 14.50 | DS | - | - | - | 15 | 68 | 13 | 4 | NP | NP | NP | - | - | - | SM | - | - | - | - | - | - | - | - |
| 16 | 15.00 | SPT | - | - | - | 58 | 20 | 16 | 6 | NP | NP | NP | - | - | - | GM | - | - | - | - | 54 | - | - | - |
| 17 | 16.50 | SPT | - | - | - | 56 | 19 | 19 | 6 | NP | NP | NP | - | - | - | GM | - | - | - | - | 64 | - | - | - |
| 18 | 17.50 | DS | - | - | - | 16 | 42 | 22 | 20 | 29 | 20 | 9 | - | - | - | SC | - | - | - | - | - | - | - | - |
| 19 | 18.00 | SPT | - | - | - | 13 | 23 | 31 | 33 | 36 | 30 | 6 | - | - | - | MI | - | - | - | - | 59 | - | - | - |
| 20 | 20.00 | SPT | - | - | - | 2 | 25 | 40 | 33 | 38 | 32 | 6 | - | - | - | MI | - | - | - | - | 94 | - | - | - |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COMPRESSOR HOUSE
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DPD TRAIN
CWPH-I
CWPH-II
CWPH-III
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PROCESS CONDENSATE SURGE TANK
PROPANE SLOP OIL SPHERE TANK
PUBLIC SPHERE
WASTE CAUSTIC WASH UNIT
WASH UNIT
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KCT Consultancy Services, Ahmedabad

Project : L & T , HAZIRA

Bore Hole No. : 4 — Date of commencement: 07-02-10

Co-ordinates: N-365, E-1025 — Date of Completion: 07-07-10

Reduced Level: 98.466m

Depth of Termination : 20.0 m — Diameter of Bore : 150 mm

Depth of Water Table : Encountered at m depth during investigation

BORE LOG DATA SHEET

| Method of Boring | Depth m | Casing | Notation | Soil Description | Depth of Sample m | Drill Run From m | Drill Run To m | Type of Sample | SPT N Value/Penetration of S.S.S $N_1$ | $N_2$ | $N_3$ | N | Core Recovery (%) | RQD (%) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rotary Drilling by mud circulation | 0.00 | Not Used | | | 0.00 | 0.00 | 0.50 | DS | - | - | - | - | - | - | |
| | 0.50 | | | | 0.50 | 0.50 | 1.50 | SPT | 6 | 9 | 10 | 19 | - | - | |
| | 1.00 | | | Dark brownish, fine to very fine grained, silty clays of high plasticity with occational gravels (CH) | | | | | | | | | | | |
| | 1.50 | | | | 1.50 | 1.50 | 2.50 | SPT | 5 | 6 | 10 | 16 | - | - | |
| | 2.00 | | | | | | | | | | | | | | |
| | 2.50 | | | | 2.50 | 2.50 | 3.00 | UDS | - | - | - | - | - | - | |
| | 3.00 | | | 0.00 to 3.50 m | 3.00 | 3.00 | 4.50 | SPT | 2 | 3 | 5 | 8 | - | - | |
| | 3.50 | | | | | | | | | | | | | | |
| | 4.00 | | | Blackish grey, fine to very fine grained, silt of high compressibility with occational gravels (MH) 3.50 to 5.15m | | | | | | | | | | | |
| | 4.50 | | | | 4.50 | 4.50 | 5.50 | SPT | 1 | 1 | 1 | 2 | - | - | |
| | 5.00 | | | | | | | | | | | | | | |
| | 5.50 | | | Blackish grey, fine to very fine grained, silty sand with occational gravels (SM) 5.15 to 6.70 m | 5.50 | 5.50 | 6.00 | UDS | - | - | - | - | - | - | |
| | 6.00 | | | | 6.00 | 6.00 | 7.50 | SPT | 2 | 4 | 6 | 10 | - | - | |
| | 6.50 | | | | | | | | | | | | | | |
| | 7.00 | | | Blackish, fine to very fine grained, silt of high compressibility with occational gravels (MH) | | | | | | | | | | | |
| | 7.50 | | | | 7.50 | 7.50 | 8.50 | SPT | 2 | 3 | 5 | 8 | - | - | |
| | 8.00 | | | 6.70 to 8.70 m | | | | | | | | | | | |
| | 8.50 | | | | 8.50 | 8.50 | 9.00 | UDS | - | - | - | - | - | - | |
| | 9.00 | | | | 9.00 | 9.00 | 10.50 | SPT | 5 | 5 | 10 | 15 | - | - | |
| | 9.50 | | | | | | | | | | | | | | |
| | 10.00 | | | Blackish, fine to medium grained, silty sand with occational gravels (SM) | | | | | | | | | | | |
| | 10.50 | | | | 10.50 | 10.50 | 11.50 | SPT | 6 | 8 | 11 | 19 | - | - | |
| | 11.00 | | | | | | | | | | | | | | |
| | 11.50 | | | | 11.50 | 11.50 | 12.00 | DS | - | - | - | - | - | - | |
| | 12.00 | | | 8.70 to 12.60 m | 12.00 | 12.00 | 13.50 | SPT | 7 | 9 | 13 | 22 | - | - | |
| | 12.50 | | | | | | | | | | | | | | |
| | 13.00 | | | | | | | | | | | | | | |
| | 13.50 | | | | 13.50 | 13.50 | 14.50 | SPT | 12 | 13 | 15 | 28 | - | - | |
| | 14.00 | | | Blackish, fine to medium grained, silty sand with occational gravels (SM) | | | | | | | | | | | |
| | 14.50 | | | | 14.50 | 14.50 | 15.00 | DS | - | - | - | - | - | - | |
| | 15.00 | | | | 15.00 | 15.00 | 16.50 | SPT | 17 | 20 | 21 | 41 | - | - | |
| | 15.50 | | | | | | | | | | | | | | |
| | 16.00 | | | 12.60 to 16.00 m | | | | | | | | | | | |
| | 16.50 | | | Dark brownish, fine to medium grained, silty sand with little plastic fines and little gravels (SM) 16.00 to 17.90 m | 16.50 | 16.50 | 17.50 | SPT | 13 | 21 | 38 | 59 | - | - | |
| | 17.00 | | | | | | | | | | | | | | |
| | 17.50 | | | | 17.50 | 17.50 | 18.00 | DS | - | - | - | - | - | - | |
| | 18.00 | | | Dark brown,fine to very fine grained, sandy clays of intermediate plasticity with occational gravels (CI) 17.90 to 19.60 m | 18.00 | 18.00 | 20.00 | SPT | 42 | 52 10cm | - | >100 | - | - | |
| | 18.50 | | | | | | | | | | | | | | |
| | 19.00 | | | | | | | | | | | | | | |
| | 19.50 | | | Reddish brown, fine to coarse grained, silty sand with little plastic fines and litttel gravels (SM) | | | | | | | | | | | |
| | 20.00 | | | | 20.00 | 20.00 | 20.45 | SPT | 33 | 42 | 52 | 94 | - | - | |
| | | | | 19.60 to 20.00 m | | | | | | | | | | | |

KCT Consultancy Services, Ahmedabad

Project : L & T , HAZIRA

Bore Hole No. : 5 — Date of commencement: 15/7/2010

Co-ordinates: N-780, E-1100 — Date of Completion: 19/7/2010

Reduced Level: 99.423m

Depth of Termination : 25.0 m — Diameter of Bore : 150 mm

Depth of Water Table : Encountered at 3.40m depth during investigation

BORE LOG DATA SHEET

| Method of Boring | Depth m | Casing | Notation | Soil Description | Depth of Sample m | Drill Run From m | Drill Run To m | Type of Sample | SPT N Value/Penetration of S.S.S $N_1$ | $N_2$ | $N_3$ | N | Core Recovery (%) | RQD (%) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rotary Drilling by mud circulation | 0.00 | Not Used | | Dark brownish, fine to medium grained, filled up clayey sand with debries 0.00 to 0.70 m | 0.00 | 0.00 | 1.50 | DS | - | - | - | - | - | - | |
| | 0.50 | | | | | | | | | | | | | | |
| | 1.00 | | | Dark brownish, fine to very fine grained, silty clays of high plasticity with occational gravels and occational fine sand (CH) 0.70 to 2.20 m | | | | | | | | | | | |
| | 1.50 | | | | 1.50 | 1.50 | 2.50 | SPT | 4 | 7 | 9 | 16 | - | - | |
| | 2.00 | | | | | | | | | | | | | | |
| | 2.50 | | | Dark brownish, fine to very fine grained, silty clays of high plasticity with occational gravels (CH) 2.20 to 3.70 m | 2.50 | 2.50 | 3.00 | UDS | - | - | - | - | - | - | |
| | 3.00 | | | | 3.00 | 3.00 | 4.50 | SPT | 1 | 2 | 2 | 4 | - | - | |
| | 3.50 | | | | | | | | | | | | | | |
| | 4.00 | | | Blackish brown, fine to very fine grained, silty sand with occational gravels (SM) | | | | | | | | | | | |
| | 4.50 | | | | 4.50 | 4.50 | 5.50 | SPT | 2 | 3 | 3 | 6 | - | - | |
| | 5.00 | | | | | | | | | | | | | | |
| | 5.50 | | | 3.70 to 6.00 m | 5.50 | 5.50 | 6.00 | UDS | - | - | - | - | - | - | |
| | 6.00 | | | Blackish grey, fine to very fine grained, silt of high compressibility with occational gravels (MH) 6.00 to 7.25 m | 6.00 | 6.00 | 7.50 | SPT | 4 | 4 | 5 | 9 | - | - | |
| | 6.50 | | | | | | | | | | | | | | |
| | 7.00 | | | | | | | | | | | | | | |
| | 7.50 | | | | 7.50 | 7.50 | 8.50 | SPT | 7 | 12 | 15 | 27 | - | - | |
| | 8.00 | | | | | | | | | | | | | | |
| | 8.50 | | | | 8.50 | 8.50 | 9.00 | UDS | - | - | - | - | - | - | |
| | 9.00 | | | | 9.00 | 9.00 | 10.50 | SPT | 10 | 14 | 16 | 30 | - | - | |
| | 9.50 | | | | | | | | | | | | | | |
| | 10.00 | | | Blackish grey, fine to medium grained, sislty sand with little gravels (SM) | | | | | | | | | | | |
| | 10.50 | | | | 10.50 | 10.50 | 11.50 | SPT | 9 | 11 | 12 | 23 | - | - | |
| | 11.00 | | | | | | | | | | | | | | |
| | 11.50 | | | | 11.50 | 11.50 | 12.00 | DS | - | - | - | - | - | - | |
| | 12.00 | | | | 12.00 | 12.00 | 13.50 | SPT | 18 | 20 | 25 | 45 | - | - | |
| | 12.50 | | | | | | | | | | | | | | |
| | 13.00 | | | | | | | | | | | | | | |
| | 13.50 | | | | 13.50 | 13.50 | 14.50 | SPT | 11 | 17 | 22 | 39 | - | - | |
| | 14.00 | | | 7.25 to 14.95 m | | | | | | | | | | | |
| | 14.50 | | | Blackish grey, fine to coarse grained, clayey sand (SC) 14.95 to 15.30 m | 14.50 | 14.50 | 15.00 | DS | - | - | - | - | - | - | |
| | 15.00 | | | | 15.00 | 15.00 | 16.50 | SPT | 10 | 18 | 20 | 38 | - | - | |
| | 15.50 | | | | | | | | | | | | | | |
| | 16.00 | | | | | | | | | | | | | | |
| | 16.50 | | | Blackish grey, fine to very fine grained, silty sand with occational gravels (SM) | 16.50 | 16.50 | 17.50 | SPT | 20 | 35 | 45 | 80 | - | - | |
| | 17.00 | | | | | | | | | | | | | | |
| | 17.50 | | | | 17.50 | 17.50 | 18.00 | DS | - | - | - | - | - | - | |
| | 18.00 | | | | 18.00 | 18.00 | 19.50 | SPT | 21 | 40 | 52 | 92 | - | - | |
| | 18.50 | | | 15.30 to 19.20 m | | | | | | | | | | | |
| | 19.00 | | | | | | | | | | | | | | |
| | 19.50 | | | Dark brownish, fine to very fine grained, silt of intermediate compressibility with occational gravels(MI) 19.20 to 20.50 m | 19.50 | 19.50 | 20.50 | SPT | 18 | 32 | 45 | 77 | - | - | |
| | 20.00 | | | | | | | | | | | | | | |
| | 20.50 | | | Dark brownish, fine to coarse grained, silty sand with some gravels (SM) 20.50 to 21.00 m | 20.50 | 20.50 | 21.00 | DS | - | - | - | - | - | - | |
| | 21.00 | | | Dark brownish, fine to medium grained, silt of intermediate compressibility with little gravels (MI) 21.00 to 22.10 m | 21.00 | 21.00 | 22.50 | SPT | 20 | 35 | 48 | 83 | - | - | |
| | 21.50 | | | | | | | | | | | | | | |
| | 22.00 | | | | | | | | | | | | | | |
| | 22.50 | | | | 22.50 | 22.50 | 23.50 | SPT | 23 | 41 | 50 | 91 | - | - | |
| | 23.00 | | | | | | | | | | | | | | |
| | 23.50 | | | Dark brownish, fine to coarse grained, silt of intermediate compressibility with much gravels (MI) | 23.50 | 23.50 | 25.00 | UDS | - | - | - | - | - | - | |
| | 24.00 | | | | | | | | | | | | | | |
| | 24.50 | | | | | | | | | | | | | | |
| | 25.00 | | | | 25.00 | 25.00 | 25.50 | SPT | 20 | 65 | 40 | >100 | - | - | |
| | | | | 22.10 to 25.00 m | | | | | | | | | 5cm | | |

KCT Consultancy Services, Ahmedabad

Project : L & T , HAZIRA

Bore Hole No. : 6 — Date of commencement: 19/7/2010

Co-ordinates: N-799, E-1170 — Date of Completion: 20/7/2010

Reduced Level: 99.620m

Depth of Termination : 20.0 m — Diameter of Bore : 150 mm

Depth of Water Table : Encountered at 3.60m depth during investigation

BORE LOG DATA SHEET

| Method of Boring | Depth m | Casing | Notation | Soil Description | Depth of Sample m | Drill Run From m | Drill Run To m | Type of Sample | SPT N Value/Penetration of S.S.S $N_1$ | $N_2$ | $N_3$ | N | Core Recovery (%) | RQD (%) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rotary Drilling by mud circulation | 0.00 | Not Used | | Blackish brown, fine to very fine grained, filled up silty clays of high plasticity with occational gravels and some fine sand with debries 0.00 to 0.65 m | 0.00 | 0.00 | 1.50 | DS | - | - | - | - | - | - | |
| | 0.50 | | | | | | | | | | | | | | |
| | 1.00 | | | | | | | | | | | | | | |
| | 1.50 | | | Blackish brown, fine to very fine grained, silty clays of high plasticity with occational gravels and some fine sand (CH) | 1.50 | 1.50 | 2.50 | SPT | 5 | 8 | 10 | 18 | - | - | |
| | 2.00 | | | | | | | | | | | | | | |
| | 2.50 | | | | 2.50 | 2.50 | 3.00 | UDS | - | - | - | - | - | - | |
| | 3.00 | | | 0.65 to 3.60 m | 3.00 | 3.00 | 4.50 | SPT | 1 | 2 | 2 | 4 | - | - | |
| | 3.50 | | | | | | | | | | | | | | |
| | 4.00 | | | Blackish brown, fine to very fine grained, silty sand with occational gravels (SM) 3.60 to 5.20 m | | | | | | | | | | | |
| | 4.50 | | | | 4.50 | 4.50 | 5.50 | SPT | 2 | 3 | 3 | 6 | - | - | |
| | 5.00 | | | | | | | | | | | | | | |
| | 5.50 | | | Blackish, fine to very fine grained, silt of high compressibility with occational gravels(MH) 5.20 to 6.60 m | 5.50 | 5.50 | 6.00 | DS | - | - | - | - | - | - | |
| | 6.00 | | | | 6.00 | 6.00 | 7.50 | SPT | 2 | 2 | 2 | 4 | - | - | |
| | 6.50 | | | | | | | | | | | | | | |
| | 7.00 | | | Blackish, fine to very fine grained, silty sand with occational gravels(SM) 6.60 to 8.90m | | | | | | | | | | | |
| | 7.50 | | | | 7.50 | 7.50 | 8.50 | SPT | 4 | 5 | 7 | 12 | - | - | |
| | 8.00 | | | | | | | | | | | | | | |
| | 8.50 | | | | 8.50 | 8.50 | 9.00 | UDS | - | - | - | - | - | - | |
| | 9.00 | | | | 9.00 | 9.00 | 10.50 | SPT | 7 | 9 | 11 | 20 | - | - | |
| | 9.50 | | | Blackish, fine to very fine grained, silty sand with much gravels(SM) 8.90 to 10.70 m | | | | | | | | | | | |
| | 10.00 | | | | | | | | | | | | | | |
| | 10.50 | | | | 10.50 | 10.50 | 11.50 | SPT | 10 | 15 | 18 | 33 | - | - | |
| | 11.00 | | | | | | | | | | | | | | |
| | 11.50 | | | Blackish, fine to very fine grained, silty sand with occational gravels(SM) 10.70 to 12.60 m | 11.50 | 11.50 | 12.00 | DS | - | - | - | - | - | - | |
| | 12.00 | | | | 12.00 | 12.00 | 13.50 | SPT | 12 | 19 | 23 | 42 | - | - | |
| | 12.50 | | | Dark brownish with whitish grey coarse sand, fine to coarse grained, silty sand with some gravels (SM) 12.60 to 14.00 m | | | | | | | | | | | |
| | 13.00 | | | | | | | | | | | | | | |
| | 13.50 | | | | 13.50 | 13.50 | 14.50 | SPT | 12 | 20 | 24 | 44 | - | - | |
| | 14.00 | | | Brownish, coarse grained, silty gravels (GM) 14.00 to 14.80 m | | | | | | | | | | | |
| | 14.50 | | | | 14.50 | 14.50 | 15.00 | DS | - | - | - | - | - | - | |
| | 15.00 | | | Brownish grey, fine to very fine grained, silty sand with occational gravels (SM) 14.80 to 15.50 m | 15.00 | 15.00 | 16.50 | SPT | 15 | 22 | 26 | 48 | - | - | |
| | 15.50 | | | Brownish grey, fine to very fine grained, clayey sand with little plastic fines and occational gravels (SC) 15.50 to 17.45 m | | | | | | | | | | | |
| | 16.00 | | | | | | | | | | | | | | |
| | 16.50 | | | | 16.50 | 16.50 | 17.50 | SPT | 17 | 24 | 28 | 52 | - | - | |
| | 17.00 | | | | | | | | | | | | | | |
| | 17.50 | | | | 17.50 | 17.50 | 18.00 | UDS | - | - | - | - | - | - | |
| | 18.00 | | | | 18.00 | 18.00 | 20.00 | SPT | 15 | 21 | 30 | 51 | - | - | |
| | 18.50 | | | Dark brownish, fine to very fine grained, silty clays of high plasticity with occational gravels(CH) | | | | | | | | | | | |
| | 19.00 | | | | | | | | | | | | | | |
| | 19.50 | | | | | | | | | | | | | | |
| | 20.00 | | | | 20.00 | 20.00 | 20.45 | SPT | 23 | 32 | 40 | 72 | - | - | |

17.45 to 20.00 m

KCT Consultancy Services, Ahmedabad

Project : L & T , HAZIRA

Bore Hole No. : 9 — Date of commencement: 07-12-10

Co-ordinates: N-1095, E-1750 — Date of Completion: 13/7/2010

Reduced Level: 99.232m

Depth of Termination : 20.0 m — Diameter of Bore : 150 mm

Depth of Water Table : Encountered at 3.50m depth during investigation

BORE LOG DATA SHEET

| Method of Boring | Depth m | Casing | Notation | Soil Description | Depth of Sample m | Drill Run From m | Drill Run To m | Type of Sample | SPT N Value/Penetration of S.S.S $N_1$ | $N_2$ | $N_3$ | N | Core Recovery (%) | RQD (%) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rotary Drilling by mud circulation | 0.00 | Not Used | | Blackish, fine to very fine grained, filled up clayey sand with debries 0.00 to 0.70 m | 0.00 | 0.00 | 1.50 | DS | - | - | - | - | - | - | |
| | 0.50 | | | | | | | | | | | | | | |
| | 1.00 | | | | | | | | | | | | | | |
| | 1.50 | | | Blackish, fine to very fine grained, silty clays of high plasticity with occational gravels (CH) 0.70 to 3.45 m | 1.50 | 1.50 | 2.50 | SPT | 4 | 7 | 8 | 15 | - | - | |
| | 2.00 | | | | | | | | | | | | | | |
| | 2.50 | | | | 2.50 | 2.50 | 3.00 | UDS | - | - | - | - | - | - | |
| | 3.00 | | | | 3.00 | 3.00 | 4.50 | SPT | 5 | 3 | 5 | 8 | - | - | |
| | 3.50 | | | | | | | | | | | | | | |
| | 4.00 | | | Backish, fine to very fine grained, silty sand with occational gravels (SM) 3.45 to 5.95 m | | | | | | | | | | | |
| | 4.50 | | | | 4.50 | 4.50 | 5.50 | SPT | 4 | 6 | 7 | 13 | - | - | |
| | 5.00 | | | | | | | | | | | | | | |
| | 5.50 | | | | 5.50 | 5.50 | 6.00 | UDS | - | - | - | - | - | - | |
| | 6.00 | | | | 6.00 | 6.00 | 7.50 | SPT | 7 | 9 | 12 | 21 | - | - | |
| | 6.50 | | | | | | | | | | | | | | |
| | 7.00 | | | | | | | | | | | | | | |
| | 7.50 | | | Blackish brown, fine to very fine grained, silty sand with occational gravels (SM) | 7.50 | 7.50 | 8.50 | SPT | 6 | 10 | 14 | 24 | - | - | |
| | 8.00 | | | | | | | | | | | | | | |
| | 8.50 | | | | 8.50 | 8.50 | 9.00 | UDS | - | - | - | - | - | - | |
| | 9.00 | | | | 9.00 | 9.00 | 10.50 | SPT | 5 | 14 | 14 | 28 | - | - | |
| | 9.50 | | | | | | | | | | | | | | |
| | 10.00 | | | 5.95 to 10.50 m | | | | | | | | | | | |
| | 10.50 | | | Blackish brown, fine to coarse grained, silty sand with little plastic fines and much gravels (SM) 10.50 to 11.35 m | 10.50 | 10.50 | 11.50 | SPT | 8 | 15 | 17 | 32 | - | - | |
| | 11.00 | | | | | | | | | | | | | | |
| | 11.50 | | | | 11.50 | 11.50 | 12.00 | DS | - | - | - | - | - | - | |
| | 12.00 | | | Blackish brown, fine to medium grained, silty sand with little gravels (SM) | 12.00 | 12.00 | 13.50 | SPT | 10 | 18 | 22 | 44 | - | - | |
| | 12.50 | | | | | | | | | | | | | | |
| | 13.00 | | | | | | | | | | | | | | |
| | 13.50 | | | 11.35 to 14.10 m | 13.50 | 13.50 | 14.50 | SPT | 11 | 18 | 25 | 43 | - | - | |
| | 14.00 | | | Dark brownish and slightly blackish, fine to coarse grained, silty sand with much gravels (SM) 14.10 to 15.00 m | | | | | | | | | | | |
| | 14.50 | | | | 14.50 | 14.50 | 15.00 | DS | - | - | - | - | - | - | |
| | 15.00 | | | | 15.00 | 15.00 | 16.50 | SPT | 15 | 24 | 30 | 54 | - | - | |
| | 15.50 | | | Blackish, coarse grained, silty gravels (GM) | | | | | | | | | | | |
| | 16.00 | | | | | | | | | | | | | | |
| | 16.50 | | | 15.00 to 17.05 m | 16.50 | 16.50 | 17.50 | SPT | 18 | 30 | 34 | 64 | - | - | |
| | 17.00 | | | Brownish, fine to coarse grained, clayey sand with much gravels (SC) 17.05 to 18.00 m | | | | | | | | | | | |
| | 17.50 | | | | 17.50 | 17.50 | 18.00 | DS | - | - | - | - | - | - | |
| | 18.00 | | | | 18.00 | 18.00 | 20.00 | SPT | 15 | 26 | 33 | 59 | - | - | |
| | 18.50 | | | Dark brownish, fine to medium grained, silt of intermediate compressibility with occational gravels (MI) | | | | | | | | | | | |
| | 19.00 | | | | | | | | | | | | | | |
| | 19.50 | | | | | | | | | | | | | | |
| | 20.00 | | | | 20.00 | 20.00 | 20.45 | SPT | 16 | 46 | 48 | 94 | - | - | |
| | | | | 18.00 to 20.00 m | | | | | | | | | | | |

# Results of Block Vibration Test

**(As per IS : 5249, 1992, reaffirmed 1995)**

Project :Proposed structures of plant of Additional gas processing facilities project (Phase 4 ) of ONGC at Hazira, Surat, L & T Ltd

| | |
|---|---|
| Test No. | 1 (N 789, E 1087 ) |

**Data**

| | |
|---|---|
| Size of the block | = 0.75 m wide, 1.00 m long and 0.75 m deep |
| Depth of Conducting test | = 2.50 m from EGL |
| Base Area of the Block (A1) | = 0.75 sq. m |
| Mass of the block | = 1406.25 kg |
| Mass of the vibrator | = 37.0 kg |
| Total vibrating mass (M) | = Mass of block + mass of vibrator =1443.25 kg |
| Acceleration due to gravity (g) | = 9.81 m/sec$^2$ |

**Terminology**

| | | |
|---|---|---|
| $C_u$ - | Coefficient of elastic uniform compression in kg / cm$^3$ | |
| $C_\tau$ - | Coefficient of elastic uniform shear in kg / cm$^3$ | = 0.50 X Cu |
| $C_\phi$ - | Coefficient of elastic non uniform compression in kg / cm$^3$ | = 1.73 X Cu |
| $C_\psi$ - | Coefficient of elastic non uniform shear in kg / cm$^3$ | = 0.75 X Cu |

The above coefficients are reported for foundation contact area, A of 10.0 m$^2$ (1,00,000 cm$^2$) or more

| | |
|---|---|
| $C_{u1}$ - | Coefficient of elastic uniform compression in kg / cm$^3$ for block of size 0.75m wide, 1.00m long and 0.75m deep= Cu / $\sqrt{A1 / A}$ <br> = { 4 X $\pi^2$ X $f_{nz}^2$ X M / (A1 X g)} X $10^{-6}$ kg / cm$^3$ |
| G - | Modulus of rigidity of strata in Kg / cm$^2$, G = Cu X $\sqrt{}$ A X (1 - $\mu$ ) / 2.13 |
| $\mu$ - | Poisson's ratio = 0.4 for this particular situation |
| E - | Modulus of elasticity of strata in kg / cm$^2$ = G X 2 X (1 + $\mu$) |
| $f_{nz}$ - | Resonance frequency of foundation block – soil system in cycles / sec |
| $\epsilon$ - | Damping coefficient |

## Calculations

From chart between amp v/s. freq $f_{nz}$ = 21.6 cycles / sec and $\epsilon$ = 0.09

Coefficient of Elastic uniform compression

Cu1 = {4 * $\pi^2$*$21.6^2$*1443.25 / (0.75 * 9.81)} * $10^{-6}$ = 3.61 kg/cu.cm

Cu = 3.61 * $\sqrt{}$ 0.75/10.0 = 0.99 kg/cu.cm

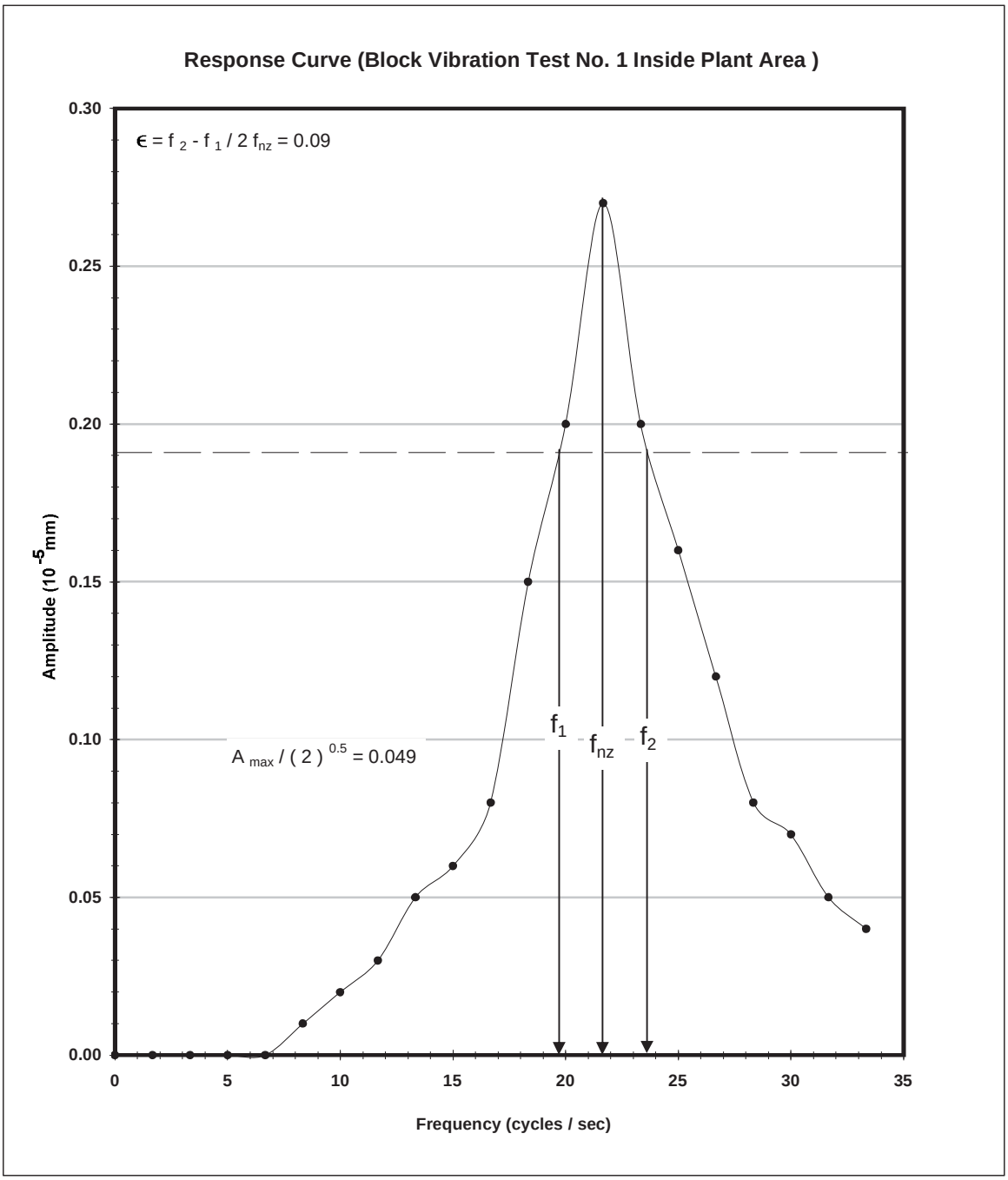
Coefficient of elastic uniform shear $C_\tau$ = 0.5*0.99 = 0.49 kg/cu.cm

Coefficient of elastic non–uniform compression $C_\phi$ = 1.73*0.99 = 1.71 kg/cu.cm

Coefficient of elastic non – uniform shear $C\psi$= 0.75*0.99 = 0.74 kg/cu.cm

Modulus of rigidity of strata G = 0.99 * $\sqrt{}$ 100000* (1.0 – 0.40) / 2.13 = 88.2 kg/sq.cm

Modulus of elasticity of strata E= 88.2* 2 * (1 + 0.40) = 246.9 kg/sq. cm




| | | | |
|---|---|---|---|
| Amax = | 0.270 | damping coefficient | 0.09 |
| A max / sqrt ( 2 ) = | 0.191 | | |
| f 1 = | 19.7 | | |
| f 2 = | 23.7 | | |
| f nz = | 21.6 | | |

11-06-2012

KCT Consultancy Services

# RESULTS OF ELECTRICAL RESISTIVITY

( IS : 3043, 1987 )

ERT No. : 3

Name of Project : Proposed structures of plant of Additional gas processing facilities project (Phase4) of ONGC at Hazira, Surat, L&T Ltd (Inside Plant area)

Battery Condition : Good

Climatic Condition : Humid and moderately hot

Resistivity at given depth $\rho = 2 \pi S R$

Where

$\rho$ = Resistivity in ohm - m ( $\Omega$ m )

$\pi$ = Value of pi - 22 / 7

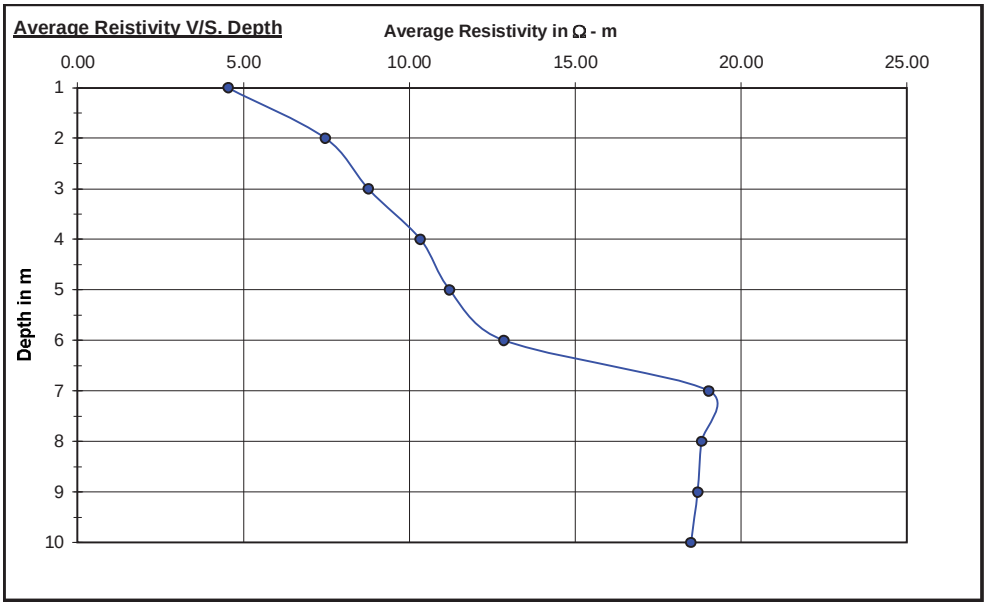
S = Electrode Spacing ( equal to the depth at which resistivity is determined ) in m

R = V / I in ohm ( $\Omega$ )

V = Voltage Drop between inner electrodes in Volt

I = Current applied in outer electrodes in Amp.

| Spacing of Electrode in ( m ) | Direction | | | | Average Resistivity ( $\Omega$ - m ) |
|---|---|---|---|---|---|
| | N - S | | E - W | | |
| | Resistence Observed in $\Omega$ | Resistivity $\rho$ in $\Omega$ m | Resistence Observed in $\Omega$ | Resistivity $\rho$ in $\Omega$ m | |
| 1 | 0.99 | 6.22 | 0.83 | 5.22 | 4.54 |
| 2 | 0.88 | 11.06 | 0.63 | 7.92 | 7.47 |
| 3 | 0.68 | 12.82 | 0.50 | 9.42 | 8.77 |
| 4 | 0.59 | 14.83 | 0.45 | 11.31 | 10.33 |
| 5 | 0.50 | 15.71 | 0.40 | 12.57 | 11.21 |
| 6 | 0.48 | 18.10 | 0.38 | 14.33 | 12.85 |
| 7 | 0.98 | 43.10 | 0.30 | 13.19 | 19.03 |
| 8 | 0.88 | 44.23 | 0.25 | 12.57 | 18.81 |
| 9 | 0.78 | 44.11 | 0.22 | 12.44 | 18.69 |
| 10 | 0.68 | 42.73 | 0.20 | 12.57 | 18.49 |




**( K K Thaker )** **(  )**

11-06-2012

| | | |
|---|---|---|
| LARSEN & TOUBRO LIMITED<br>E&C DIVISION | GEOTECHNICAL INVESTIGATION REPORT – INSIDE AREA | **DOCUMENT NO.**<br>A067-LT-00-CV-04-RP-0004 |
| **PROJECT : Additional Gas Processing Facilities (Phase-IV)** | | **REVISION : 01** |
| **CUSTOMER : ONGC,HAZIRA** | | |

# Annexure II

## *RECORD NOTES OF ENGINEERING MEETING*

ONGC-AGPF at Hazira, Engineering Kick-off Meeting at EIL Baroda on 03-04 June 2010

The following points for Geotechnical Investigation were discussed and agreed up on:

A. Geotechnical Field Survey
   a. Block Vibration Test shall be carried out as per IS:5249 (latest revision). Vertical vibration test, horizontal resonance and shear wave measurement to be carried out at field to generate dynamic soil parameters
   b. Specification does not specify the minimum/required nos. Of laboratory testing on samples collected from boreholes. A guideline for minimum laboratory testing for each borehole on samples collected from boreholes is given in Cl. 2.2.2.5 Doc. No. 6962-00-50-48-SOW-01 to be followed.
B. Geotechnical Scheme Drawing No D-5014-ONGC(AGPF)-CE-GC-0001, Rev 00
   a. Relocate BH-10, BH-3 to centre line of unit to get fair idea of subsoil of the whole unit area. BH-01 to shift to E:1000 (approx) to cover soil of entire piperack along N-alignment
   b. BH-10 and BH-02 borehole depth to be 25.0m as per tender requirement
   c. Shift BH-6 from DPDU to offsite piperack to cover soil of piperack area. Depth of BH-5 to be 25.0m as per tender requirement
   d. Depth of BVT shall be decided as per field soil data of nearby BH-5 ( approx depth of compressor foundation).
   e. Field CBR not suitable considering presence of expansive soil in this plant area. Instead of field CBR, Laboratory CBR on borrow soil shall be carried out. CBR tests shall be on soaked and unsoaked samples compacting 95% maximum lab dry density as per IS:2721 Part VIII.
   f. One borehole of similar depth as proposed for boundary wall to be added for boundary wall to cover soil of entire stretch of boundary wall.

M/S L & T proposed to proceed Geotechnical Investigation immediately with incorporation of above points. M/S EIL agreed to it.

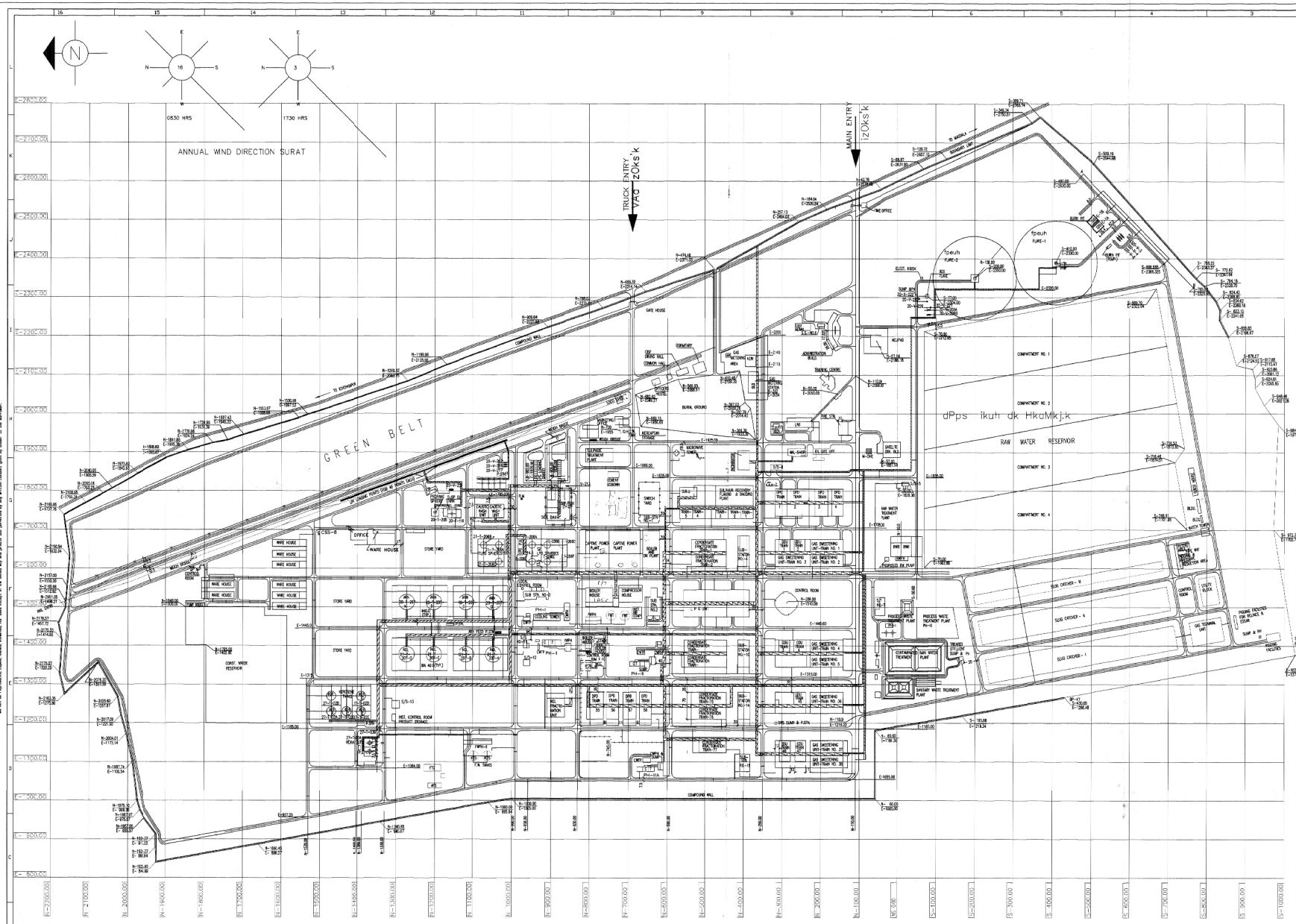
M/s EIL

(S. DEBNATH)

04/06/2010

M/s L&T

(SUBHATOSH NANDI)




| REFERENCE DRAWING | NO |
|---|---|
| | |

NOTES :-

1. ALL DIMENSIONS, CO-ORDINATES, & LEVELS ARE IN METRE.
2. LEVEL 100.00 CORRESPONDES TO 8.0 M OF ABOVE MEAN SEA LEVEL.
3. RACKS/TRACKS/SLEEPERS REQUIRED AS PER PIPING/ELECT./INST. WHICH ARE NOT SHOWN IN THE DRAWING SHALL BE DETAILED AS PER JOB REQUIREMENT.

LEGEND:-

- FTG, AFS
- PROPOSED MODEL OCCUPATIONAL HEALTH CENTER
- PHASE-II
- PHASE-III & KRU
- PHASE-IIIA
- THERMAX BOILER
- GMS
- EXISTING FACILITIES

EXISTING PLANT CAPACITY

| UNIT | PHASE | NO. OF TRAINS | TRAIN CAPACITY | UNIT CAPACITY | TOTAL CAP. |
|---|---|---|---|---|---|
| CDU | PHASE-I | 2 +1 | 5.84 MMTPA | 11.68 MMTPA | |
| | PHASE-II | 1 | 5.84 MMTPA | 11.68 MMTPA | |
| | PHASE-III | 1 | 5.84 MMTPA | 5.84 MMTPA | |
| | PHASE-IIIA | 1 | 6.38 MMTPA | 12.80 MMTPA | 36.8 MMTPA |
| VDU | PHASE-I | 2 +1 | 4.38 MMTPA | 8.76 MMTPA | |
| | PHASE-II | 1 | 5.79 MMTPA | 11.61 MMTPA | |
| | PHASE-III | 1 | 5.79 MMTPA | 5.79 MMTPA | |
| | PHASE-IIIA | 1 | 6.38 MMTPA | 12.80 MMTPA | 36.4 MMTPA |
| DHDT | PHASE-I | 2 +1 | 4.75 MMTPA | 9.50 MMTPA | |
| | PHASE-II | 1 | 5.79 MMTPA | 11.61 MMTPA | |
| | PHASE-III | 1 | 5.79 MMTPA | 11.61 MMTPA | |
| SRU | PHASE-I | 2 +1 | 700 TPD | 1400 TPD | |
| | PHASE-II | 1 | 700 TPD | 1400 TPD | |
| | PHASE-III | 1 | 700 TPD | 1400 TPD | 3500 TPD |
| CPU | PHASE-I | 2 +1 | 51.5 T/Hr | 103 T/Hr | |
| | PHASE-II | 1 | 51.5 T/Hr | 103 T/Hr | |
| | PHASE-III | 1 | 51.5 T/Hr | 103 T/Hr | |
| | PHASE-IIIA | 1 | 51.5 T/Hr | 103 T/Hr | 309.5 T/Hr |

SCHEDULE OF TANKS AND SPHERES

| S.NO. | EQUIPMENT NO. | NO. | PRODUCT | TYPE OF ROOF | DIA (M) | HEIGHT (M) | CAPACITY (CU.M.) | CLASS | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| 1. | T-306 A/B/C/D/E/F | 6 | NTA | FIXED CONE | 17.00 | | | | |
| 2. | T-307 A/B/C/D | 4 | NTA | FIXED CONE | 16.00 | | | | |
| 3. | T-308 | 1 | NTA | FIXED CONE | 16.00 | | | | |
| 4. | T-1-319 A/B/C/D | 4 | PG | DOME | 16.00 | | | | |
| 5. | T-1-317 A/B/C/D | 4 | PG | FX. TANK | 16.00 | | | | |
| 6. | T-1-321 A/B/C/D/E/F | 6 | TOLUENE | | 20.00 | | | | |
| 7. | 27-T-01 A/B | 2 | HEAVY GSN | | 20.00 | | | | |

| | |
|---|---|
| ENGINEERS INDIA LIMITED | (A Govt. of India Undertaking) |
| OIL & NATURAL GAS CORPORATION LIMITED | |

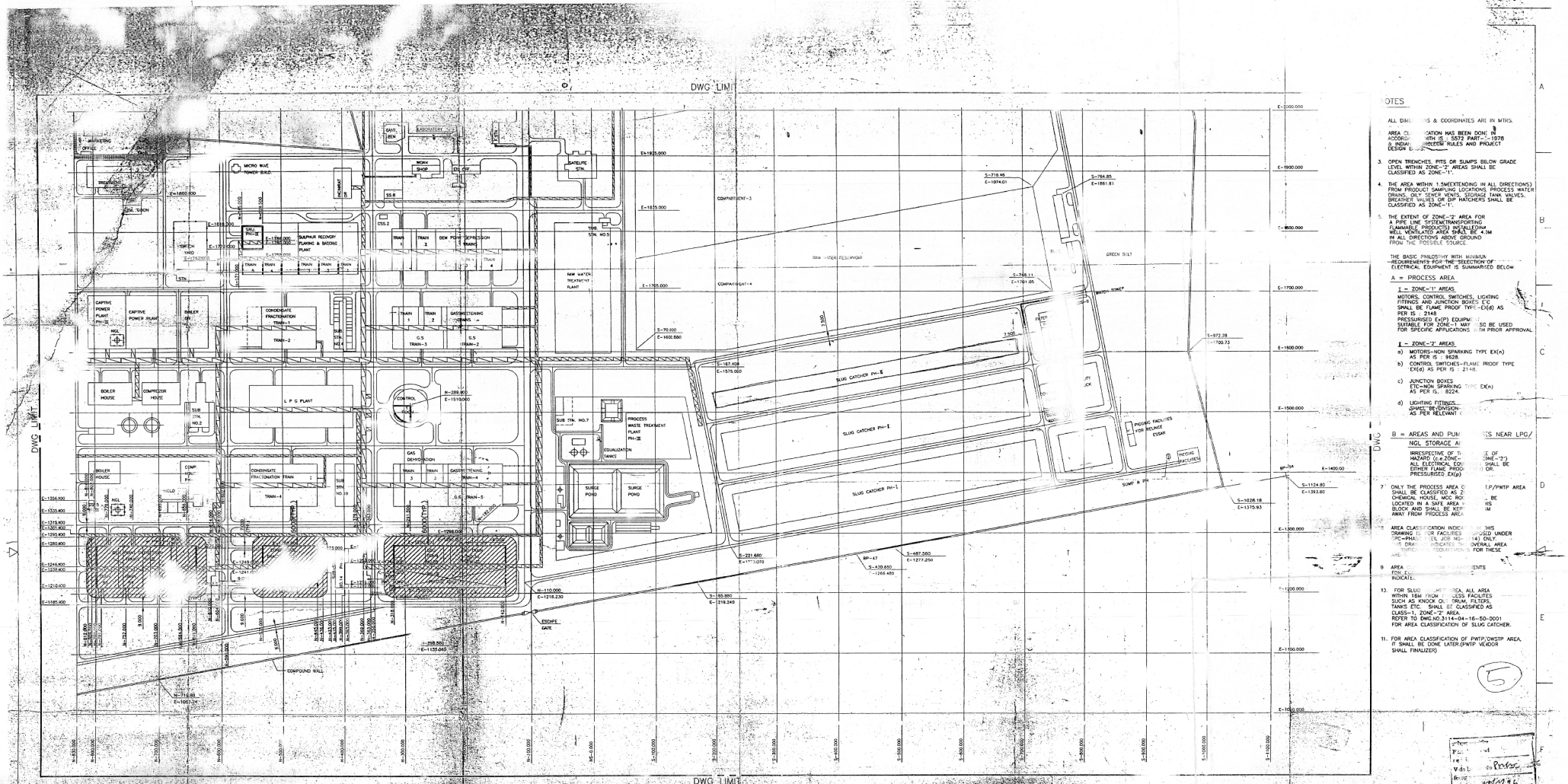
GSP-PH-II,PH-III & KRU,PH-III A,THERMEX BOILER,GMS

OVER ALL PLOT PLAN

| MICRO FILM | PROJ ENGR | MICRO FILM REF No. | SCALE | JOB NO. | UNIT | DEPT. SECTN. | DWG. No. | REV. |
|---|---|---|---|---|---|---|---|---|
| REQUIRED / NOT REQ | | | 1:3333 | 4427 | 00 | 1647 | 0001 | F1 |

EIL-501 A0-1189X841 DISTRIBUTION CODE

:g wk[k wkS] blkeaq fn;k x;k vfHkdrh bathtu;kx bathtuk ¼vkSdM dh Lkaf/kr gS½ :i esa m/kkj fn, x, gSa wkS] m/kkjdrkZ us ;g i{V Lkeks/kuk rqjar gh ns nh mldqa iqjh eafnjr fdlh Hkh ;kstuk esa ;g izfrca/k lfEefyr gksxk wkS] ;g izfrca/k mldh vkSj ls ykxw bafdr dh yxkus ds ckn gh gVk;k tk ldsxk u m/kkj fn, tkus ds ckn ;g izfrca/k ykxw jgsxk wkS] ;g izfrca/k m/kkj fn, tkus ds ckn ;g izfrca/k ykxw jgsxk ;fn m/kkjdrkZ dksbZ jkf'k nsus esa vlQy jgrk gS rks




NOTES

ALL DIMENSIONS & COORDINATES ARE IN MTRS.

AREA CLASSIFICATION HAS BEEN DONE IN ACCORDANCE WITH IS : 5572 PART-I-1978 & INDIAN PETROLEUM RULES AND PROJECT DESIGN BASIS.

3. OPEN TRENCHES, PITS OR SUMPS BELOW GRADE LEVEL WITHIN ZONE-"2" AREAS SHALL BE CLASSIFIED AS ZONE-"1".

4. THE AREA WITHIN 1.5M(EXTENDING IN ALL DIRECTIONS) FROM PRODUCT SAMPLING LOCATIONS, PROCESS WATER DRAINS, OILY SEWER VENTS, STORAGE TANK VALVES, BREATHER VALVES OR DIP HATCHERS SHALL BE CLASSIFIED AS ZONE-"1".

5. THE EXTENT OF ZONE-"2" AREA FOR A PIPE LINE SYSTEM(TRANSPORTING FLAMMABLE PRODUCTS) INSTALLED IN A WELL VENTILATED AREA SHALL BE 4.5M IN ALL DIRECTIONS ABOVE GROUND FROM THE POSSIBLE SOURCE.

THE BASIC PHILOSOPHY WITH MINIMUM REQUIREMENTS FOR THE SELECTION OF ELECTRICAL EQUIPMENT IS SUMMARISED BELOW

A = PROCESS AREA

I = ZONE-"1" AREAS

MOTORS, CONTROL SWITCHES, LIGHTING FITTINGS AND JUNCTION BOXES ETC SHALL BE FLAME PROOF TYPE-Ex(d) AS PER IS : 2148.
PRESSURISED Ex(P) EQUIPMENT SUITABLE FOR ZONE-1 MAY ALSO BE USED FOR SPECIFIC APPLICATIONS WITH PRIOR APPROVAL.

II - ZONE-"2" AREAS

a) MOTORS-NON SPARKING TYPE Ex(n) AS PER IS : 9628.

b) CONTROL SWITCHES-FLAME PROOF TYPE Ex(d) AS PER IS : 2148.

c) JUNCTION BOXES ETC-NON SPARKING TYPE Ex(n) AS PER IS : 8224.

d) LIGHTING FITTINGS SHALL BE DIVISION-II AS PER RELEVANT I.S.

B = AREAS AND PUMP HOUSES NEAR LPG/NGL STORAGE AREA

IRRESPECTIVE OF THE TYPE OF HAZARD (i.e ZONE-"1" OR ZONE-"2") ALL ELECTRICAL EQUIPMENTS SHALL BE EITHER FLAME PROOF TYPE OR PRESSURISED Ex(p)

7. ONLY THE PROCESS AREA OF LPG/PWTP AREA SHALL BE CLASSIFIED AS ZONE-"2". CHEMICAL HOUSE, MCC ROOM SHALL BE LOCATED IN A SAFE AREA WITHIN THIS BLOCK AND SHALL BE KEPT AWAY FROM PROCESS AREA.

8. AREA CLASSIFICATION INDICATED IN THIS DRAWING IS FOR FACILITIES ENGINEERED UNDER EPC-PHASE-III (JOB NO. 3114) ONLY. THIS DRAWING INDICATES THE OVERALL AREA CLASSIFICATION FOR THESE FACILITIES.

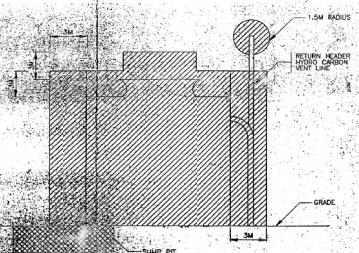
9. AREA CLASSIFICATION FOR EXISTING FACILITIES SHALL BE AS PER EARLIER DRAWINGS INDICATED.

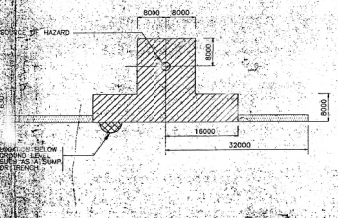
12. FOR SLUG CATCHER AREA, ALL AREA WITHIN 18M FROM THE PROCESS FACILITIES SUCH AS KNOCK OUT DRUM, FILTERS, TANKS ETC. SHALL BE CLASSIFIED AS CLASS-1, ZONE-"2" AREA. REFER TO DWG.NO.3114-04-16-50-0001 FOR AREA CLASSIFICATION OF SLUG CATCHER.

11. FOR AREA CLASSIFICATION OF PWTP/DWSTP AREA, IT SHALL BE DONE LATER.(PWTP VENDOR SHALL FINALIZER)

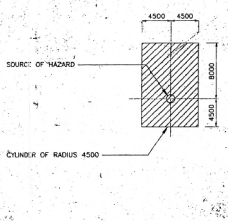
(5)

APPROVED FOR CONSTRUCTION




FREELY VENTILATED PROCESS AREA
(SOURCE OF HAZARD LOCATION ABOVE GROUND LEVEL)




FREELY VENTILATED PROCESS AREA
(ALTERNATE FOR AREAS HANDLING NATURAL GAS)

LEGEND

CLASS-1, ZONE-1, GAS GROUP IIA & IIB, TEMP. CL

CLASS-1, ZONE-2, GAS GROUP IIA & IIB, TEMP. CLASS-T3.

ADDITIONAL ZONE-2 HAZARDOUS AREA (IN CASE WHERE LARGE RELEASES OF VOLATILE PRODUCTS MAY OCCUR)

NON-HAZARDOUS AREA (SAFE AREA)

| NO. | REVISIONS | APP'D | APP'D | DATE | APP'D | DATE |
|---|---|---|---|---|---|---|
| | | | | | CLIENT | |
| 0 | A.F.C | | | | | |
| 1 | REVISED AS PER COMMENT (TRANSMITTAL NO. 6/8/94) | | | | | |
| 2 | REVISED AS PER COMMENT | B.K GHOSH | M.H LEE | 07/15 94 | | |
| 3 | FOR APPROVAL | B.K GHOSH | M.H LEE | 15/05 94 | | |

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OIL AND NATURAL GAS CORPORATION LTD.
HAZIRA PHASE III EXPANSION PROJECT

ENGINEERS INDIA LIMITED
NEW DELHI

PREPARED BY
DAELIM ENGINEERING CO. LTD.
SEOUL, KOREA

| | | |
|---|---|---|
| SCALE | 1/2200 | DATE |
| DRAWN BY | L.M.S | MAY.10.'94 |
| CHECKED BY | | |
| CHECKED BY | B.K. GHOSH | 05/12/94 |
| APPROVAL | M.H.LEE | 05/13/94 |
| APPROVAL | E.G LEE | 05/13/94 |
| CLIENT APPROVAL | | |

AREA CLASSIFICATION PLAN (OVERALL)

CONTRACT NO. 3114 | DWG. NO. 3114-00-16-50-0005 | REV.NO 0
JOB NO. 11319

RECEIVED BY HAND DELIVERY ON 07/07/2011

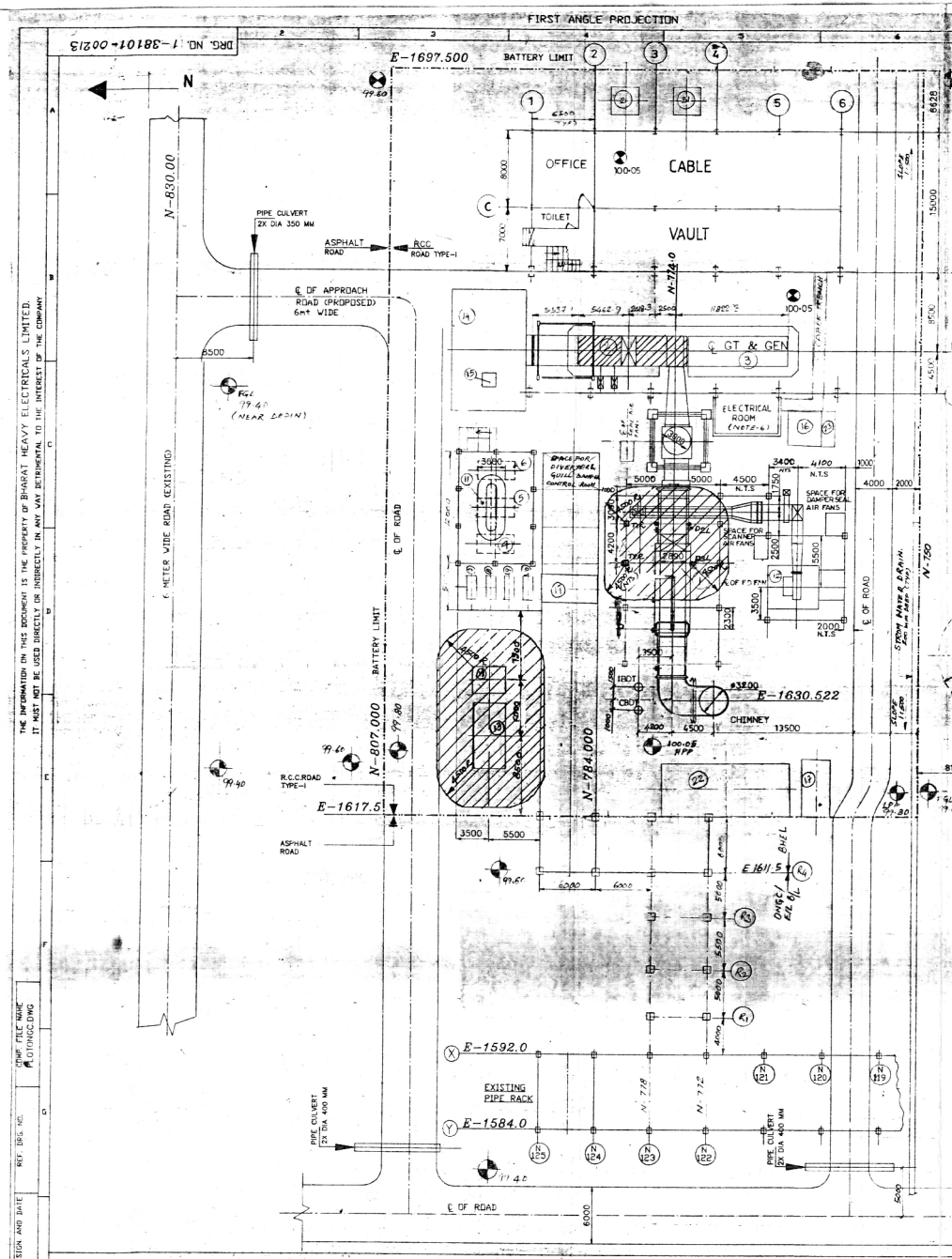
(2)

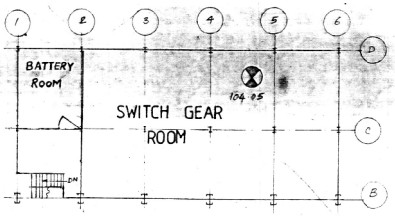
Phase-II

FIRST ANGLE PROJECTION

ALL DIMENSIONS ARE IN mm

DRG. NO. 1-38101-00213

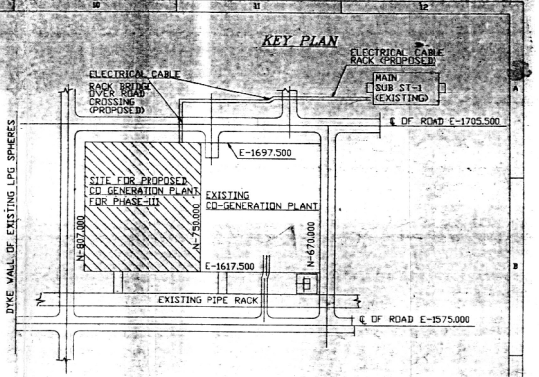



NOTES:-

1. ALL DIMENSIONS ARE IN mm AND ELEVATIONS & GRID COORDINATES IN METERS.
2. MINIMUM 4M CLEAR SPACE IS REQUIRED ALL ALONG THE LENGTH OF GT HALL AND ENTRANCE FOR TRUCK MOVEMENT DURING ERECTION AND MAINTENANCE.
3. FILTER OUTLINES ARE TYPICAL AND SHALL BE REVISED AFTER ORDER PLACEMENT AS PER VENDOR DRAWING.
4. RECOMMENDED CRANE CAPACITY 20/5 TONNES. HOOK ELEVATION 10.5 M ABOVE FINISHED FLOOR LEVEL OF GT-HALL. REMOVAL OF STATOR IS NOT CONSIDERED FOR MAINTENANCE
5. -FINISHED FLOOR LEVEL: 100.05 M -SURROUNDING GROUND LEVEL: 99.6 M -MACHINE BASE LINE: 100.45 M -CRANE HOOK: 110.55 M -HIGH PAVEMENT POINT: 100.05 ; LOW PAVEMENT POINT : 99.80
6. FOR DETAILS REFER ELECTRICAL ROOM LAYOUT DRG. NO. 2-38101-00103
7. ▨ REPRESENTS HAZARDOUS AREA AS PER NFPA CLASS I DIVISION 2 GROUP C AND D.

KEY PLAN




EQUIPMENT LIST

| ITEM NO | TAG NO | DESCRIPTION | SIZE IN mt | REMARKS |
|---|---|---|---|---|
| 1 | 26-X001 | BOILER | 22.0x22.0 | INCL. AUX. |
| 2. | 24-GT001 | GAS TURBINE | 4.11.8x3.3 | |
| 3 | 24-G001 | GENERATOR | 2.10/4x3.3 | |
| 4 | 24-P001 | BOILER FEED PUMP-1 | 4.0x2.0 | |
| 5 | 24-P002 | BOILER FEED PUMP-2 | 4.0x2.0 | |
| 6 | 24-P003 | BOILER FEED PUMP-3 | 4.0x2.0 | |
| 7 | 24-P004 | D.M. WATER PUMP-1 | 2.0x1.0 | |
| 8 | 24-P005 | D.M.WATER PUMP-2 | 2.0x1.0 | |
| 9 | 26-P006 | RETURN CONDENSATE PUMP-1 | 2.5x1.0 | |
| 10 | 26-P007 | RETURN CONDENSATE PUMP-2 | 2.5x1.0 | |
| 11 | 26-V001 | DEAERATOR | 7.0x3.0 | |
| 12 | 26-F001 | F.D.FAN | — | INCL IN SG BLDG |
| 13 | 26-T001 | FUEL GAS CONDITIONING SKID | 7.0x3.5 | |
| 14 | 26-TF001 | TURBINE INTAKE AIR FILTER | 13.0x8.0 | |
| 15 | 26-AP001 | AIR PROCESSING UNIT | 9.0x1.5 | |
| 16 | 26-BSCT | BLACK START COOLING TOWER | 3.5X3.5 | |
| 17 | 26-COM1 | COMPRESSOR WASH SKID | 6.0X3.0 | |
| 18 | 26-NGC | NG COND DRAIN DISPOSAL SYSTEM | 3.0x3.0 | |
| 19 | 26-DMW/CP | NOx CONTROL SKID | 6X2.375 | SECOND PIPE RACK |
| 20 | — | FIRE PROTECTION | 3.0x1.5 | |
| 21 | 26-TR 1 | TRANSFORMER | 3.5x3.5 | |
| 22 | | CHEMICAL DOSING ROOM | 13.5X5.7 | |
| 23 | 26-IMP | PUMP SAIL FOR COOLING TOWER | 2.5x1.0 | |
| 24 | | | | |
| 25 | | | | |
| 26 | | | | |
| 27 | | | | |

FINAL

10 15 20 25 30 mts

CONSULTANT: ENGINEERS INDIA LTD.
JOB NO: 3114

TYPE OF PRODUCT OR NAME OF CUSTOMER/PROJECT: ONGC HAZIRA - PH-III COGEN PLANT
OIL & NATURAL GAS CORP. LTD.

ADDITIONAL INFORMATION
STATUS OF DRAWING
DISTRIBUTION OF PRINTS

BHARAT HEAVY ELECTRICALS LTD HYDERABAD

| | NAME | SIGN. | DATE |
|---|---|---|---|
| DRN. | RLCS | — | — |
| CHD. | S.B.RAO | | 2.11.96 |
| APPD. | A.V.SAGAR | | 3.11.96 |

DEPT. PED | CODE 450 | UNTOL DIMESN CLASS | SCALE 1:250 | WEIGHT | REF. TO ASSY DRG. | ITEM NO. | NO OF ITEM

TITLE: HAZARDOUS AREA CLASSIFICATION DIAGRAM

CARD SIZE | DRAWING NO. 1-38101-002/3 | REV. 0

SHEET NO. 1 | NO OF SHEETS 1

| REV. | DATE | ALTERED / CHECKED |
|---|---|---|

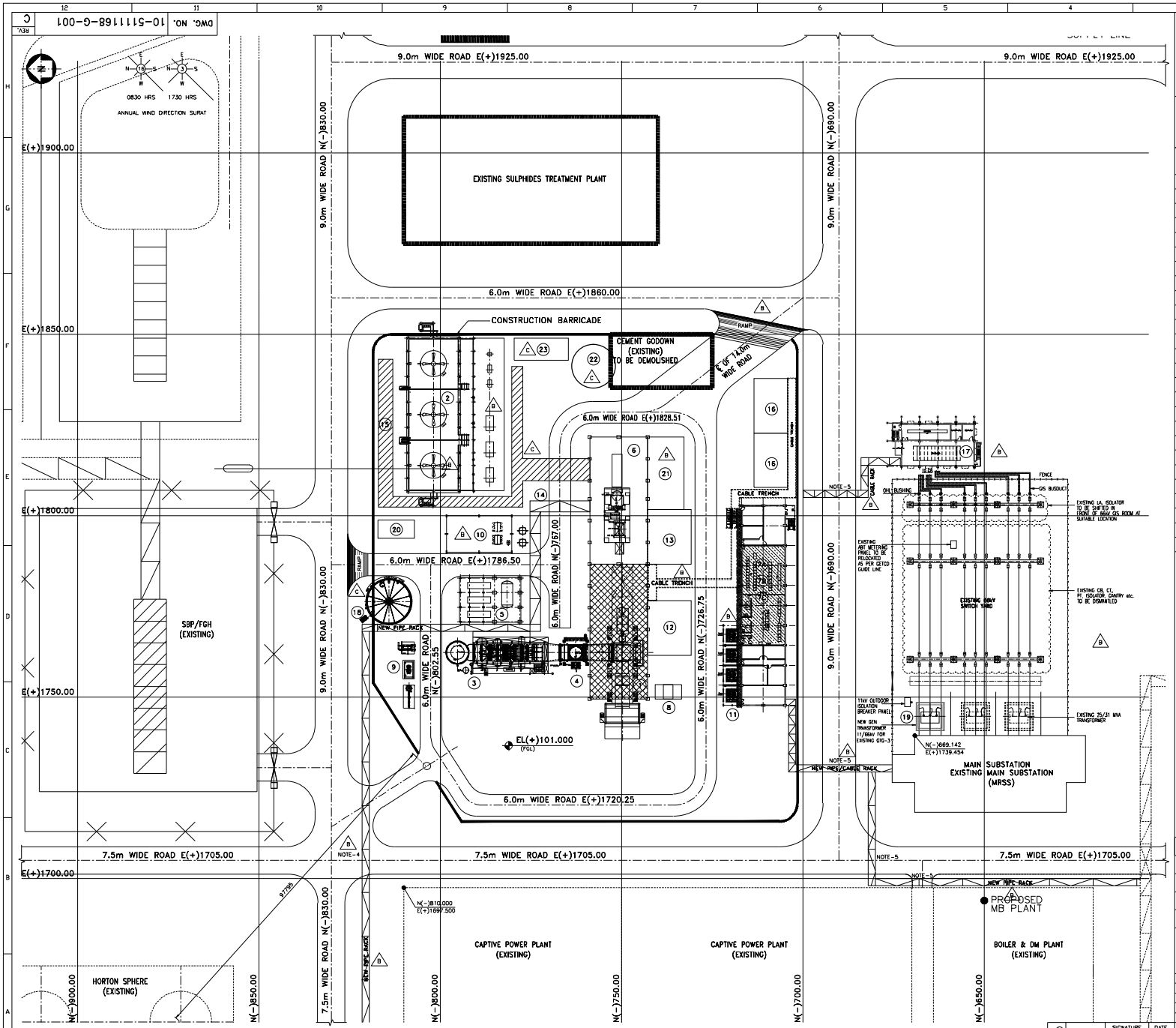
THE INFORMATION ON THIS DOCUMENT IS THE PROPERTY OF BHARAT HEAVY ELECTRICALS LIMITED. IT MUST NOT BE USED DIRECTLY OR INDIRECTLY IN ANY WAY DETRIMENTAL TO THE INTEREST OF THE COMPANY

DUMP FILE NAME: CLOTHING.DWG

REF. DRG. NO.

SIGN AND DATE

INVENTORY NO




NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETRES AND COORDINATES ARE IN METRES.
2. EL.99.7 REFER TO FINISHED GROUND LEVEL OF THIS AREA WHICH CORRESPONDS RL 6.00 FROM MSL & EL.101.20 REFER TO FGL OF PROPOSED POWER PLANT WHICH CORRESPONDS TO RL 7.50 FROM MSL.
3. EFFLUENTS TO BE ROUTED TO THE OWS SHALL BE TERMINATED AT THE NEAREST OWS DRAIN PIT.
4. PIPE RACK HEIGHT SHALL BE 11 M FOR CRANE MOVEMENT.
5. PIPE RACK HEIGHT SHALL BE 7.5 M FOR VEHICLE MOVEMENT. B

REFERENCE DRAWINGS:-

1. OVERALL PLOT PLAN — 4427-00-16-47-0001
2. SITE GRADING PLAN — 10-5111168-C-002

LIST OF MAJOR BUILDINGS / STRUCTURE :- B

| ITEM NO. | DESCRIPTION | DIMENSION (M) | NOS. |
|---|---|---|---|
| 1 | GAS TURBINE GENERATOR | 47 x 14 | 1 |
| 2 | COOLING TOWER & CT PUMP AREA | 50 x 27 | 1 |
| 3 | HEAT RECOVERY STEAM GENERATOR & MAIN STACK | 32 x 12 | 1 |
| 4 | BYPASS STACK | – | 1 |
| 5 | DEAERATOR & BFP PUMP AREA | 17 x14 | 1 |
| 6 | GTG / STG HALL | 72 x 16 | 1 |
| 7A | CABLE SPREADER ROOM | – | 1 |
| 7B | SWITCH GEAR ROOM | 55 x 12 | 1 |
| 7C | CONTROL ROOM | – | 1 |
| 8 | LOCAL CONTROL ROOM FOR GTG | 7 x 4 | 1 |
| 9 | FUEL GAS CONDITIONING SYSTEM | 19 x 5 | 1 |
| 10 | AIR COMPRESSOR & WORK SHOP | 18 x 10 | 1 |
| 11 | LT AUXILIARY TRANSFORMER | 6 x 6 | 4 |
| 12 | GTG TRANSFORMER | 15 x 12 | 1 |
| 13 | STG TRANSFORMER | 15 x 12 | 1 |
| 14 | PIPE/CABLE RACK | – | – |
| 15 | BURIED COOLING WATER HEADER | – | – |
| 16 | STATION TRANSFORMERS | 15 x 12 | 2 |
| 17 | 66kv INDOOR GAS INSULATED SUB STATION (GIS) | – | 1 |
| 18 | DM WATER TANK | – | 1 |
| 19 | NEW GENERATOR TRANSFORMER FOR EXISTING GTG-3 | 15 x 12 | 1 |
| 20 | HOLDING POND & TRANSFER PUMP AREA | 10 x 5 | 1 |
| 21 | BLACK START CUM EMERGENCY DG SHED | 20 x 10 | 1 |
| 22 | CW MAKE-UP WATER STORAGE TANK | – | 1 |
| 23 | CW DOSING SYSTEM C | – | 1 |

FOR TENDER PURPOSE ONLY

| REV. | DATE | DESCRIPTION | DRN. | STR. | MECH. | ELEC. | INST. | APPD. |
|---|---|---|---|---|---|---|---|---|
| C | 08.06.12 | FOR TENDER PURPOSE ONLY | MKM | sd/- | sd/- | sd/- | sd/- | sd/- |
| | | | | PMB | SKS | APK | MAG | FWR |
| B | 17.05.12 | FOR TENDER PURPOSE ONLY | MKM | sd/- | sd/- | sd/- | sd/- | sd/- |
| | | | | PMB | SKS | APK | MAG | FWR |
| A | 08.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | MKM | sd/- | sd/- | sd/- | sd/- | sd/- |
| | | | | PMB | SKS | APK | MAG | FWR |

FICHTNER
Consulting Engineers (India) Private Limited
Mumbai

CLIENT
OIL AND NATURAL GAS CORPORATION LTD.
COMBINED CYCLE CAPTIVE POWER PLANT
AT HAZIRA PLANT, GUJARAT.

| | SIGNATURE | | DATE |
|---|---|---|---|
| DRAWN | | MKM | 08.04.12 |
| DESIGNED | sd/- | SKS | 08.04.12 |
| CHECKED | sd/- | SKS | 08.04.12 |
| APPROVED | sd/- | FWR | 08.04.12 |
| PROJ. MGR. | sd/- | SG | 08.04.12 |

TITLE
PLOT PLAN

| CLEARED (FOR RD ONLY) | | SIGNATURE | | DATE |
|---|---|---|---|---|
| | STRUCTURAL | – | – | SVK |
| | MECHANICAL | – | – | FWR |
| | ELECTRICAL | – | – | AVD |
| | INST | – | – | BV |

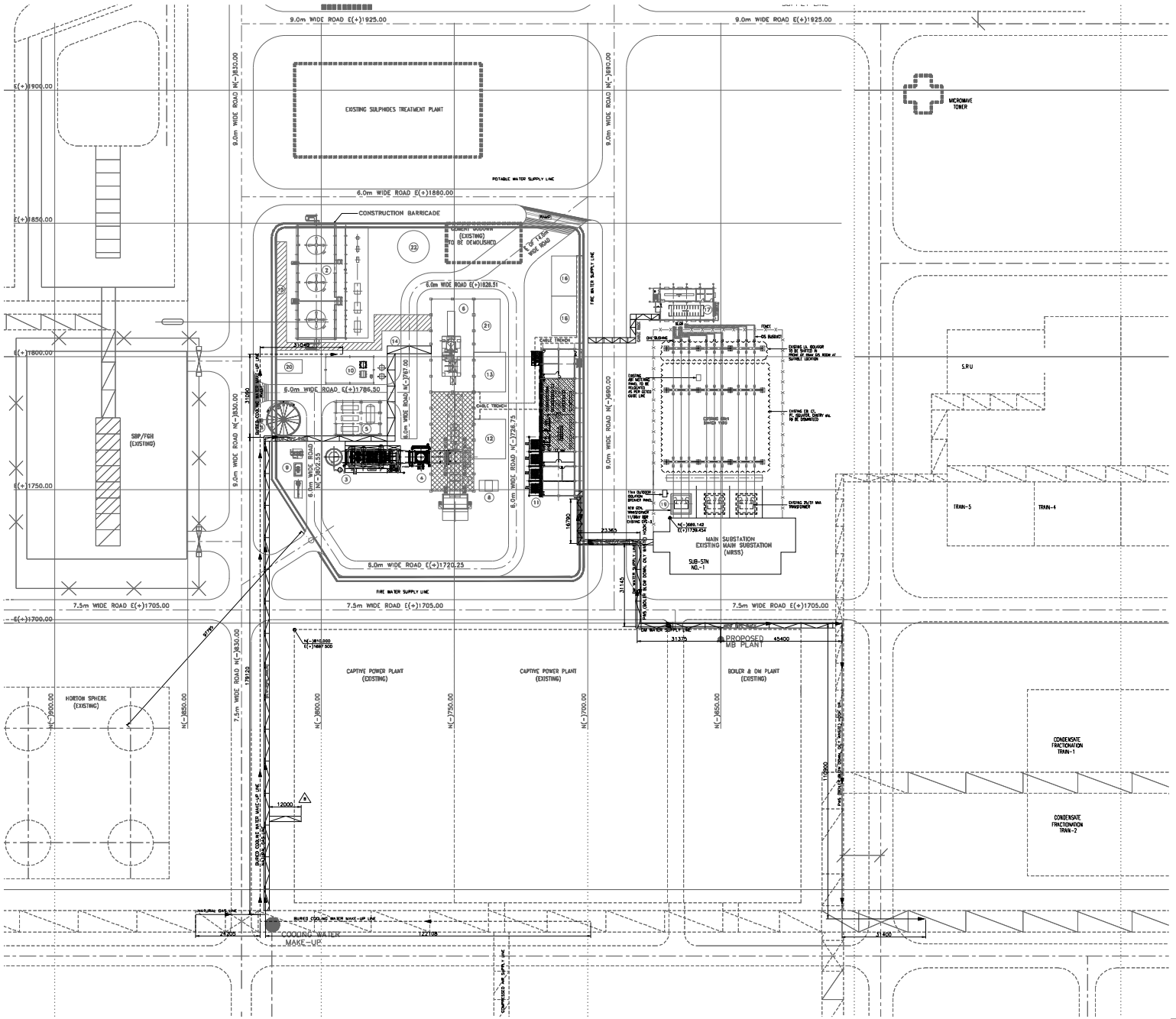
| RELEASED FOR | |
|---|---|
| | PRELIMINARY |
| ✓ | TENDER |
| | ENGINEERING |
| | CONSTRUCTION |

DEPT. : MECHANICAL | FI JOB No.: 5111168 | SCALE : 1:500 | REV : C

DWG.NO. 10-5111168-G-001

File name: 10-5111168-G-001.dwg---MKM---Jun.27'2012---11:33:35

DWG.NO. 00-5111168-G-002 B




**NOTES:-**

1. ALL DIMENSIONS ARE IN MILLIMETRES AND COORDINATES ARE IN METRES.
2. EFFLUENTS TO BE ROUTED TO THE OWS SHALL BE TERMINATED AT THE NEAREST OWS DRAIN PIT.

**REFERENCE DRAWINGS:-**

1. OVERALL PLOT PLAN ——— 4427-00-16-47-0001

FOR TENDER PURPOSE ONLY

| REV | DATE | DESCRIPTION | DRN. | STR | MECH | ELEC | INST. | PIPE. |
|---|---|---|---|---|---|---|---|---|
| | | | | CHECKED & CLEARED | | | | |
| B | 11.06.12 | FOR TENDER PURPOSE ONLY | MHM | PMB | SKS | APK | MNG | PWR |
| A | 17.05.12 | FOR TENDER PURPOSE ONLY | MHM | PMB | SKS | APK | MNG | PWR |

FICHTNER Consulting Engineers (India) Private Limited Mumbai

CLIENT: OIL AND NATURAL GAS CORPORATION LTD. COMBINED CYCLE CAPTIVE POWER PLANT AT HAZIRA PLANT, GUJARAT.

| | SIGNATURE | DATE |
|---|---|---|
| DRAWN | MHM | 02.04.12 |
| DESIGNED | M/- | 02.04.12 |
| CHECKED | M/- | 02.04.12 |
| APPROVED | M/- | 02.04.12 |
| PROJ. MGR | M/- | 02.04.12 |

TITLE : KEY PLAN SHOWING TERMINAL POINTS (IN EXISTING PLANT AREA)

| CLEARED (SIGNATURE) | | SIGNATURE | DATE |
|---|---|---|---|
| | STRUCTURAL | SVK | – |
| | MECHANICAL | PWR | – |
| | PROCESS | – | – |
| | ELECTRICAL | AVD | – |
| | INST. | SV | – |

| ISSUED FOR | |
|---|---|
| PRELIMINARY | |
| TENDER | ✓ |
| ENGINEERING | |
| CONSTRUCTION | |

DEPT : MECHANICAL | JOB No. 5111168 | SCALE : 1:500 | REV :

DWG.NO. 00-5111168-G-002 B

File name: 00-5111168-G-002.dwg---MHM---Jun.11"2012---15:23:44

DWG. NO. 10-5111168-M-002 REV. B

## ROTATING EQUIPMENT

- HORIZONTAL CENTRIFUGAL PUMP M : MOTOR DRIVEN E : ENGINE DRIVEN T : TURBINE DRIVEN
- BOREWELL PUMP
- VERTICAL PUMP (SUMP, WET PIT, CANNED)
- VACCUM PUMP
- PLUNGER PUMP
- GEAR PUMP
- DIAPHRAGM PUMP
- SCREW PUMP
- RECIPROCATING AIR / GAS COMPRESSOR
- SCREW AIR / GAS COMPRESSOR
- FAN / BLOWER
- AGITATOR
- CURRENT GENERATOR GENERAL
- ELECTRIC MOTOR
- DIESEL ENGINE
- GAS TURBINE
- STEAM TURBINE GENERAL

## TANKS / VESSELS

- PRESSURE VESSEL VERTICAL (SHOWN) OR HORIZONTAL
- CONE ROOF TANK
- FLOATING ROOF TANK
- TANK
- DEAERATOR WITH STROAGE TANK

## SEPARATORS

- SEPARATORS, GENERAL
- FLASH VESSEL
- STRAINERS, GENERAL
- COARSE SCREEN
- FINE SCREEN
- TRAVELLING SCREEN
- THICKENER
- DRYER
- CONICAL TYPE STRAINER
- 'Y' TYPE STRAINER

## FILTERS

- GAS FILTER, GENERAL
- BAG FILTER
- CARTRIDGE FILTER
- GRAVEL FILTER
- MIXED BED FILTER
- ION EXCHANGE FILTER
- DEGASIFIER
- OIL FILTER

## HEAT EXCHANGERS

- TURBINE CONDENSER
- HEAT EXCHANGER
- AIR COOLED CONDENSER
- RADIATOR COOLER

## VALVES

- GATE (OPEN)
- GATE VALVE WITH GLAND SEALING
- GATE (CLOSED)
- GLOBE (OPEN)
- GLOBE VALVE WITH GLAND SEALING
- GLOBE (CLOSED)
- BALL (OPEN)
- BALL (CLOSED)
- NON-RETURN /CHECK
- BUTTERFLY VALVE
- BUTTERFLY VALVE NORMALLY CLOSED (NC)
- ANGLE
- THREE-WAY
- DIAPHRAGM VALVE
- DIAPHRAGM VALVE NORMALLY CLOSED
- SAFETY / RELIEF
- STRAIGHT PRV
- STRAIGHT PRV WITH BUILT IN SPRAY CONNECTION
- ANGLE PRV WITH BUILT IN SPRAY CONNECTION
- FLOAT
- NEEDLE
- PLUG
- VALVE WITH INTEGRAL BYPASS
- AUTOMATIC RECIRCULATION VALVE
- FOUR WAY VALVE
- ACTUATED VALVES

## PIPING

- STEAM
- WATER / CONDENSATE
- OIL (NAPHTHA,HSD & LUBE)
- FLUE GAS
- AIR
- BURIED
- OILY WASTE
- WASTE WATER
- HEAT TRACING S-STEAM TRACED
- HEAT TRACING E-ELECTRICAL TRACED
- FLEXIBLE HOSE
- SPRAY NOZZLES
- SPRINKLER DEVICE
- PIPE CROSS OVER
- REMOVABLE SPOOL
- FLANGE
- HOSE CONNECTION
- UNION
- CONCENTRIC REDUCER / ENLARGER
- ECCENTRIC REDUCER / ENLARGER
- WELDED CAP
- SCREWED CAP
- DESIGNATE PIPING CLASS CHANGE
- BLIND FLANGE

## MISCELLANEOUS

- THERMOWELL
- EXPANSION JOINT
- FLEXIBLE JOINT
- STEAM TRAP
- TIMER OPERATED AUTO DRAIN TRAP (ADT)
- VENT
- BIRD SCREEN
- DIRECT DRAIN
- VACCUM BREAKER
- RUPTURE DISC

## MISCELLANEOUS (CONTD.)

- INDIRECT DRAIN OR FUNNEL DRAIN
- FLAME ARRESTER
- BREATHER VALVE
- FOOT VALVE
- DISSOLVING BASKET
- ORIFICE \ FLOW RESTRICTOR
- SPECTACLE BLIND
- FLOW NOZZLE
- FENCE
- GAS DAMPER
- GAS DAMPER (GUILLOTINE TYPE)
- GAS DAMPER (DIVERTER TYPE)
- DESUPERHEATER/ATTEMPERATOR
- SILENCER
- INSTRUMENTATION LINE BREAK OR RESUMPTION POINT
- PROCESS LINE BREAK OR RESUMPTION POINT
- BOUNDARY OF EQUIPMENT PACKAGE
- DOWNWARD SLOPE
- UPWARD SLOPE
- BUILDING PENETRATION (OUTDOOR / INDOOR)
- SCOPE MARK
- DRAIN LEG
- VENT & DRAIN
  V : HIGH POINT VENT
  D : LOW POINT DRAIN
  HV : HYDRO TEST VENT
  HD : HYDRO TEST DRAIN
- RESIN TRAP
- EJECTOR

FOR TENDER PURPOSE ONLY

| REV. | DATE | DESCRIPTION | DRN. | STR. | MECH. | ELEC. | INST. | APPD. |
|---|---|---|---|---|---|---|---|---|
| | | | | CHECKED & CLEARED | | | | |
| B | 17.05.12 | FOR TENDER PURPOSE ONLY | MKM | – | SKS | – | MAG | FWR |
| A | 06.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | MKM | – | SKS | – | MAG | FWR |

**FICHTNER**
Consulting Engineers (India) Private Limited
Mumbai

CLIENT: OIL AND NATURAL GAS CORPORATION LTD.
COMBINED CYCLE CAPTIVE POWER PLANT AT HAZIRA PLANT, GUJARAT.

| | SIGNATURE | | DATE |
|---|---|---|---|
| DRAWN | ~~MKM~~ | MKM | 06.04.12 |
| DESIGNED | sd/- | SKS | 06.04.12 |
| CHECKED | sd/- | SKS | 06.04.12 |
| APPROVED | sd/- | FWR | 06.04.12 |
| PROJ. MGR. | sd/- | SG | 06.04.12 |

TITLE: SYMBOLS & LEGEND (EQUIPMENT & PIPING)

| CLEARED (FOR RO ONLY) | | SIGNATURE | | DATE |
|---|---|---|---|---|
| | STRUCTURAL | – | – | SVK |
| | MECHANICAL | – | – | FWR |
| | ELECTRICAL | – | – | AVD |
| | INST | – | – | BV |

| RELEASED FOR | |
|---|---|
| | PRELIMINARY |
| ✓ | TENDER |
| | ENGINEERING |
| | CONSTRUCTION |

DEPT : MECHANICAL | FI JOB No.: 5111168 | SCALE : NTS | REV. : B

DWG.NO. 10-5111168-M-002

File name: 5111168M002.dwg---MKM---May.17"2012---10:34:15

REV. B — DWG. NO. 10-5111168-M-003

| FIRST LETTER (NOTE – 1) | | SENSING DEVICE (NOTE 6) | | SUCCEEDING LETTERS (NOTE – 1) DISPLAY DEVICE | | | | | | CONTROL DEVICE (NOTE. 1) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MEASURED OR INITIATING VARIABLE (NOTE 3) | SYMBOL | PRIMARY ELEMENT | TRANSMITTER | INDICATOR | RECORDER | INTEGRATING INDICATOR | ALARM ANNUNCIATOR (NOTE 4) LOW | ALARM ANNUNCIATOR (NOTE 4) HIGH | ALARM ANNUNCIATOR (NOTE 4) HIGH & LOW | CONTROLLER STATION MAN/AUTO | CONTROLLER | CONTROL VALVE | SELF ACTUATED VALVE | OTHER FINAL CONTROL ELE. | SWITCH (NOTE 2) | LOCAL OBSERVATION GLASS | TEST POINT COMPUTER (NOTE 5) | RELAY OR CHOICE VALVE | UNCLASSIFIED | BISTABLE CONTROL | |
| TYPICAL SYMBOL | ( ) | ( ) E | ( ) T | ( ) I | ( ) R | ( ) QI | ( ) AL | ( ) AH | ( ) AHL | ( ) K | ( ) C | ( ) V | ( ) CV | ( ) Z | ( ) S | ( ) G | ( ) P | ( ) Y | ( ) N | ( ) X | ( ) B |
| ANALYSIS | A | AE | AT | AI | AR | | AAL | AAH | AAHL | AK | AC | AV | ACV | AZ | AS | | AP | AY | AN | AX | AB |
| BURNER FLAME | B | BE | BT | BI | BR | | BAL | | | | BC | BV | | | BS | BG | BP | BY | BN | | BB |
| CONDUCTIVITY | C | CE | CT | CI | CR | | CAL | CAH | CAHL | CK | CC | CV | | CZ | CS | | CP | CY | CN | CX | CB |
| DENSITY (MASS) OR SP.GR. | D | DE | DT | DI | DR | | DAL | DAH | DAHL | DK | DC | DV | | DZ | DS | | DP | DY | DN | DX | DB |
| VOLTAGE (EMF) | E | EE | ET | EI | ER | | EAL | EAH | EAHL | EK | EC | | | EZ | ES | | | EY | EN | EX | EB |
| FLOW | F | FE | FT | FI | FR | FQI | FAL | FAH | FAHL | FK | FC | FV | FCV | FZ | FS | FG | FP | FY | FN | FX | FB |
| GAGING (DIMENSIONAL) | G | GE | GT | GI | GR | | GAL | GAH | GAHL | GK | GC | | | | GS | | | GY | GN | | GB |
| HAND (MANUAL) | H | | | | | | | | | | HC | HV | HCV | HZ | HS | | | HY | HN | | |
| CURRENT | I | IE | IT | II | IR | IQI | IAL | IAH | IAHL | IK | IC | | | IZ | IS | | | IY | IN | IX | IB |
| POWER | J | JE | JT | JI | JR | JQI | JAL | JAH | JAHL | JK | JC | | | JZ | JS | | | JY | JN | JX | JB |
| TIME | K | | KT | KI | KR | KQI | KAL | KAH | KAHL | | KC | KV | | KZ | KS | | | KY | KN | KX | KB |
| LEVEL | L | LE | LT | LI | LR | | LAL | LAH | LAHL | LK | LC | LV | LCV | LZ | LS | LG | LP | LY | LN | LX | LB |
| MOISTURE OR HUMIDITY | M | ME | MT | MI | MR | | MAL | MAH | MAHL | MK | MC | MV | | MZ | MS | | MP | MY | MN | MX | MB |
| USER'S CHOICE | O | | | | | | | | | | | | | | | | | | | | |
| PRESSURE | P | PE | PT | PI | PR | | PAL | PAH | PAHL | PK | PC | PV | PCV | PZ | PS | | PP | PY | PN | PX | PB |
| PRESSURE DIFFERENTIAL | PD | | PDT | PDI | PDR | | PDAL | PDAH | PDAHL | PDK | PDC | PDV | PDCV | PDZ | PDS | | | | | | |
| QUANTITY OR EVENT | Q | | QT | QI | QR | QQI | QAL | QAH | QAHL | QK | QC | QV | | QZ | QS | | | QY | QN | QX | QB |
| SPEED OR FREQUENCY | S | | ST | SI | SR | SQI | SAL | SAH | SAHL | SK | SC | | | SZ | SS | | | SY | SN | SX | SB |
| TEMPERATURE | T | TE | TT | TI | TR | | TAL | TAH | TAHL | TK | TC | TV | TCV | TZ | TS | | TP | TY | TN | TX | TB |
| MULTIVARIABLE | U | | | UI | UR | | UAL | UAH | UAHL | | UC | UV | | UZ | US | | | UY | UN | UX | UB |
| VISCOSITY | V | | VT | VI | VR | | VAL | VAH | VAHL | VK | VC | VV | | VZ | VS | | VP | VY | VN | VX | VB |
| WEIGHT OR FORCE | W | WE | WT | WI | WR | WQI | WAL | WAH | WAHL | WK | WC | WV | | WZ | WS | | | WY | WN | WX | WB |
| UNCLASSIFIED (NOTE. 8) | X | | | | | | | | | | | | | | | | | | | | |
| VIBRATION | Y | YE | YT | YI | YR | | | YAH | | | | | | | YS | | YP | YY | YN | YX | YB |
| POSITION | Z | ZE | ZT | ZI | ZR | | ZAL | ZAH | ZAHL | | ZC | | | ZZ | ZS | | | ZY | ZN | ZX | ZB |

**NOTES :**

1. THE INSTRUMENT LEGEND IS BASED ON ISA S5.1 FOR FURTHER DETAILS AND CLARIFICATION. REFER TO ISA STANDARD
2. THE LETTERS H, HH, L, LL AND HL ARE ADDED TO THE MEASURED VARIABLES FOR HIGH, HIGH-HIGH, LOW, LOW-LOW AND HIGH-LOW RESPECTIVELY, AS FOR ALARMS.
3. ANY FIRST LETTER MAY BE MODIFIED BY THE FOLLOWING LETTERS;
   D – DIFFERENTIAL (PD – PRESSURE DIFFERENTIAL)
   J – SCAN (AJI – SCANNING ANALYSER INDICATOR)
   Q – INTEGRATE OR TOTALIZE (FQI – FLOW INTEGRATING INDICATOR)
4. HIGH – HIGH ALARMS HAVE ( )AHH.
   LOW – LOW ALARMS HAVE ( ) ALL.
   IN INSTRUMENT CIRCLE. E.G.
   LAHH – DESIGNATES HIGH-HIGH LEVEL ALARM
   LALL – DESIGNATES LOW-LOW LEVEL ALARM
   LAHL – DESIGNATES HIGH-LOW LEVEL ALARM
5. A TEST POINT IS A PROCESS CONNECTION TO WHICH NO INSTRUMENT IS PERMANENTLY CONNECTED. BUT WHICH IS INTENDED FOR TEMPORARY. INTERMITTENT, OR FUTURE CONNECTION OF AN INSTRUMENT.
   PP – DESIGNATES PRESSURE POINT
   AP – DESIGNATES ANALYSIS POINT
   TP – DESIGNATES TEMPERATURE POINT
   TW – DESIGNATES THERMOWELL
   AW – DESIGNATES SAMPLE NOZZLE
6. A CONTROL OR SENSING DEVICE OR RELAY HAVING A DISPLAY FUNCTION SHOULD HAVE THE APPROPRIATE DISPLAY LETTERS ADDED AFTER THE MEASURED VARIABLE DESIGNATION. I.e, AI DESIGNATES ANALYSIS INDICATING CONTROL STATION.
7. VALVE BODY PORTS THAT ARE CLOSED IN NORMAL OPERATION ARE BLACKENED. THE PORTS THAT IS TO BE CLOSED WHEN THE STATE CHANGES TO OFF NORMAL WILL CONTAIN A DOT. THE OPERATION CONDITION SHOWN FOR ALL VALVE BODIES CORRESPONDS TO FULL LOAD OR NORMAL OPERATION REGARDLESS OF THE TYPE OF ACTUATOR OR WHETHER THE ACTUATOR IS ENERGIZED OR DE-ENERGIZED DURING THIS MODE OF OPERATION.
8. THE LETTER X IS FOR UNLISTED MEANINGS THAT WILL BE USED ONLY ONCE OR TO LIMITED EXTENT.IT MAY HAVE ANY NUMBER OF MEANINGS AS A FIRST LETTER AND ANY NUMBER OF MEANINGS AS A SUCCEEDING LETTER.EXCEPT FOR ITS USE WITH DISTINCTIVE SYMBOLS. THE MEANINGS WILL BE DEFINED OUTSIDE THE INSTRUMENT CIRCLE.

## GENERAL INSTRUMENTS

- INSTRUMENT FOR SINGLE MEASURED VARIABLE AND ANY NUMBER OF FUNCTION. INSTRUMENT IS LOCALLY MOUNTED.
- INSTRUMENT IS MOUNTED ON A LOCAL PANEL (NOT IN CCR)
- INSTRUMENT IS MOUNTED ON CONTROL DESK OR PANEL (IN CCR ALONG WITH DCS)
- DCS FUNCTION
- SUPERVISORY CONTROL & SHARED DISPLAY NORMALLY ACCESSIBLE TO OPERATOR INDICATOR/CONTROLLER/RECORDER OR ALARM POINTS – USUALLY USED TO INDICATE DISPLAY
- DCS INTERLOCK
- INTERLOCK OTHER THAN DCS
- PLC FUNCTION

## SENSOR

**FLOW**

- ORIFICE PLATE
- RESTRICTION ORIFICE
- FLOW NOZZLE
- ROTAMETER
- POSITIVE DISPLACEMENT TYPE FLOW METER
- TURBINE OR PROPELLER TYPE
- FLOW GLASS

**PRESSURE**

- DIRECT CONNECTED
- WITH DIAPHRAGM SEAL PIPED

## SENSOR (CONT.)

- TI – THERMOMETER OR TEMPERATURE INDICATOR
  TW – THERMOWELL
  TE – TEMPERATURE ELEMENT
- GAGE GLASS OR FLOAT OR DISPLACEMENT TYPE LEVEL INSTRUMENT
- INTERNAL BALL– FLOAT TYPE
- TANK GAUGE

## SIGNAL & LINES

- CONNECTION TO PROCESS OR MECHANICAL LINE OR INSTRUMENT SUPPLY
- PNEUMATIC SIGNAL
- ELECTRIC SIGNAL
- SOFTWARE SIGNALS
- CAPILLARY TUBE(FIELD SYSTEM)
- HYDRAULIC SIGNAL
- ELECTROMAGNETIC OR SONIC SIGNAL (WITHOUT WIRING OR TUBING)

## VALVE BODIES & FAILURE MODES (NOTE 7)

- TWO-WAY(TYPICAL GLOBE SHOWN)
  FO – INDICATES FAIL OPEN
  FC – INDICATES FAIL CLOSED
  FL – INDICATES FAIL LOCKED (POSITION DOES NOT CHANGE)
  FI – INDICATES FAIL INDETERMINATE
- THREE – WAY
- FOUR – WAY

## SELF – ACTUATED DEVICES

- PRESSURE REDUCING REGULATOR SELF CONTAINED
- PRESSURE REDUCING REGULATOR WITH EXTERNAL PRESSURE TAP
- TEMPERATURE REGULATOR FILLED-SYSTEM TYPE
- SOLENOID OPERATED PNEUMATIC CONTROL & SHUT-OFF VALVE
- SOLENOID VALVE – 3WAY

## VALVE BODY WITH ACTUATOR–TYPICAL

- VALVE SHOWN WILL CLOSE UPON LOSS OF INSTRUMENT AIR SUPPLY TO DIAPHRAGM
- CONTROL SIGNAL
- CONTROL VALVES WITH ELECTROPNEUMATIC POSITIONER FAIL CLOSE WITH ARROW DOWNWARD FAIL OPEN WITH ARROW UPWARD FL : FAIL TO LOCK (STAY PUT WITH AIR LOCK RELAY)
- SELF REGULATING VALVE (DOWN STREAM)
- SELF REGULATING VALVE (UP STREAM)

## INSTRUMENT TAGGING DETAILS

XXXX – INST. SYMBOL & LEGEND
XXX X – ALPHA CHARACTER
SERIAL NUMBER

## VALVES ACTUATORS

- ELECTRIC MOTOR
- SOLENOID (2–WAY)
- HYDRAULIC
- C : CHAIN
  T : TAP IN BOTTOM OF BODY (FOR ASME TEST)
  X : EXTENSION STEM
  G : GEAR OPERATED
  A : AIR WRENCH
  B : WITH INTEGRAL BYPASS VALVE
  D : DEEP STUFFING BOX AND LANTERN GLAND
- PNEUMATIC DIAPHRAGM
- PNEUMATIC DIAPHRAGM WITH POSITIONER
- DIAPHRAGM PRESSURE–BALANCED
- ROTARY MOTOR (SHOWN TYPICALLY WITH ELECTRIC SIGNAL)
- PNEUMATIC CYLINDER SINGLE–ACTING
- HYDRAULIC CYLINDER DOUBLE –ACTING
- PNEUMATIC CYLINDER DOUBLE–ACTING
- PNEUMATIC CYLINDER DOUBLE ACTING WITH PILOT VALVE
- ELECTRO–OR PNEUMATIC HYDRAULIC

## FUNCTION SYMBOLS

- PNEUMATIC TO CURRENT CONVERTER
- CURRENT TO PNEUMATIC CONVERTER

**FOR TENDER PURPOSE ONLY**

| REV. | DATE | DESCRIPTION | DRN. | STR. | MECH. | ELEC. | INST. | APPD. |
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| B | 17.05.12 | FOR TENDER PURPOSE ONLY | MKM | – | SKS | – | MAG | FWR |
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| | | | | – | SKS | – | MAG | FWR |

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CLIENT: ONGC — OIL AND NATURAL GAS CORPORATION LTD.
COMBINED CYCLE CAPTIVE POWER PLANT AT HAZIRA PLANT, GUJARAT.

| | SIGNATURE | DATE |
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| DRAWN | MKM | 06.04.12 |
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| CHECKED | sd/– SKS | 06.04.12 |
| APPROVED | sd/– FWR | 06.04.12 |
| PROJ. MGR. | sd/– SG | 06.04.12 |

TITLE: SYMBOLS & LEGEND (CONTROL & INSTRUMENTS)

| CLEARED (FOR RO ONLY) | | SIGNATURE | | DATE |
|---|---|---|---|---|
| | STRUCTURAL | – | – | SVK |
| | MECHANICAL | – | – | FWR |
| | ELECTRICAL | – | – | AVD |
| | INST. | – | – | BV |

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DEPT. : MECHANICAL | FI JOB No.: 5111168 | SCALE : NTS | REV. : B

DWG.NO. 10-5111168-M-003

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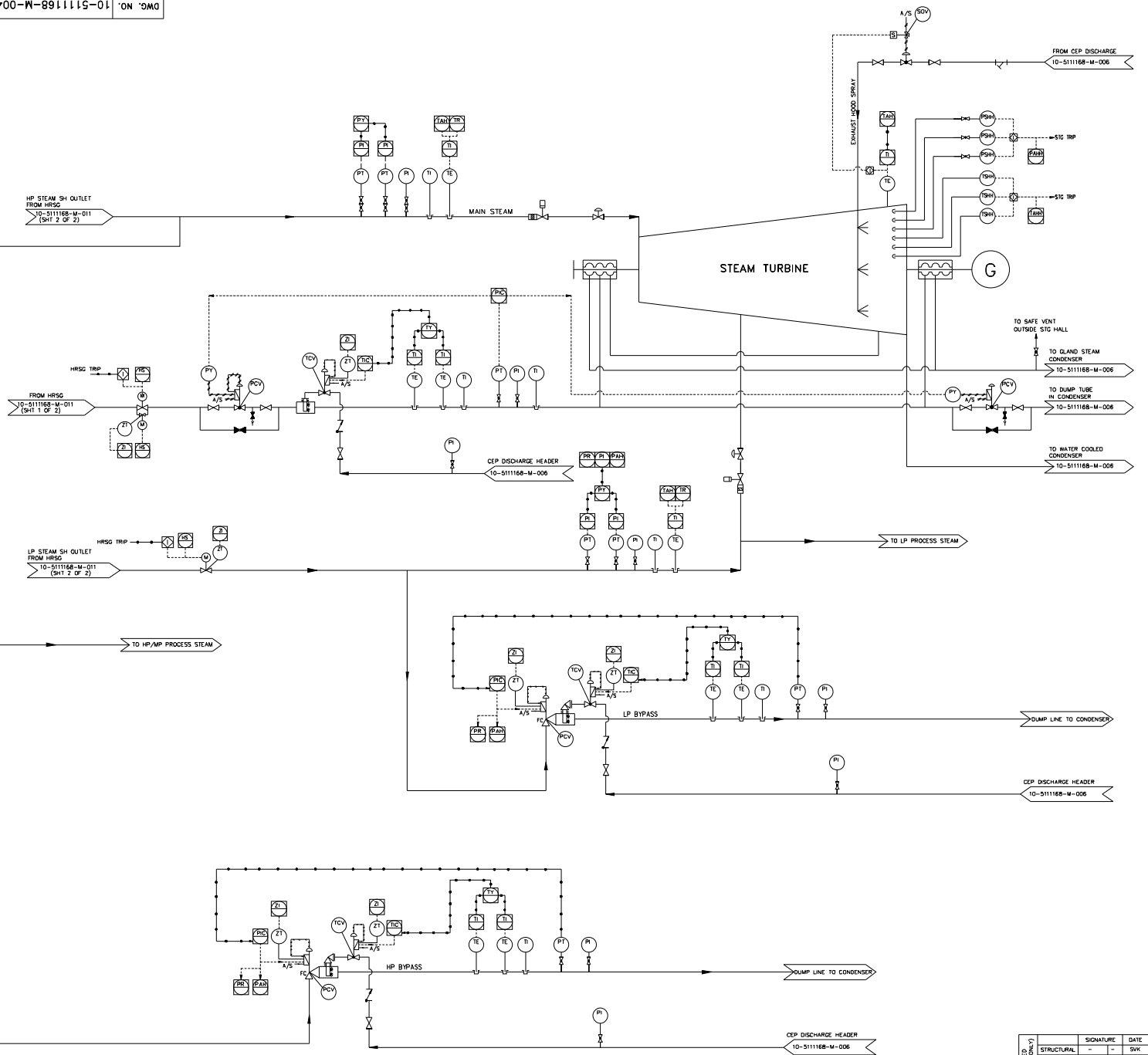


## NOTES:

1. HIGH POINT VENTS AND LOW POINT DRAINS SHALL BE PROVIDED AT SUITABLE LOCATIONS AS PER PIPING LAYOUT.
2. ALL INSTRUMENTS SHALL BE WITH PROCESS ISOLATION VALVE AND AN INSTRUMENT ISOLATION VALVE, WITH PROVISION FOR VENT AND DRAIN.
3. ALL TEMPERATURE INSTRUMENTS SHALL BE PROVIDED WITH THERMOWELL.
4. ALL CONTROL & MOTORISED VALVES SHALL BE PROVIDED WITH OPEN & CLOSE LIMIT SWITCHES WITH DCS INDICATION AND TORQUE SWITCHES.
5. TG BYPASS VALVES SHALL BE OF 100% CAPACITY.
6. ALL CONTROL VALVES SHALL HAVE POSITION TRANSMITTER WITH DCS INDICATION
7. HP/LP STEAM LINES SHALL HAVE START-UP VENTS AND ADEQUATE DRAINS TO ENABLE PLANT START-UP OPERATION
8. ALL DRAINS LOCATED IN THE HP/LP STEAM LINES UPSTREAM OF STEAM TURBINE SHALL BE AS PER ASME TDP-1, 1995
9. ALL EXTERNAL DRAINS SHALL BE CONNECTED TO ATMOSPHERIC FLASH TANK
10. ALL TURBINE DRAINS SHALL BE CONNECTED TO CONDENSER
11. THE FOLLOWING PERMISSIVES SHALL BE GIVEN FOR HP BYPASS VALVE OPERATION
    a) CONDENSER PRESSURE NOT HIGH HIGH
    b) SPRAY VALVE OPEN
    c) TURBINE EXHAUST TEMPERATURE NOT HIGH HIGH
    d) CONDENSATE EXTRACTION PUMP RUNNING
12. THE FOLLOWING PERMISSIVES SHALL BE GIVEN FOR LP BYPASS VALVE OPERATION
    a) CONDENSER PRESSURE NOT HIGH HIGH
    b) TURBINE EXHAUST TEMPERATURE NOT HIGH HIGH
    c) CONDENSATE EXTRACTION PUMP RUNNING

## REFERENCE DRGS.:

1. 10-5111168-M-002 – SYMBOLS & LEGEND (EQUIPMENT & PIPING)
2. 10-5111168-M-003 – SYMBOLS & LEGEND (CONTROL & INSTRUMENTS)
3. 10-5111168-M-005 – P & ID FEED WATER SYSTEM (2 SHEETS)
4. 10-5111168-M-006 – P & ID CONDENSATE SYSTEM
5. 10-5111168-M-011 – P & ID HRSG (HP/LP SECTION) (2 SHEETS)

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| B | 17.05.12 | FOR TENDER PURPOSE ONLY | MKM | – | SKS | – | MAG | FWR |
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AT HAZIRA PLANT, GUJARAT.

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| CHECKED | sd/– | SKS | 06.04.12 |
| APPROVED | sd/– | FWR | 06.04.12 |
| PROJ. MGR. | sd/– | SG | 06.04.12 |

TITLE
# P & I DIAGRAM FOR STEAM SYSTEM

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| | STRUCTURAL | – | – | SVK |
| | MECHANICAL | – | – | FWR |
| | ELECTRICAL | – | – | AVD |
| | INST. | – | – | BV |

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DEPT. : MECHANICAL | FI JOB No : 5111168 | SCALE : NTS | REV : B

DWG.NO. 10-5111168-M-004

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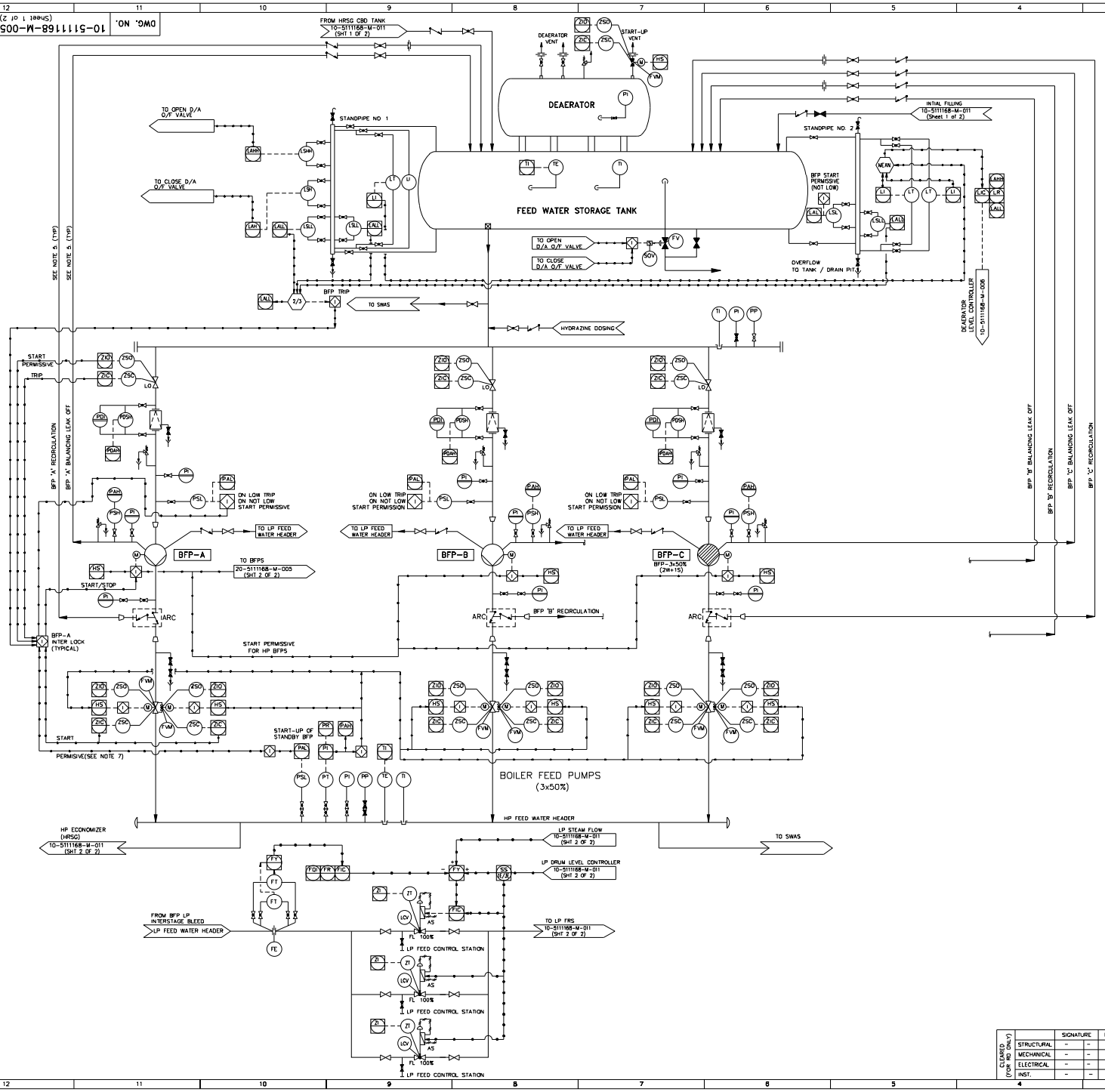
DWG. NO. 10-5111168-M-005 (Sheet 1 of 2) REV. B




## NOTES:

1. HIGH POINT VENTS AND LOW POINT DRAINS/STEAM TRAPS SHALL BE PROVIDED AT SUITABLE LOCATIONS AS PER PIPING LAYOUT.
2. ALL INSTRUMENTS SHALL BE WITH PROCESS ISOLATION VALVE AND AN INSTRUMENT ISOLATION VALVE, WITH PROVISION FOR VENT AND DRAIN
3. ALL TEMPERATURE INSTRUMENTS ARE PROVIDED WITH THERMOWELL.
4. ALL CONTROL & MOTORISED VALVES SHALL BE PROVIDED WITH OPEN & CLOSE LIMIT SWITCHES WITH DCS INDICATION AND TORQUE SWITCHES.
5. PUMP BALANCING LEAK OFF AND RECIRCULATION LINE SIZING SHALL BE AS PER ACTUAL PUMP REQT.
6. ALL DRAIN LINES SHALL BE 1" SIZE UNLESS OTHERWISE STATED.
7. DISCHARGE VALVE SHOULD BE IN CLOSED POSITION WHILE STARTING THE FIRST PUMP.
8. VORTEX BREAKER SHALL BE PROVIDED FOR DEAERATOR OUTLET NOZZLE

## LEGEND:

| | | |
|---|---|---|
| ARC | – | AUTOMATIC RECIRCULATION CONTROL VALVE |
| D/A | – | DEAERATOR |
| O/F | – | OVER FLOW |

## REFERENCE DRGS.:

| | | | |
|---|---|---|---|
| 1. | 10-5111168-M-002 | – | SYMBOLS & LEGEND (EQUIPMENT & PIPING) |
| 2. | 10-5111168-M-003 | – | SYMBOLS & LEGEND (CONTROL & INSTRUMENTS) |
| 3. | 20-5111168-M-005 | – | P & ID FEED WATER SYSTEM (SHT 2 OF 2) |
| 4. | 10-5111168-M-006 | – | P & ID CONDENSATE SYSTEM |
| 5. | 10-5111168-M-008 | – | P & ID MAKE-UP WATER SYSTEM (2 SHEETS) |
| 6. | 10-5111168-M-011 | – | P & ID HRSG (LP SECTION) (SHEET 2 OF 2) |

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| APPROVED | sd/– | FWR | 06.04.12 |
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TITLE: P & I DIAGRAM FOR LP FEED WATER SYSTEM

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| | INST. | – | – | BV |

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DEPT. : MECHANICAL | FI JOB No.: 5111168 | SCALE : NTS | REV : B

DWG.NO. 10-5111168-M-005 (Sheet 1 of 2)

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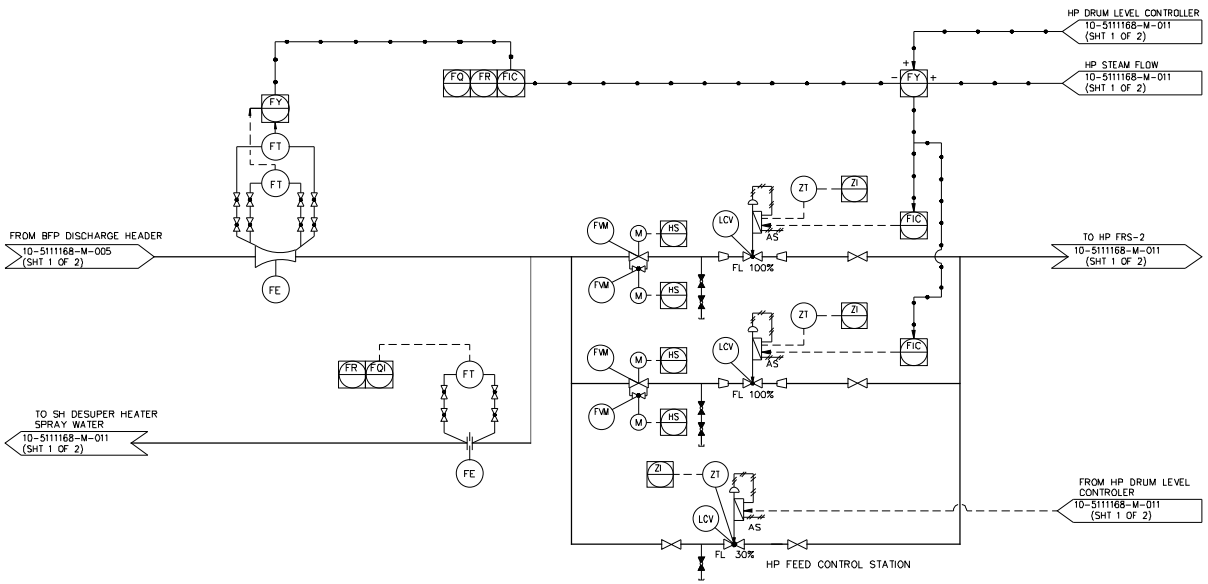


## NOTES:

1. HIGH POINT VENTS AND LOW POINT DRAINS/STEAM TRAPS SHALL BE PROVIDED AT SUITABLE LOCATIONS AS PER PIPING LAYOUT.
2. ALL INSTRUMENTS SHALL BE WITH PROCESS ISOLATION VALVE AND AN INSTRUMENT ISOLATION VALVE, WITH PROVISION FOR VENT AND DRAIN.
3. ALL TEMPERATURE INSTRUMENTS ARE PROVIDED WITH THERMOWELL.
4. ALL CONTROL & MOTORISED VALVES SHALL BE PROVIDED WITH OPEN & CLOSE LIMIT SWITCHES WITH DCS INDICATION AND TORQUE SWITCHES.
5. PUMP BALANCING LEAK OFF AND RECIRCULATION LINE SIZING SHALL BE AS PER ACTUAL PUMP REQT.
6. ALL DRAIN LINES SHALL BE 1" SIZE UNLESS OTHERWISE STATED.
7. DISCHARGE VALVE SHOULD BE IN CLOSED POSITION WHILE STARTING THE FIRST PUMP.
8. THE EQUIPMENT SHOWN IS FOR 1 HRSG ONLY. SIMILAR ARRANGEMENT WILL BE PROVIDED FOR THE OTHER HRSG ALSO.

## REFERENCE DRGS.:

| | | | |
|---|---|---|---|
| 1. | 10-5111168-M-002 | – | SYMBOLS & LEGEND (EQUIPMENT & PIPING) |
| 2. | 10-5111168-M-003 | – | SYMBOLS & LEGEND (CONTROL & INSTRUMENTS) |
| 3. | 10-5111168-M-005 | – | P & ID FEED WATER SYSTEM (SHT 1 OF 2) |
| 4. | 10-5111168-M-006 | – | P & ID CONDENSATE SYSTEM |
| 5. | 10-5111168-M-008 | – | P & ID MAKE-UP WATER SYSTEM (2 SHEETS) |
| 6. | 10-5111168-M-011 | – | P & ID HRSG (2 SHEETS) |

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TITLE :

# P & I DIAGRAM FOR HP FEED WATER SYSTEM

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| ELECTRICAL | – | – | AVD |
| INST. | – | – | BV |

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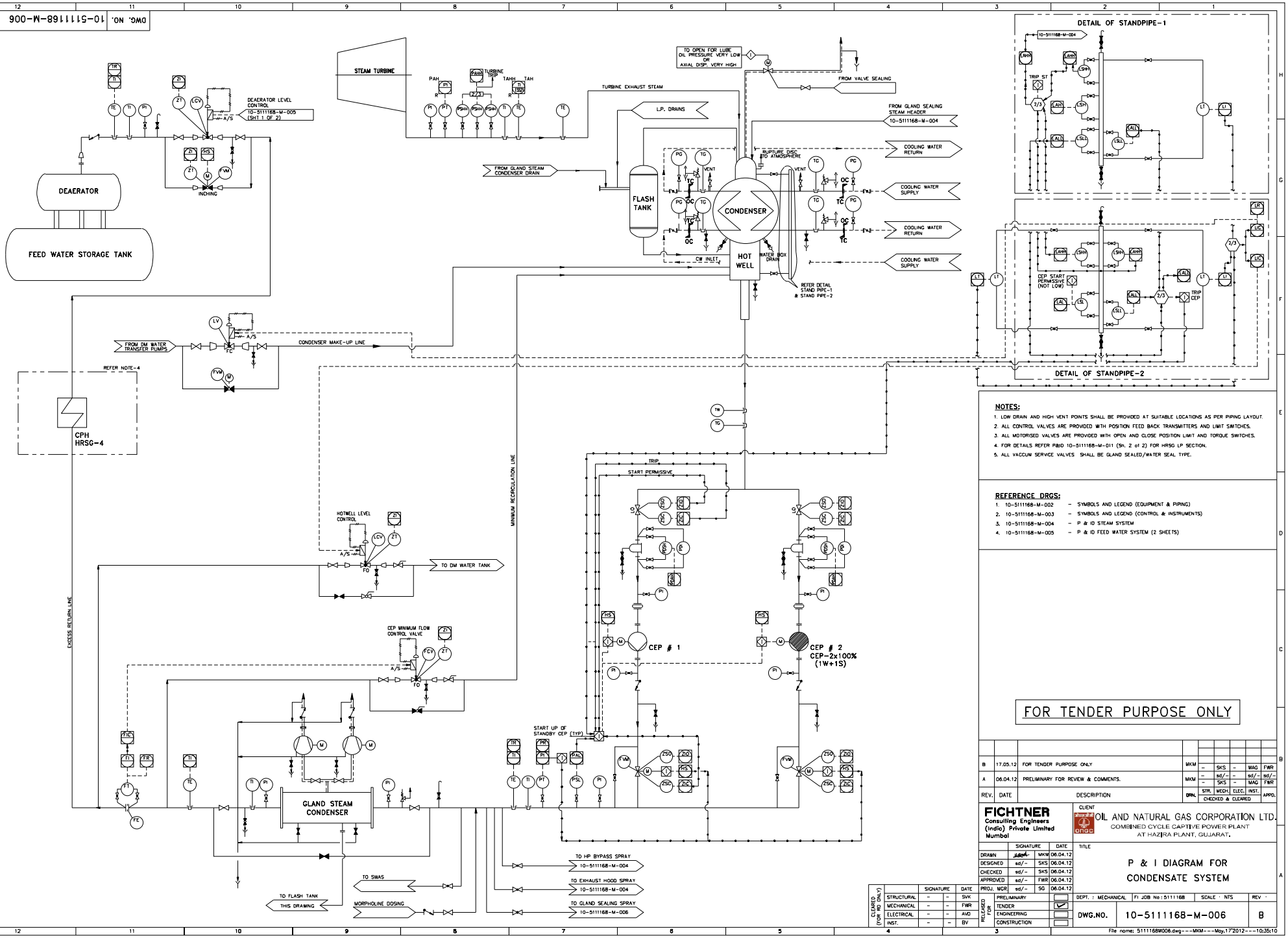
| CONSTRUCTION | | |

DEPT. : MECHANICAL | FI JOB No.: 5111168 | SCALE : NTS | REV. :

DWG.NO. 20-5111168-M-005 (Sheet 2 of 2) | B




**NOTES:**

1. LOW DRAIN AND HIGH VENT POINTS SHALL BE PROVIDED AT SUITABLE LOCATIONS AS PER PIPING LAYOUT.
2. ALL CONTROL VALVES ARE PROVIDED WITH POSITION FEED BACK TRANSMITTERS AND LIMIT SWITCHES.
3. ALL MOTORISED VALVES ARE PROVIDED WITH OPEN AND CLOSE POSITION LIMIT AND TORQUE SWITCHES.
4. FOR DETAILS REFER P&ID 10-5111168-M-011 (Sh. 2 of 2) FOR HRSG LP SECTION.
5. ALL VACCUM SERVICE VALVES SHALL BE GLAND SEALED/WATER SEAL TYPE.

**REFERENCE DRGS:**

1. 10-5111168-M-002 – SYMBOLS AND LEGEND (EQUIPMENT & PIPING)
2. 10-5111168-M-003 – SYMBOLS AND LEGEND (CONTROL & INSTRUMENTS)
3. 10-5111168-M-004 – P & ID STEAM SYSTEM
4. 10-5111168-M-005 – P & ID FEED WATER SYSTEM (2 SHEETS)

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| PROJ. MGR. | sd/– | SG | 06.04.12 |

TITLE

# P & I DIAGRAM FOR CONDENSATE SYSTEM

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| | MECHANICAL | – | – | FWR |
| | ELECTRICAL | – | – | AVD |
| | INST. | – | – | BV |

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| ✓ | TENDER |
| | ENGINEERING |
| | CONSTRUCTION |

DEPT. : MECHANICAL | FI JOB No : 5111168 | SCALE : NTS | REV : B

DWG.NO. 10-5111168-M-006

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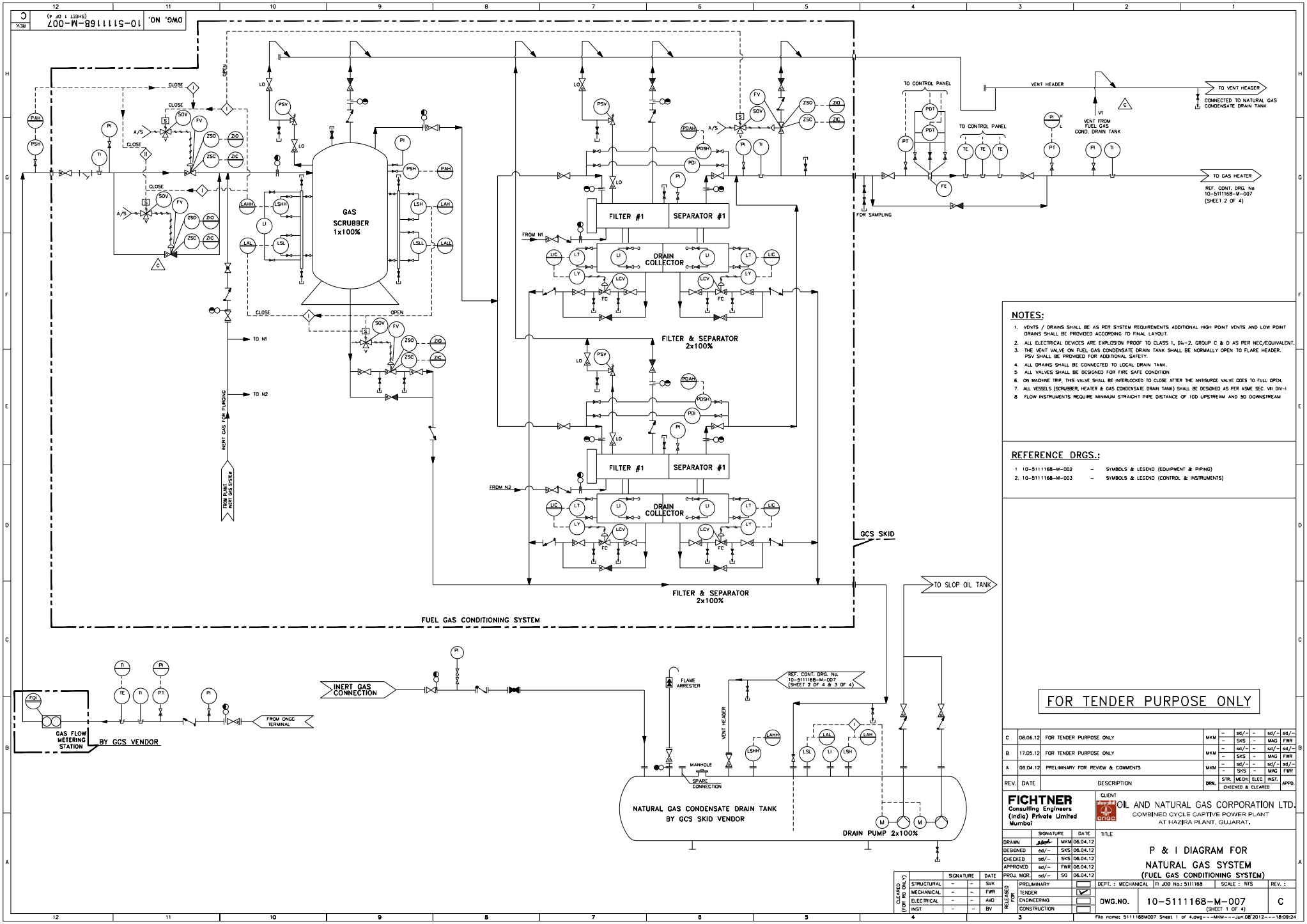


## NOTES:

1. VENTS / DRAINS SHALL BE AS PER SYSTEM REQUIREMENTS ADDITIONAL HIGH POINT VENTS AND LOW POINT DRAINS SHALL BE PROVIDED ACCORDING TO FINAL LAYOUT.
2. ALL ELECTRICAL DEVICES ARE EXPLOSION PROOF TO CLASS I, Div-2, GROUP C & D AS PER NEC/EQUIVALENT.
3. THE VENT VALVE ON FUEL GAS CONDENSATE DRAIN TANK SHALL BE NORMALLY OPEN TO FLARE HEADER. PSV SHALL BE PROVIDED FOR ADDITIONAL SAFETY.
4. ALL DRAINS SHALL BE CONNECTED TO LOCAL DRAIN TANK.
5. ALL VALVES SHALL BE DESIGNED FOR FIRE SAFE CONDITION
6. ON MACHINE TRIP, THIS VALVE SHALL BE INTERLOCKED TO CLOSE AFTER THE ANTISURGE VALVE GOES TO FULL OPEN.
7. ALL VESSELS (SCRUBBER, HEATER & GAS CONDENSATE DRAIN TANK) SHALL BE DESIGNED AS PER ASME SEC. VIII DIV-1
8. FLOW INSTRUMENTS REQUIRE MINIMUM STRAIGHT PIPE DISTANCE OF 10D UPSTREAM AND 5D DOWNSTREAM

## REFERENCE DRGS.:

1. 10-5111168-M-002 – SYMBOLS & LEGEND (EQUIPMENT & PIPING)
2. 10-5111168-M-003 – SYMBOLS & LEGEND (CONTROL & INSTRUMENTS)

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| | | | | – | SKS | – | MAG | FWR |
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| | | | | – | SKS | – | MAG | FWR |

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| APPROVED | sd/– | FWR | 06.04.12 |
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TITLE

# P & I DIAGRAM FOR NATURAL GAS SYSTEM
## (FUEL GAS CONDITIONING SYSTEM)

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| | STRUCTURAL | – | – | SVK |
| | MECHANICAL | – | – | FWR |
| | ELECTRICAL | – | – | AVD |
| | INST | – | – | BV |

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| | PRELIMINARY |
| ✓ | TENDER |
| | ENGINEERING |
| | CONSTRUCTION |

DEPT. : MECHANICAL | FI JOB No.: 5111168 | SCALE : NTS | REV. :

DWG.NO. 10-5111168-M-007 (SHEET 1 OF 4) C

File name: 5111168M007 Sheet 1 of 4.dwg---MKM---Jun.08'2012---18:09:24

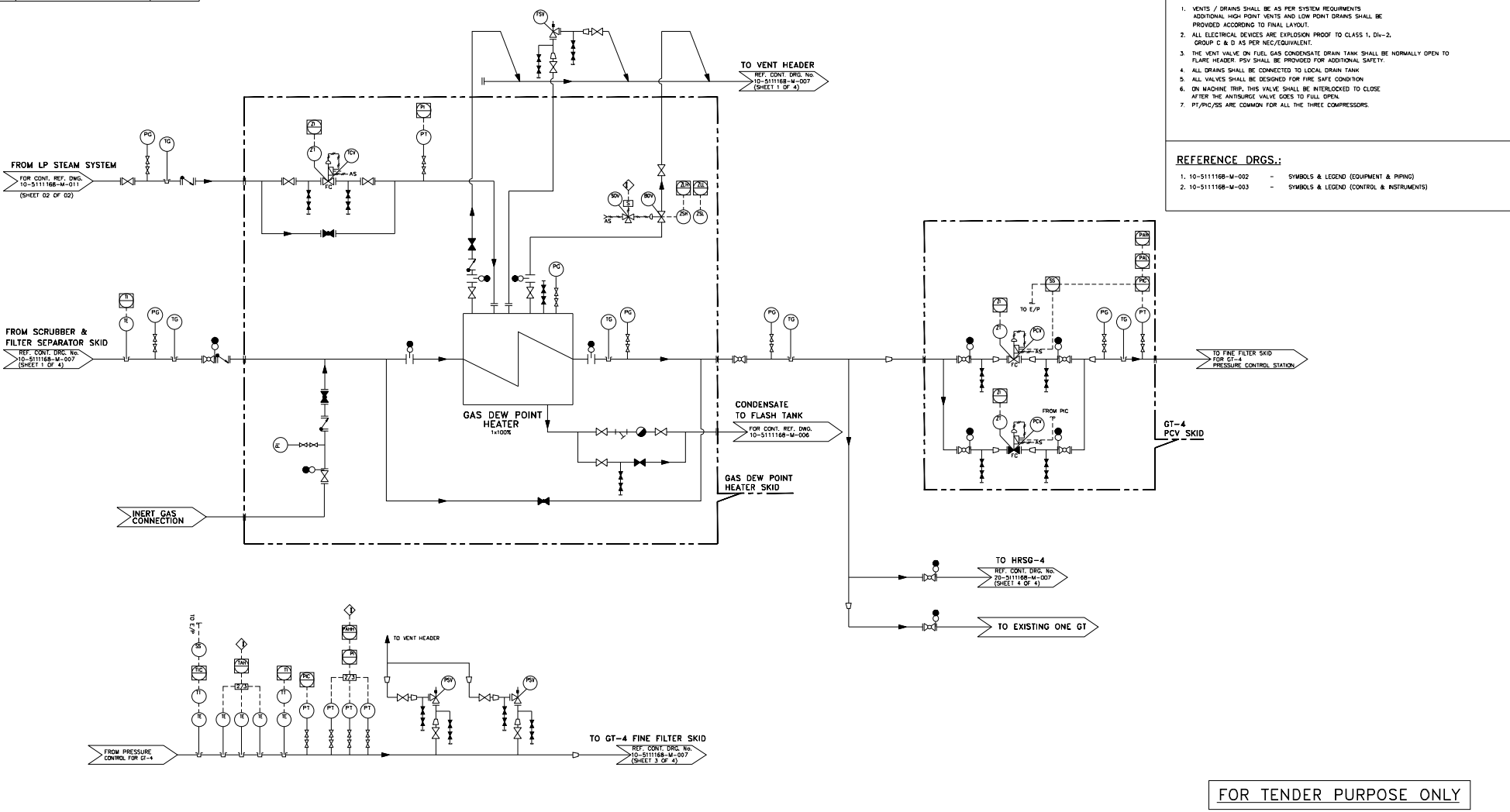
DWG. NO. 10-5111168-M-007 (SHEET 2 OF 4) REV. B

## NOTES:

1. VENTS / DRAINS SHALL BE AS PER SYSTEM REQUIRMENTS ADDITIONAL HIGH POINT VENTS AND LOW POINT DRAINS SHALL BE PROVIDED ACCORDING TO FINAL LAYOUT.
2. ALL ELECTRICAL DEVICES ARE EXPLOSION PROOF TO CLASS 1, Div-2, GROUP C & D AS PER NEC/EQUIVALENT.
3. THE VENT VALVE ON FUEL GAS CONDENSATE DRAIN TANK SHALL BE NORMALLY OPEN TO FLARE HEADER. PSV SHALL BE PROVIDED FOR ADDITIONAL SAFETY.
4. ALL DRAINS SHALL BE CONNECTED TO LOCAL DRAIN TANK
5. ALL VALVES SHALL BE DESIGNED FOR FIRE SAFE CONDITION
6. ON MACHINE TRIP, THIS VALVE SHALL BE INTERLOCKED TO CLOSE AFTER THE ANTISURGE VALVE GOES TO FULL OPEN.
7. PT/PIC/SS ARE COMMON FOR ALL THE THREE COMPRESSORS.

## REFERENCE DRGS.:

1. 10-5111168-M-002 – SYMBOLS & LEGEND (EQUIPMENT & PIPING)
2. 10-5111168-M-003 – SYMBOLS & LEGEND (CONTROL & INSTRUMENTS)




FOR TENDER PURPOSE ONLY

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| B | 17.05.12 | FOR TENDER PURPOSE ONLY | MKM | -- | SKS | -- | MAG | FWR |
| A | 08.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | MKM | -- | sd/- | -- | sd/- | sd/- |
| | | | | -- | SKS | -- | MAG | FWR |

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CLIENT: OIL AND NATURAL GAS CORPORATION LTD.
COMBINED CYCLE CAPTIVE POWER PLANT AT HAZIRA PLANT, GUJARAT.

| | SIGNATURE | DATE |
|---|---|---|
| DRAWN | ~~gbad~~ MKM | 06.04.12 |
| DESIGNED | sd/- SKS | 06.04.12 |
| CHECKED | sd/- SKS | 06.04.12 |
| APPROVED | sd/- FWR | 06.04.12 |
| PROJ. MGR | sd/- SG | 06.04.12 |

TITLE

# P & I DIAGRAM FOR NATURAL GAS SYSTEM (GAS DEW POINT HEATER & PCV)

| CLEARED (FOR RFQ ONLY) | | SIGNATURE | | DATE |
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| | STRUCTURAL | -- | -- | SVK |
| | MECHANICAL | -- | -- | FWR |
| | ELECTRICAL | -- | -- | AVD |
| | INST. | -- | -- | BV |

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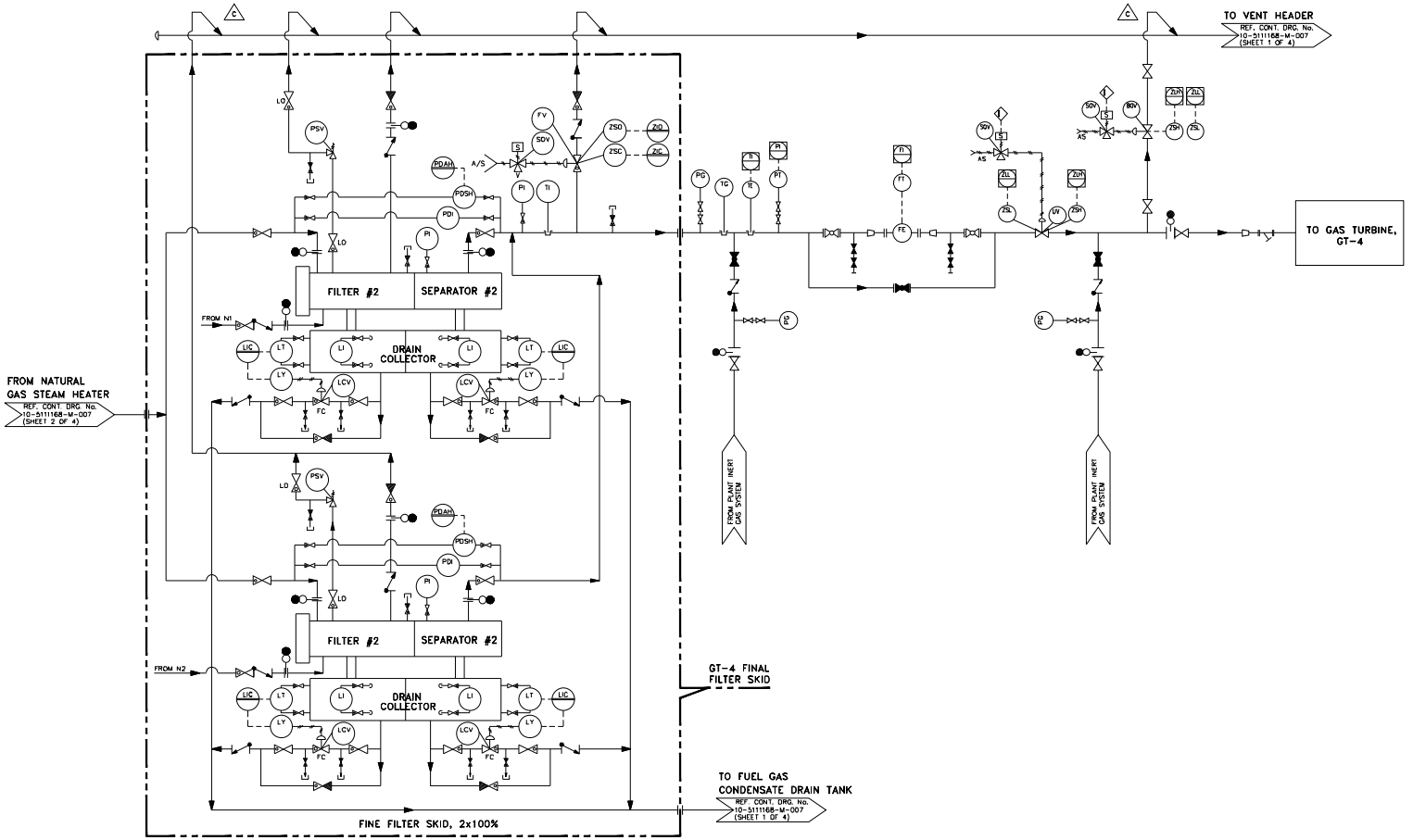
| TENDER | ☑ |
| ENGINEERING | |
| CONSTRUCTION | |

DEPT. : MECHANICAL | FI JOB No.: 5111168 | SCALE : NTS | REV. : B

DWG.NO. 10-5111168-M-007 (SHEET 2 OF 4)

File name: 5111168M007 Sheet 2 of 4.dwg---MKM---May.17'2012---10:37:23




## NOTES:

1. VENTS / DRAINS SHALL BE AS PER SYSTEM REQUIRMENTS ADDITIONAL HIGH POINT VENTS AND LOW POINT DRAINS SHALL BE PROVIDED ACCORDING TO FINAL LAYOUT.
2. FUEL GAS PIPING AT THE DOWN STREAM OF FINE FILTER SEPARATOR SHALL BE OF STAINLESS STEEL MATERIAL.
3. ALL ELECTRICAL DEVICES ARE EXPLOSION PROOF TO CLASS 1, DIV-2, GROUP C & D AS PER NEC/EQUIVALENT.
4. THE VENT VALVE ON FUEL GAS CONDENSATE DRAIN TANK SHALL BE NORMALLY OPEN TO FLARE HEADER. PSV SHALL BE PROVIDED FOR ADDITIONAL SAFETY.
5. ALL DRAINS SHALL BE CONNECTED TO LOCAL DRAIN TANK
6. ALL VALVES SHALL BE DESIGNED FOR FIRE SAFE CONDITION

## REFERENCE DRGS.:

1. 10-5111168-M-002 – SYMBOLS & LEGEND (EQUIPMENT & PIPING)
2. 10-5111168-M-003 – SYMBOLS & LEGEND (CONTROL & INSTRUMENTS)

**FOR TENDER PURPOSE ONLY**

| REV. | DATE | DESCRIPTION | DRN. | STR. | MECH. | ELEC. | INST. | APPD. |
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| | | | | – | SKS | – | MAG | FWR |
| B | 17.05.12 | FOR TENDER PURPOSE ONLY | MKM | – | sd/– | – | sd/– | sd/– |
| | | | | – | SKS | – | MAG | FWR |
| A | 06.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | MKM | – | sd/– | – | sd/– | sd/– |
| | | | | – | SKS | – | MAG | FWR |

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COMBINED CYCLE CAPTIVE POWER PLANT
AT HAZIRA PLANT, GUJARAT.

| | SIGNATURE | | DATE |
|---|---|---|---|
| DRAWN | ~~MKM~~ | MKM | 06.04.12 |
| DESIGNED | sd/– | SKS | 06.04.12 |
| CHECKED | sd/– | SKS | 06.04.12 |
| APPROVED | sd/– | FWR | 06.04.12 |
| PROJ. MGR. | sd/– | SG | 06.04.12 |

TITLE
P & I DIAGRAM FOR NATURAL GAS SYSTEM (GAS SUPPLY TO GT-4)

| CLEARED (FOR RO ONLY) | | SIGNATURE | | DATE |
|---|---|---|---|---|
| | STRUCTURAL | – | – | SVK |
| | MECHANICAL | – | – | FWR |
| | ELECTRICAL | – | – | AVD |
| | INST. | – | – | BV |

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| | PRELIMINARY |
| ✓ | TENDER |
| | ENGINEERING |
| | CONSTRUCTION |

DEPT. : MECHANICAL | FI JOB No.: 5111168 | SCALE : NTS | REV : C

DWG.NO. 10-5111168-M-007 (SHEET 3 OF 4)

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| REV. | DWG. NO. |
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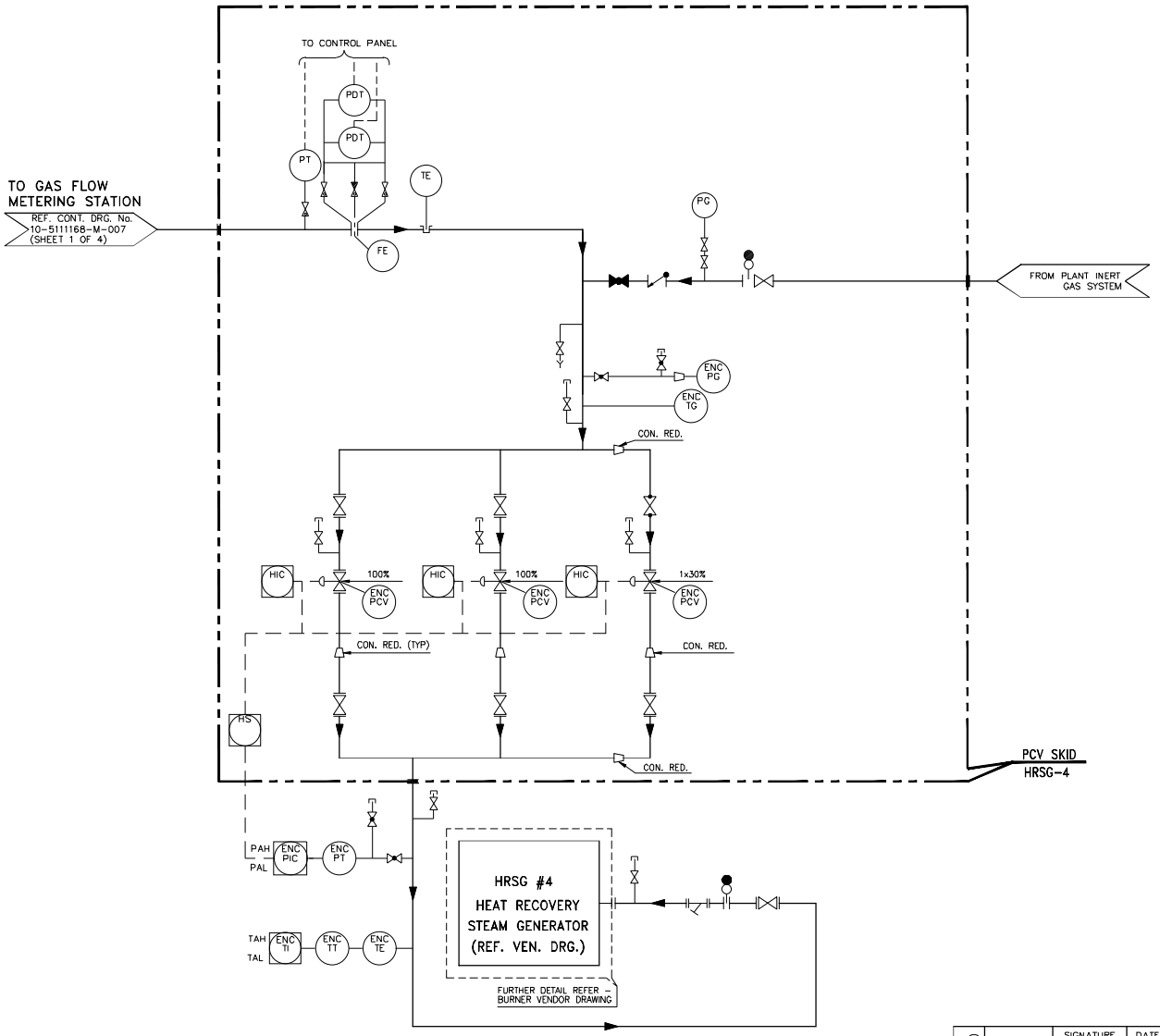
| B | 20-5111168-M-007 (Sheet 4 of 4) |




## NOTES:

1. VENTS / DRAINS SHALL BE AS PER SYSTEM REQUIRMENTS ADDITIONAL HIGH POINT VENTS AND LOW POINT DRAINS SHALL BE PROVIDED ACCORDING TO FINAL LAYOUT.
2. FUEL GAS PIPING AT THE DOWN STREAM OF FINE FILTER SEPARATOR SHALL BE OF STAINLESS STEEL MATERIAL.
3. ALL ELECTRICAL DEVICES ARE EXPLOSION PROOF TO CLASS 1, Div-2, GROUP C & D AS PER NEC/EQUIVALENT.
4. THE VENT VALVE ON FUEL GAS CONDENSATE DRAIN TANK SHALL BE NORMALLY OPEN TO VENT HEADER. PSV SHALL BE PROVIDED FOR ADDITIONAL SAFETY.
5. ALL DRAINS SHALL BE CONNECTED TO LOCAL DRAIN TANK
6. ALL VALVES SHALL BE DESIGNED FOR FIRE SAFE CONDITION

## REFERENCE DRGS.:

1. 10-5111168-M-002 – SYMBOLS & LEGEND (EQUIPMENT & PIPING)
2. 10-5111168-M-003 – SYMBOLS & LEGEND (CONTROL & INSTRUMENTS)

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| REV. | DATE | DESCRIPTION | DRN. | STR. | MECH. | ELEC. | INST. | APPD. |
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| B | 17.05.12 | FOR TENDER PURPOSE ONLY | MKM | – | SKS | – | MAG | FWR |
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| DRAWN | | MKM | 06.04.12 |
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| APPROVED | sd/– | FWR | 06.04.12 |
| PROJ. MGR. | sd/– | SG | 06.04.12 |

TITLE :

# P & I DIAGRAM FOR NATURAL GAS SYSTEM (HRSG-4 PCV SKID)

| CLEARED (FOR RO ONLY) | | SIGNATURE | | DATE |
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| | STRUCTURAL | – | – | SVK |
| | MECHANICAL | – | – | FWR |
| | ELECTRICAL | – | – | AVD |
| | INST. | – | – | BV |

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| | TENDER | ☑ |
| | ENGINEERING | ☐ |
| | CONSTRUCTION | ☐ |

| DEPT. : MECHANICAL | FI JOB No.: 5111168 | SCALE : NTS | REV. : |
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| DWG.NO. | 20-5111168-M-007 (Sheet 4 of 4) | | B |

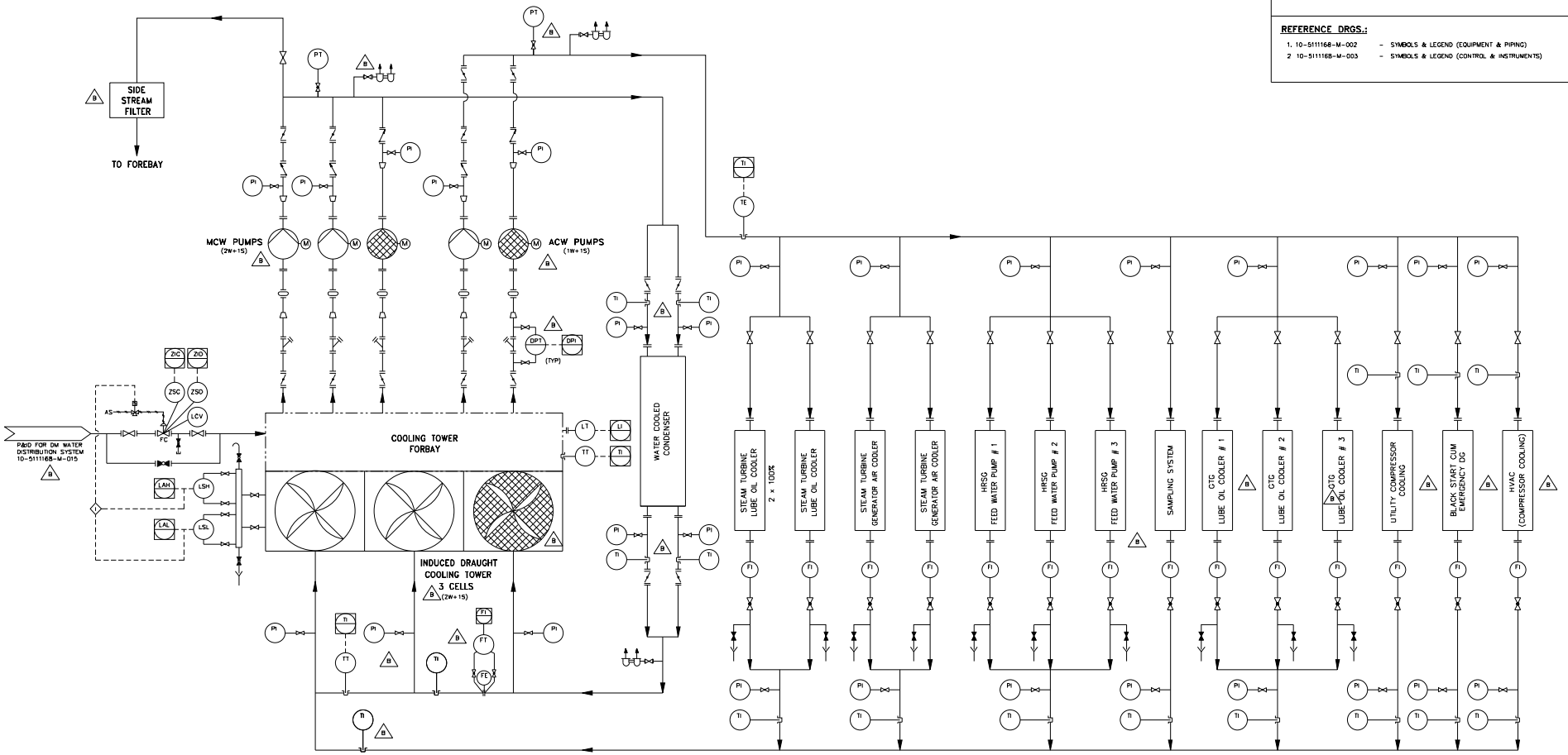
DWG. NO. 10-5111168-M-010 REV. B

**NOTES:**

1. HIGH POINT VENTS & LOW POINT DRAINS SHALL BE AS PER PIPING LAYOUT
2. ALL VENTS & DRAINS SHALL BE 25NB
3. THERMOWELLS/TEMPERATURE INSTRUMENTS INSTALLED IN LINES SMALLER THAN 80NB THEN PIPING SHALL BE EXPANDED TO 80NB TO ACCOMODATE THE ABOVE INSTRUMENTS

**REFERENCE DRGS.:**

1. 10-5111168-M-002 – SYMBOLS & LEGEND (EQUIPMENT & PIPING)
2. 10-5111168-M-003 – SYMBOLS & LEGEND (CONTROL & INSTRUMENTS)




FOR TENDER PURPOSE ONLY

| REV. | DATE | DESCRIPTION | DRN. | STR. | MECH. | ELEC. | INST. | APPD. |
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| B | 17.05.12 | FOR TENDER PURPOSE ONLY | MKM | – | SKS | – | MAG | FWR |
| A | 06.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | MKM | – | sd/– | – | sd/– | sd/– |
| | | | | – | SKS | – | MAG | FWR |

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| | SIGNATURE | | DATE |
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| DRAWN | ~~MKM~~ | MKM | 06.04.12 |
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| APPROVED | sd/– | FWR | 06.04.12 |
| PROJ. MGR. | sd/– | SG | 06.04.12 |

TITLE

# P & I DIGRAM FOR COOLING WATER SYSTEM

| CLEARED (FOR RO ONLY) | | SIGNATURE | | DATE |
|---|---|---|---|---|
| | STRUCTURAL | – | – | SVK |
| | MECHANICAL | – | – | FWR |
| | ELECTRICAL | – | – | AVD |
| | INST | – | – | BV |

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| PRELIMINARY | |
| TENDER | ✓ |
| ENGINEERING | |
| CONSTRUCTION | |

DEPT. : MECHANICAL | FI JOB No.: 5111168 | SCALE : NTS | REV. :

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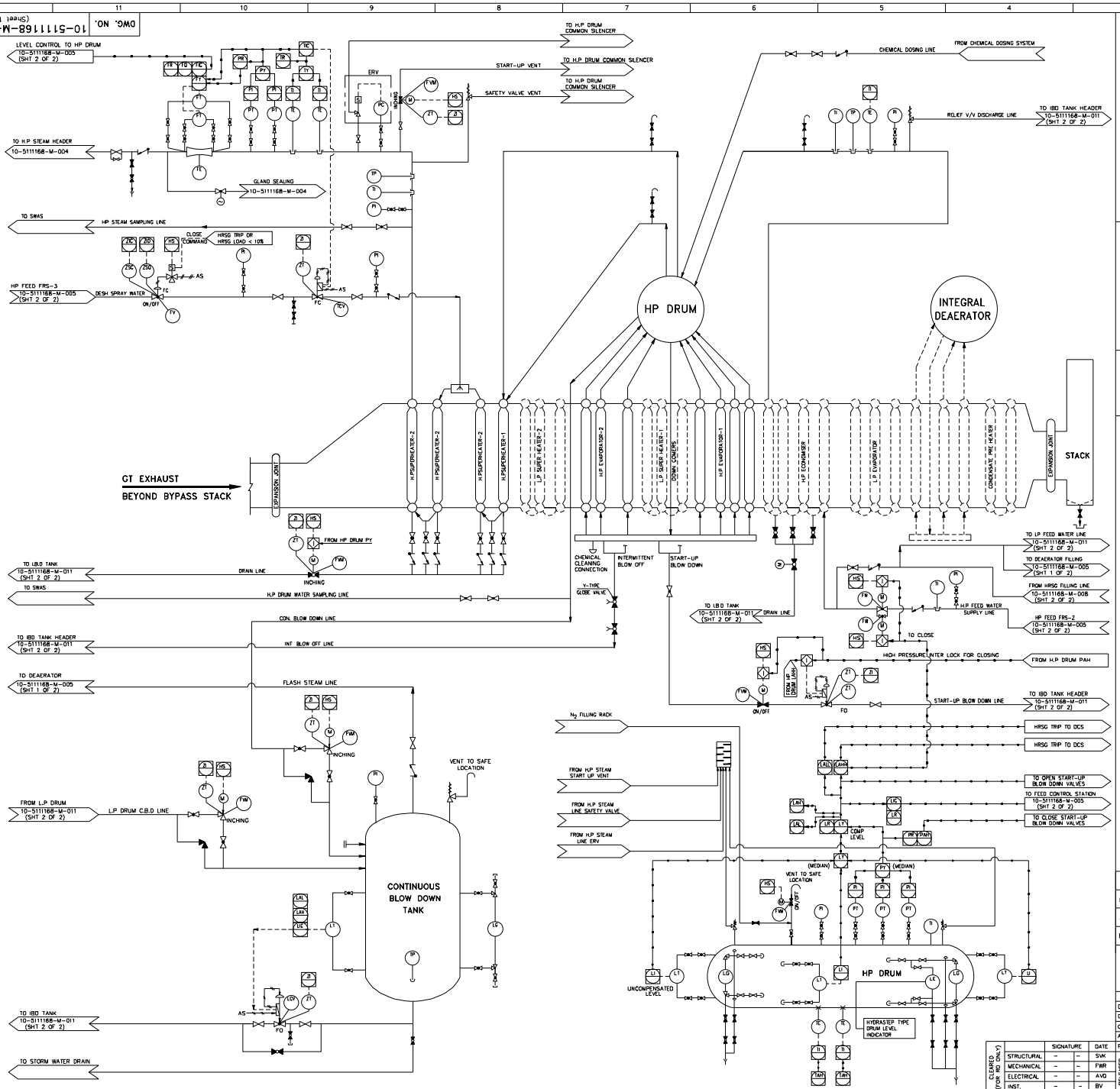


DWG. NO. 10-5111168-M-011 (Sheet 1 of 2) REV. B

## NOTES:

1. LOW DRAIN POINTS AND HIGH VENT SHALL BE PROVIDED AT SUITABLE LOCATIONS AS PER PIPING LAYOUT
2. ALL CONTROL VALVES ARE PROVIDED WITH POSITION FEED BACK TRANSMITTERS.
3. ALL MOTORIZED VALVES ARE PROVIDED WITH OPEN AND CLOSE POSITION LIMIT AND TORQUE SWITCHES.
4. ALL DRAINS AND VENTS ARE 25NB UNLESS OTHERWISE SPECIFIED.
5. ALL INSTRUMENTS SHALL BE WITH PROCESS ISOLATION VALVE AND AN INSTRUMENT ISOLATION VALVE, WITH PROVISION FOR VENT AND DRAIN.
6. ALL TEMPERATURE INSTRUMENTS SHALL BE PROVIDED WITH THERMOWELL.
7. ALL DRAINS LOCATED IN THE HP/LP STEAM LINES UPSTREAM OF STEAM TURBINE SHALL BE AS PER ASME TDP-1, 1995
8. ALL EXTERNAL DRAINS SHALL BE CONNECTED TO ATMOSPHERIC FLASH TANK
9. THE SCHEME SHOWN HERE IS ONLY FOR ONE(1) HRSG. THE SCHEME SHALL BE TYPICAL FOR OTHER HRSG ALSO.

## REFERENCE DRGS.:

1. 10-5111168-M-002 – SYMBOLS & LEGEND (EQUIPMENT & PIPING)
2. 10-5111168-M-003 – SYMBOLS & LEGEND (CONTROL & INSTRUMENTS)
3. 10-5111168-M-004 – P & ID STEAM SYSTEM
4. 10-5111168-M-005 – P & ID FEED WATER SYSTEM (2 SHEETS)
5. 10-5111168-M-006 – P & ID CONDENSATE SYSTEM
6. 10-5111168-M-008 – P & ID MAKE UP WATER SYSTEM

## LEGEND:

ERV – ELECTROMATIC RELIEF VALVE

FOR TENDER PURPOSE ONLY

| REV. | DATE | DESCRIPTION | DRN. | CHECKED & CLEARED | APPD. |
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| B | 17.05.12 | FOR TENDER PURPOSE ONLY | MKM | SKS | FWR |
| A | 06.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | MKM | SKS | FWR |

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AT HAZIRA PLANT, GUJARAT.

| | SIGNATURE | | DATE |
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| DRAWN | ~~MKM~~ | MKM | 06.04.12 |
| DESIGNED | sd/- | SKS | 06.04.12 |
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| APPROVED | sd/- | FWR | 06.04.12 |
| PROJ. MGR. | sd/- | SG | 06.04.12 |

TITLE
P & I DIAGRAM FOR HRSG (HP SECTION)

| CLEARED (FOR RD ONLY) | | SIGNATURE | | DATE |
|---|---|---|---|---|
| | STRUCTURAL | – | – | SVK |
| | MECHANICAL | – | – | FWR |
| | ELECTRICAL | – | – | AVD |
| | INST. | – | – | BV |

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DEPT. : MECHANICAL | FI JOB No : 5111168 | SCALE : NTS | REV : B

DWG.NO. 10-5111168-M-011 (Sheet 1 of 2)

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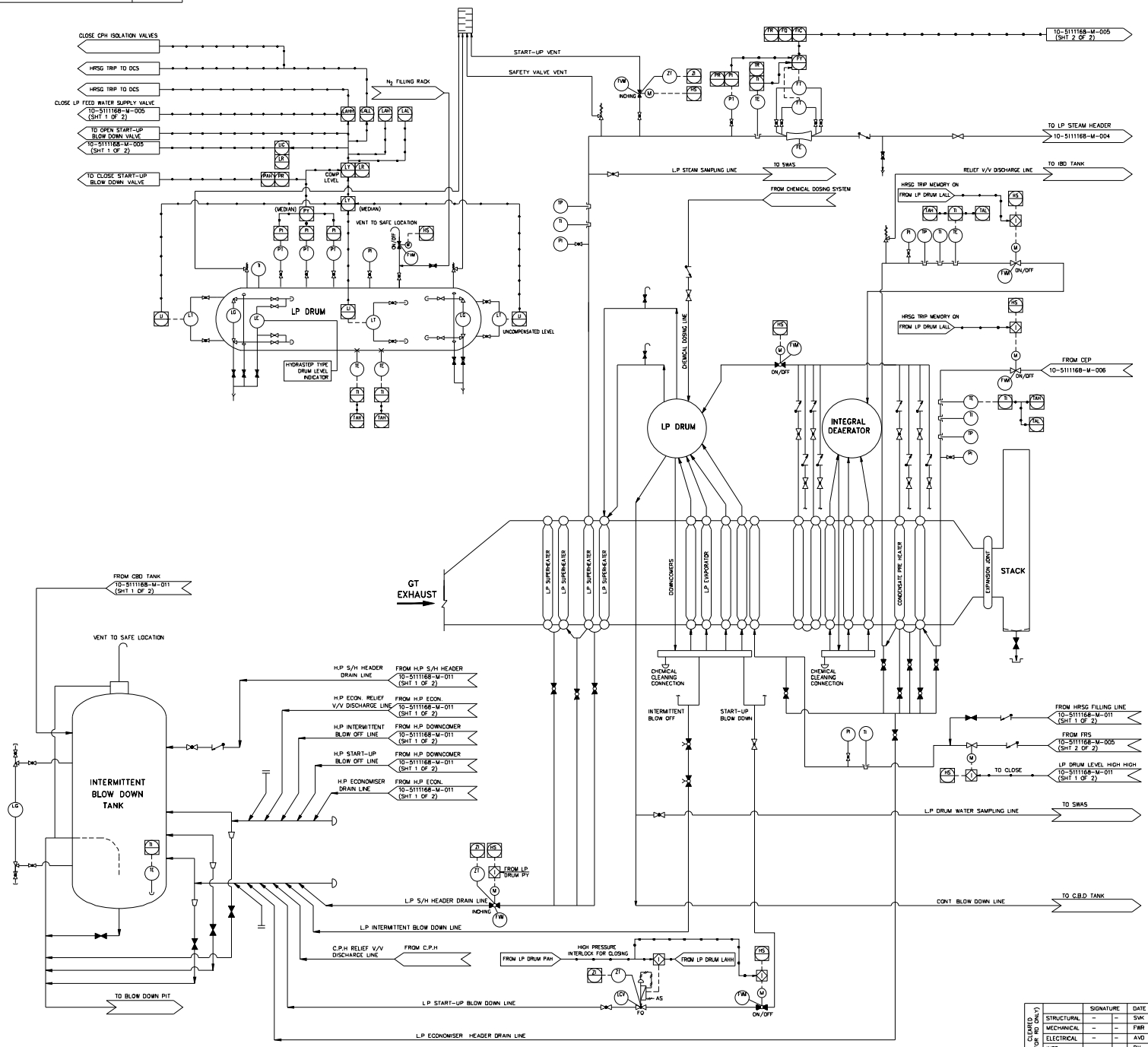
DWG. NO. 10-5111168-M-011 (Sheet 2 of 2) REV. B




## NOTES:

1. LOW DRAIN POINTS AND HIGH VENT SHALL BE PROVIDED AT SUITABLE LOCATIONS AS PER PIPING LAYOUT
2. ALL CONTROL VALVES ARE PROVIDED WITH POSITION FEED BACK TRANSMITTERS.
3. ALL MOTORISED VALVES ARE PROVIDED WITH OPEN AND CLOSE POSITION LIMIT AND TORQUE SWITCHES
4. ALL DRAINS AND VENTS ARE 25NB UNLESS OTHERWISE SPECIFIED.
5. VALVES, INSTRUMENT AND LINE TAGGING SHALL BE DONE BY EPC CONTRACTOR BASED ON AGREED PLANT IDENTIFICATION PHILOSOPHY
6. ALL INSTRUMENTS SHALL BE WITH PROCESS ISOLATION VALVE AND AN INSTRUMENT ISOLATION VALVE, WITH PROVISION FOR VENT AND DRAIN.
7. ALL TEMPERATURE INSTRUMENTS SHALL BE PROVIDED WITH THERMOWELL.
8. ALL DRAINS LOCATED IN THE HP/LP STEAM LINES UPSTREAM OF STEAM TURBINE SHALL BE AS PER ASME TDP-1, 1995
9. ALL EXTERNAL DRAINS SHALL BE CONNECTED TO ATMOSPHERIC FLASH TANK
10. THE SCHEME SHOWN HERE IS ONLY FOR ONE(1) HRSG. THE SCHEME SHALL BE TYPICAL FOR OTHER HRSG.

## REFERENCE DRGS.:

| | | | |
|---|---|---|---|
| 1. | 10-5111168-M-002 | - | SYMBOLS & LEGEND (EQUIPMENT & PIPING) |
| 2. | 10-5111168-M-003 | - | SYMBOLS & LEGEND (CONTROL & INSTRUMENTS) |
| 3. | 10-5111168-M-004 | - | P & ID STEAM SYSTEM |
| 4. | 10-5111168-M-005 | - | P & ID FEED WATER SYSTEM (2 SHEETS) |
| 5. | 10-5111168-M-006 | - | P & ID CONDENSATE SYSTEM |

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| REV. | DATE | DESCRIPTION | DRN. | STR. | MECH. | ELEC. | INST. | APPD. |
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| B | 17.05.12 | FOR TENDER PURPOSE ONLY | MKM | - | SKS | - | MAC | FWR |
| A | 06.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | MKM | - | sd/- | - | sd/- | sd/- |
| | | | | - | SKS | - | MAC | FWR |

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AT HAZIRA PLANT, GUJARAT.

| | SIGNATURE | | DATE |
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| APPROVED | sd/- | FWR | 06.04.12 |
| PROJ. MGR | sd/- | SG | 06.04.12 |

TITLE
# P & I DIAGRAM FOR HRSG (LP SECTION)

| CLEARED (FOR RD ONLY) | | SIGNATURE | | DATE |
|---|---|---|---|---|
| | STRUCTURAL | - | - | SVK |
| | MECHANICAL | - | - | FWR |
| | ELECTRICAL | - | - | AVD |
| | INST. | - | - | BV |

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DEPT. : MECHANICAL | FI JOB No.: 5111168 | SCALE : NTS | REV :

DWG.NO. 10-5111168-M-011 (Sheet 2 of 2) B

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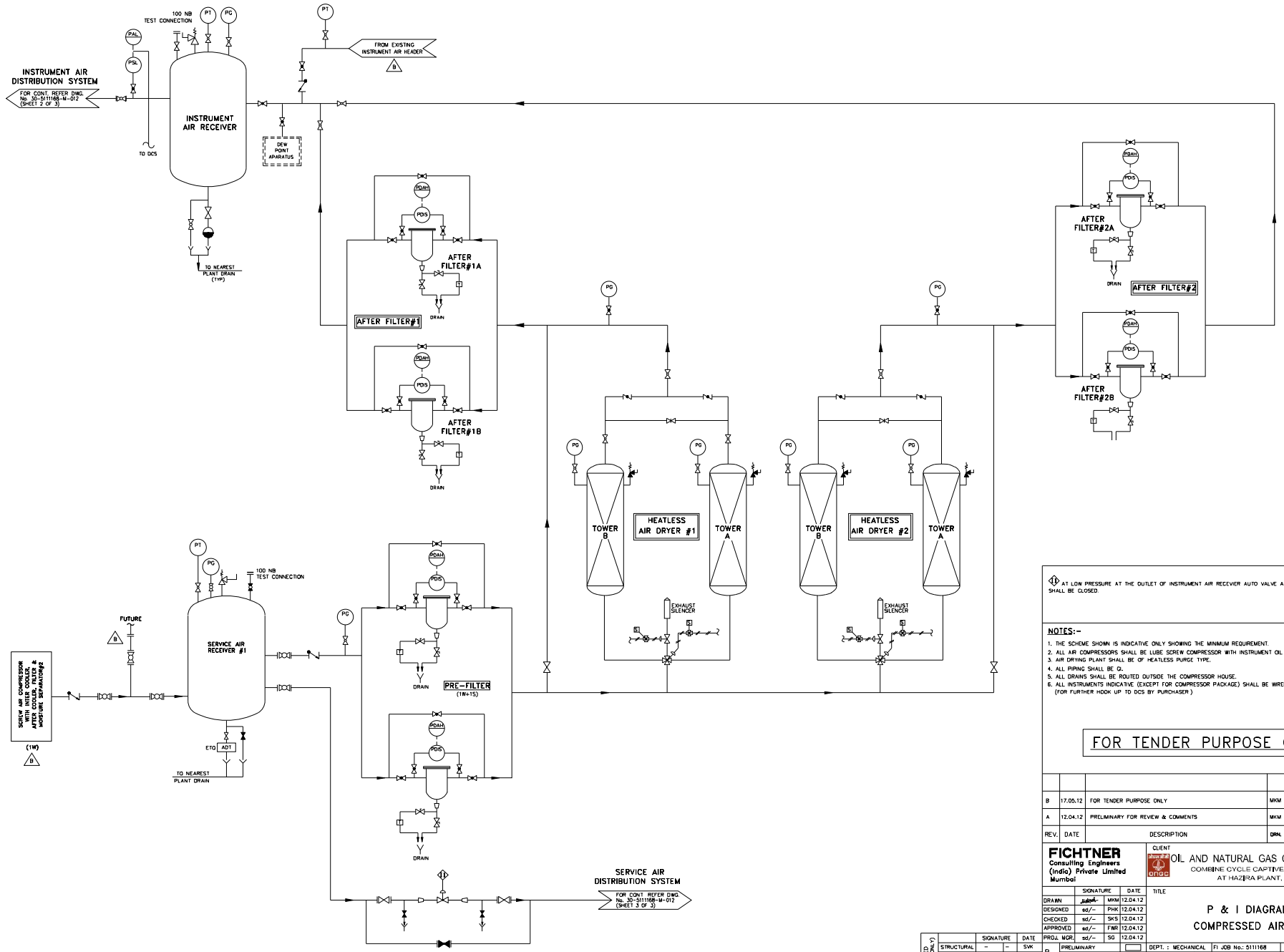


1. AT LOW PRESSURE AT THE OUTLET OF INSTRUMENT AIR RECEIVER AUTO VALVE AT THE OUTLET OF SERVICE AIR SHALL BE CLOSED.

**NOTES:-**

1. THE SCHEME SHOWN IS INDICATIVE ONLY SHOWING THE MINIMUM REQUIREMENT.
2. ALL AIR COMPRESSORS SHALL BE LUBE SCREW COMPRESSOR WITH INSTRUMENT OIL QUALITY : ISO 8573.1 CLASS1
3. AIR DRYING PLANT SHALL BE OF HEATLESS PURGE TYPE.
4. ALL PIPING SHALL BE Q.
5. ALL DRAINS SHALL BE ROUTED OUTSIDE THE COMPRESSOR HOUSE.
6. ALL INSTRUMENTS INDICATIVE (EXCEPT FOR COMPRESSOR PACKAGE) SHALL BE WIRED UPTO JUNCTION BOX (FOR FURTHER HOOK UP TO DCS BY PURCHASER )

**FOR TENDER PURPOSE ONLY**

| REV. | DATE | DESCRIPTION | DRN. | STR. | MECH. | ELEC. | INST. | APPD. |
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| B | 17.05.12 | FOR TENDER PURPOSE ONLY | MKM | - | SKS | - | MAG. | FWR |
| A | 12.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | MKM | - | sd/- | - | sd/- | sd/- |
| | | | | - | SKS | - | MAG | FWR |

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CLIENT: OIL AND NATURAL GAS CORPORATION LTD.
COMBINE CYCLE CAPTIVE POWER PLANT AT HAZIRA PLANT, GUJARAT.

| | SIGNATURE | | DATE |
|---|---|---|---|
| DRAWN | ~~jubeel~~ | MKM | 12.04.12 |
| DESIGNED | sd/- | PHK | 12.04.12 |
| CHECKED | sd/- | SKS | 12.04.12 |
| APPROVED | sd/- | FWR | 12.04.12 |
| PROJ. MGR. | sd/- | SG | 12.04.12 |

TITLE: P & I DIAGRAM FOR COMPRESSED AIR SYSTEM

| CLEARED (FOR RO ONLY) | | SIGNATURE | | DATE |
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| | STRUCTURAL | - | - | SVK |
| | MECHANICAL | - | - | FWR |
| | ELECTRICAL | - | - | AVD |
| | INST | - | - | BV |

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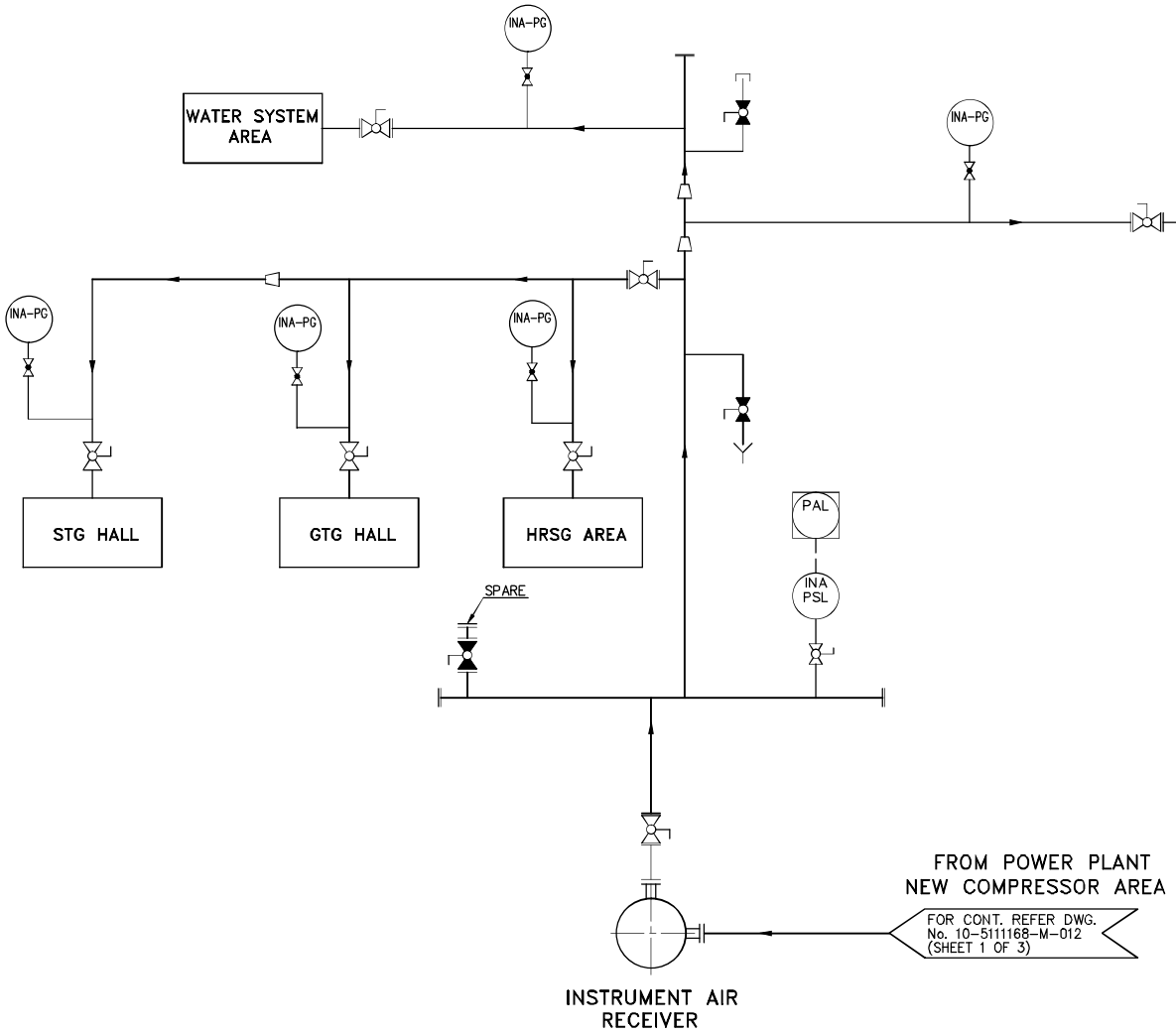
| | PRELIMINARY |
| ✓ | TENDER |
| | ENGINEERING |
| | CONSTRUCTION |

DEPT. : MECHANICAL | FI JOB No.: 5111168 | SCALE : NTS | REV. :

DWG.NO. 10-5111168-M-012 (SHEET 1 OF 3) B




FOR TENDER PURPOSE ONLY

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Mumbai.

CLIENT :
OIL AND NATURAL GAS CORPORATION LTD.
COMBINED CYCLE CAPTIVE POWER PLANT
AT HAZIRA PLANT, GUJARAT.

NOTES:-
1. THE SCHEME SHOWN IS INDICATIVE ONLY SHOWING THE MINIMUM REQUIREMENT.
2. ALL PIPING SHALL BE GI.
3. ALL INSTRUMENTS ARE INDICATIVE.

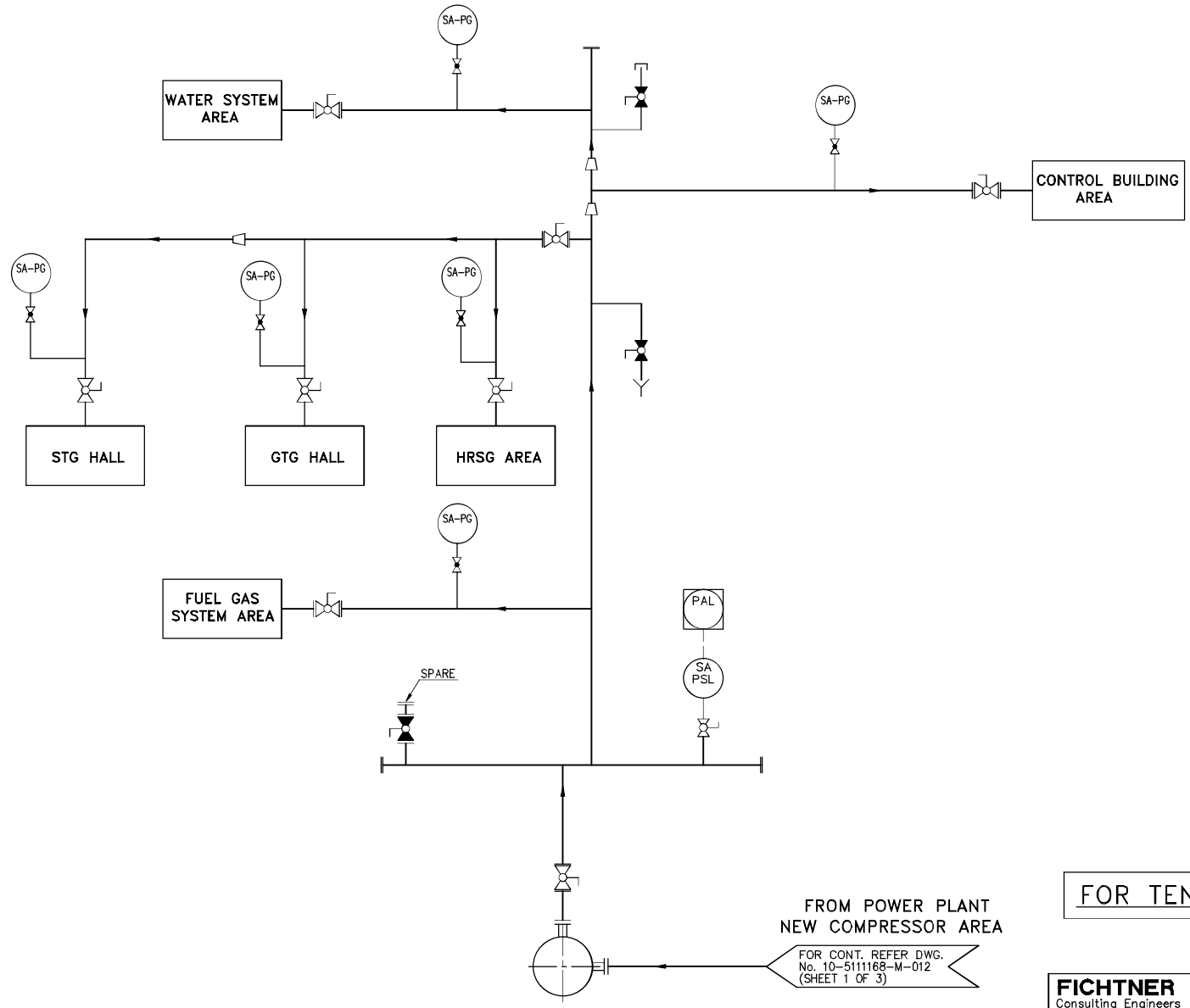
| REV. | DATE | DESCRIPTION | SIG. |
|---|---|---|---|
| B | 17.05.12 | FOR TENDER PURPOSE ONLY | sd/- |
| A | 19.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | sd/- |

| DRN. | CHKD. | APPD. | DATE |
|---|---|---|---|
| MKM | SKS | FWR | 17.05.12 |

TITLE
P & I DIAGRAM FOR
INSTRUMENT AIR DISTRIBUTION SYSTEM

DWG. No.:30-5111168-M-012 | SHEET : 2 OF 3 | SCALE : NTS | REV. B

FILE NAME: 5111168M012 Sheet 2 of 3.dwg---MKM---June 11, 2012---15:53:38




FOR TENDER PURPOSE ONLY

NOTES:-

1. THE SCHEME SHOWN IS INDICATIVE ONLY SHOWING THE MINIMUM REQUIREMENT.
2. ALL PIPING SHALL BE GI.
3. ALL INSTRUMENTS ARE INDICATIVE.

| REV. | DATE | DESCRIPTION | SIG. |
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| B | 17.05.12 | FOR TENDER PURPOSE ONLY | sd/- |
| A | 19.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | sd/- |

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| MKM | SKS | FWR | 17.05.12 |
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COMBINED CYCLE CAPTIVE POWER PLANT AT HAZIRA PLANT, GUJARAT.

TITLE
P & I DIAGRAM FOR SERVICE AIR DISTRIBUTION SYSTEM

DWG. No.:30-5111168-M-012 | SHEET : 3 OF 3 | SCALE : NTS | REV. B

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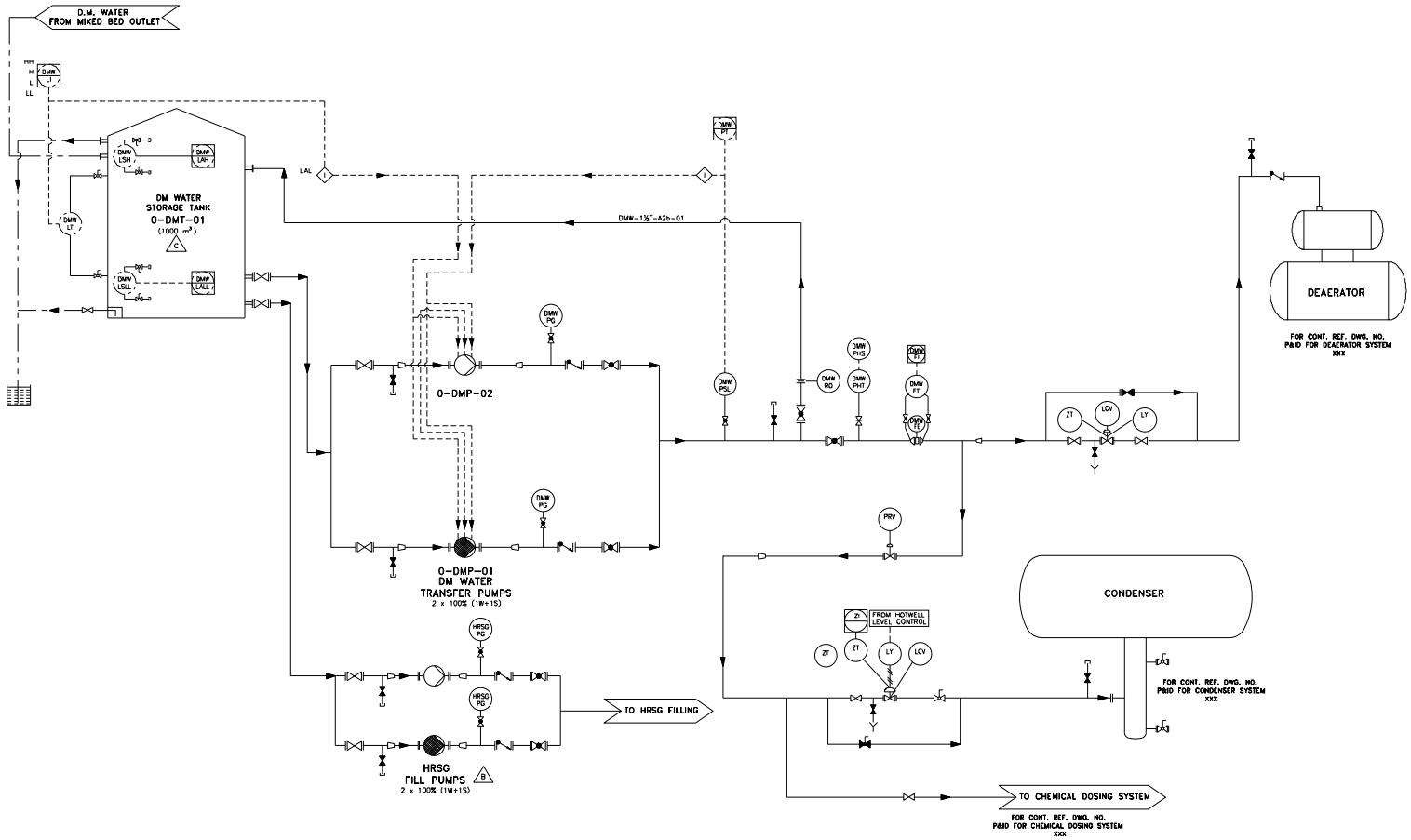
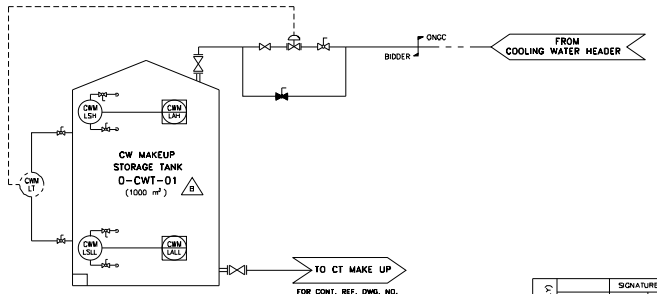
DWG. NO. 10-5111168-M-015 REV. C




## LEGEND

1. OC ---------- OTHER CONTRACTOR
2. WTPV ---------- WATER TREATMENT PLANT VENDOR
3. PC ---------- PIPING CONTRACTOR
4. TC ---------- TURBINE CONTRACTOR
5. CC ---------- COOLING TOWER CONTRACTOR

## REFERENCE DRGS.:

1. 10-5111168-M-002 – SYMBOLS & LEGEND (EQUIPMENT & PIPING)
2. 10-5111168-M-003 – SYMBOLS & LEGEND (CONTROL & INSTRUMENTS)
3. 10-5111168-M-010 – P & I DIAGRAM FOR COOLING WATER SYSTEM

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| DRAWN | ~~MKM~~ | MKM | 16.04.12 |
| DESIGNED | sd/– | RC | 16.04.12 |
| CHECKED | sd/– | SKS | 16.04.12 |
| APPROVED | sd/– | FWR | 16.04.12 |
| PROJ. MGR. | sd/– | SG | 16.04.12 |

TITLE
# P & I DIAGRAM FOR DM WATER DISTRIBUTION SYSTEM

| CLEARED (FOR RO ONLY) | | SIGNATURE | | DATE |
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| | STRUCTURAL | – | – | SVK |
| | MECHANICAL | – | – | FWR |
| | ELECTRICAL | – | – | AVD |
| | INST | – | – | BV |

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DEPT. : MECHANICAL | FI JOB No.: 5111168 | SCALE : NTS | REV. : C

DWG.NO. 10-5111168-M-015

File name: 5111168M015.dwg---MKM---Jun,11'2012---10:32:42

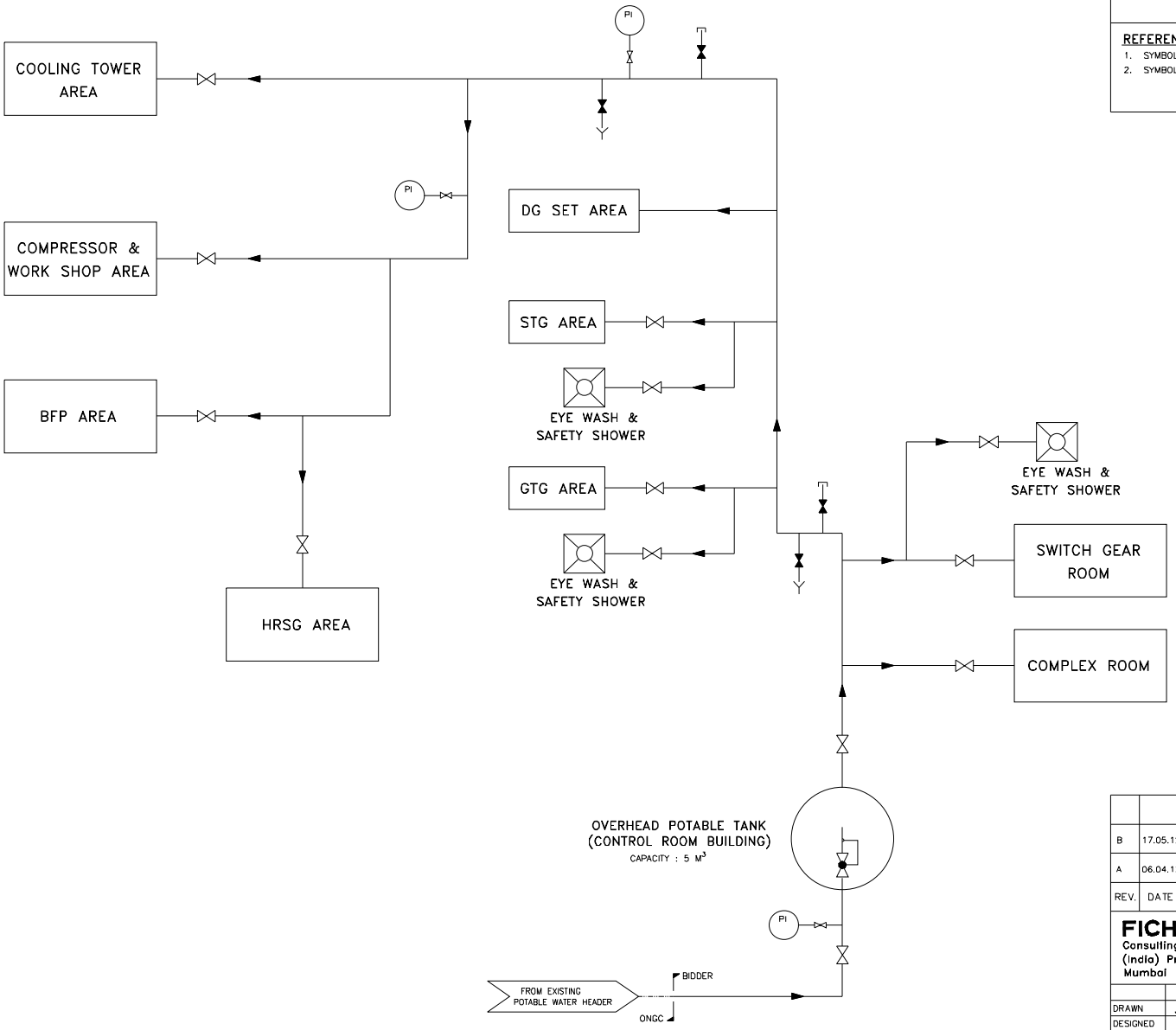
DWG. NO. 20-5111168-M-017 REV. B

**NOTES:-**

1. POTABLE WATER TAP POINTS SHALL BE PROVIDED WITH OV STERILIZER.

**REFERENCE DRAWINGS:-**

1. SYMBOLS & LEGEND (EQUIPMENT & PIPING) ——— 10-5111168-M-002
2. SYMBOLS & LEGEND (CONTROL & INSTRUMENTS) ——— 10-5111168-M-003

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| A | 06.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | MKM | – | sd/– | – | sd/– | sd/– |
| | | | | – | SKS | – | MAG | FWR |

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| DESIGNED | sd/– | AAP | 06.04.12 |
| CHECKED | sd/– | SKS | 06.04.12 |
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TITLE :

# P & I DIAGRAM FOR POTABLE WATER DISTRIBUTION SYSTEM

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| | MECHANICAL | – | – | FWR |
| | ELECTRICAL | – | – | AVD |
| | INST. | – | – | BV |

| RELEASED FOR | | |
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| | PRELIMINARY | ☐ |
| | TENDER | ☑ |
| | ENGINEERING | ☐ |
| | CONSTRUCTION | ☐ |

DEPT. : MECHANICAL | FI JOB No.: 5111168 | SCALE : NTS | REV. :

DWG.NO. 20-5111168-M-017 | B

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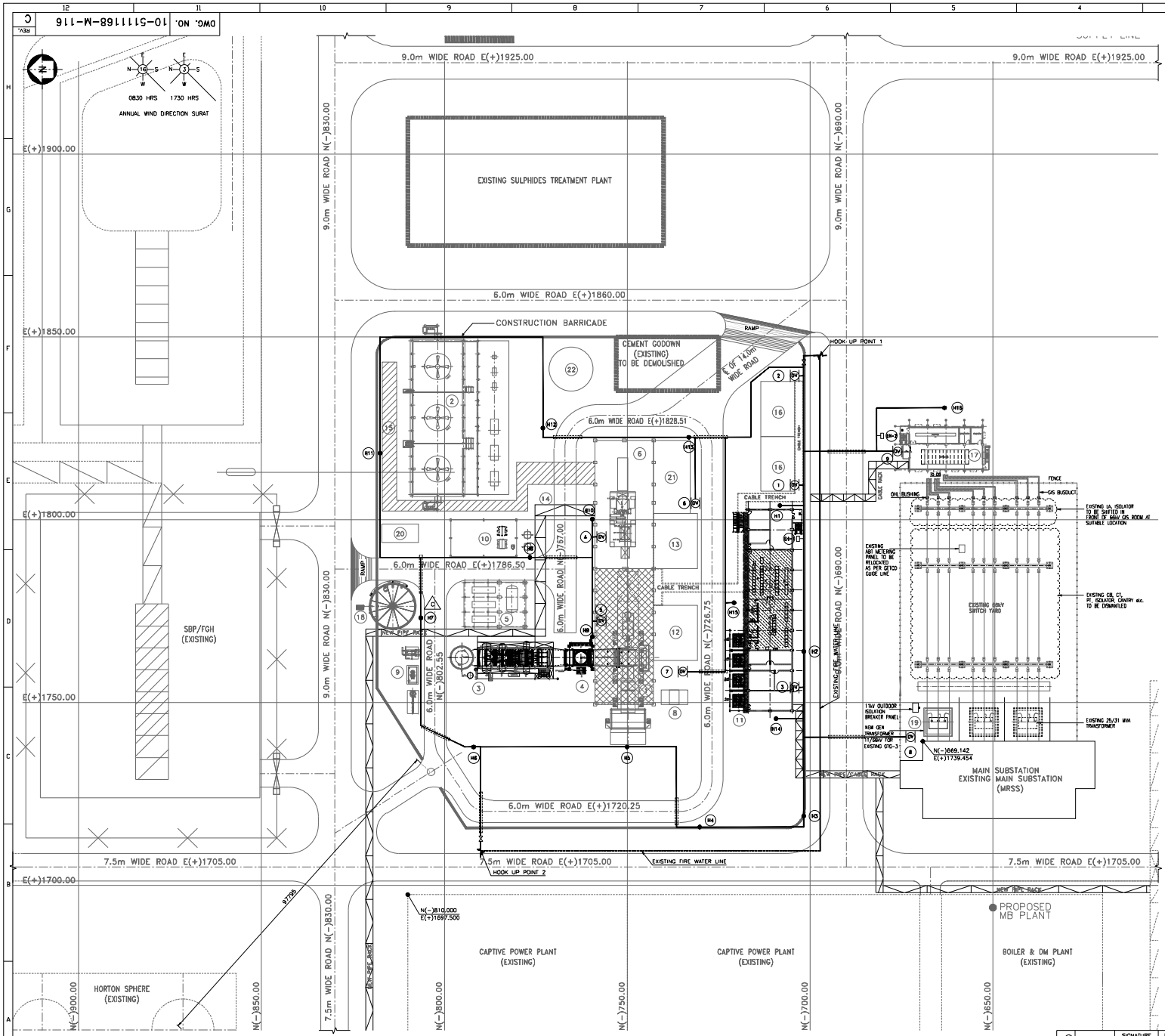


DWG. NO. 10-5111168-M-116 REV. C

**NOTES:-**

1. ALL DIMENSIONS ARE IN MILLIMETRES AND COORDINATES ARE IN METRES.
2. EL.99.5 REFER TO FINISHED GROUND LEVEL OF THIS AREA WHICH CORRESPONDS RL.6.00 FROM MSL & EL.101.00 REFER TO FGL. OF PROPOSED POWER PLANT WHICH CORRESPONDS TO RL 7.50 FROM MSL.
3. THE FIRE HYDRANT LAYOUT WITH No. OF DELUGE VALVES, HYDRANTS, PIPING SHOWN IS INDICATIVE & CONCEPTUAL ONLY. THE DETAILED DESIGN MEETING THE TAC/NFPA/OISD REQUIREMENTS SHALL BE CARRIED OUT BY FIRE PROTECTION SYSTEM VENDOR.

**REFERENCE DRAWINGS:-**

1. PLOT PLAN ——— 10.5111168-G-001

**LEGENDS:**

| | |
|---|---|
| -------- | FIRE HYDRANT LINE |
| -------- | EXISTING FIRE HYDRANT LINE |
| -------- | EXISTING FIRE HYDRANT LINE (UNDER GROUND) |
| H1 H2 -------- | YARD HYDRANT |
| -------- | HUME PIPES |
| 1 2 3 -------- | FIRE ESCAPE HYDRANT |
| DV -------- | DELUGE VALVE |
| -------- | ISOLATION VALVE |

**SPECIAL NOTES:**

1. TOTAL No. OF FIRE HYDRANTS = 16
2. TOTAL No OF ESCAPE HYDRANT = 2
3. TOTAL No OF DELUGE VALVE = 9

**LIST OF MAJOR BUILDINGS / STRUCTURE :-** B

| ITEM NO. | DESCRIPTION | DIMENSION (M) | NOS. |
|---|---|---|---|
| 1 | GAS TURBINE GENERATOR | 47 x 14 | 1 |
| 2 | COOLING TOWER & CT PUMP AREA | 50 x 27 | 1 |
| 3 | HEAT RECOVERY STEAM GENERATOR & MAIN STACK | 32 x 12 | 1 |
| 4 | BYPASS STACK | – | 1 |
| 5 | DEAERATOR & BFP PUMP AREA | 17 x14 | 1 |
| 6 | GTG / STG HALL | 72 x 16 | 1 |
| 7A | CABLE SPREADER ROOM | – | 1 |
| 7B | SWITCH GEAR ROOM | 55 x 12 | 1 |
| 7C | CONTROL ROOM | – | 1 |
| 8 | LOCAL CONTROL ROOM FOR GTG | 7 x 4 | 1 |
| 9 | FUEL GAS CONDITIONING SYSTEM | 19 x 5 | 1 |
| 10 | AIR COMPRESSOR & WORK SHOP | 18 x 10 | 1 |
| 11 | LT AUXILIARY TRANSFORMER | 6 x 6 | 4 |
| 12 | GTG TRANSFORMER | 15 x 12 | 1 |
| 13 | STG TRANSFORMER | 15 x 12 | 1 |
| 14 | PIPE/CABLE RACK | – | – |
| 15 | BURIED COOLING WATER HEADER | – | – |
| 16 | STATION TRANSFORMERS | 15 x 12 | 2 |
| 17 | 66kv INDOOR GAS INSULATED SUB STATION (GIS) | – | 1 |
| 18 | DM WATER TANK | – | 1 |
| 19 | NEW GENERATOR TRANSFORMER FOR EXISTING GTG-3 | 15 x 12 | 1 |
| 20 | HOLDING POND & TRANSFER PUMP AREA | 10 x 5 | 1 |
| 21 | BLACK START CUM EMERGENCY DG SHED | 20 x 10 | 1 |
| 22 | CW MAKE-UP WATER STORAGE TANK | – | 1 |

**FOR TENDER PURPOSE ONLY**

| REV. | DATE | DESCRIPTION | DRN. | STR. | MECH. | ELEC. | INST. | APPD. |
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| | | | | PMB | SKS | APK | MAG | FWR |
| B | 17.05.12 | FOR TENDER PURPOSE ONLY | MKM | sd/- | sd/- | sd/- | sd/- | sd/- |
| | | | | PMB | SKS | APK | MAG | FWR |
| A | 06.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | MKM | sd/- | sd/- | sd/- | sd/- | sd/- |
| | | | | PMB | SKS | APK | MAG | FWR |

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| DRAWN | MKM | | 06.04.12 |
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| CHECKED | sd/- | SKS | 06.04.12 |
| APPROVED | sd/- | FWR | 06.04.12 |
| PROJ MGR | sd/- | SG | 06.04.12 |

TITLE
FIRE HYDRANT LAYOUT

CLEARED (FOR RD ONLY)

| | SIGNATURE | | DATE |
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| STRUCTURAL | – | – | SVK |
| MECHANICAL | – | – | FWR |
| ELECTRICAL | – | – | AVD |
| INST. | – | – | BV |

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DEPT. : MECHANICAL | FI JOB No : 5111168 | SCALE : 1:500 | REV : C

DWG.NO. 10-5111168-M-116

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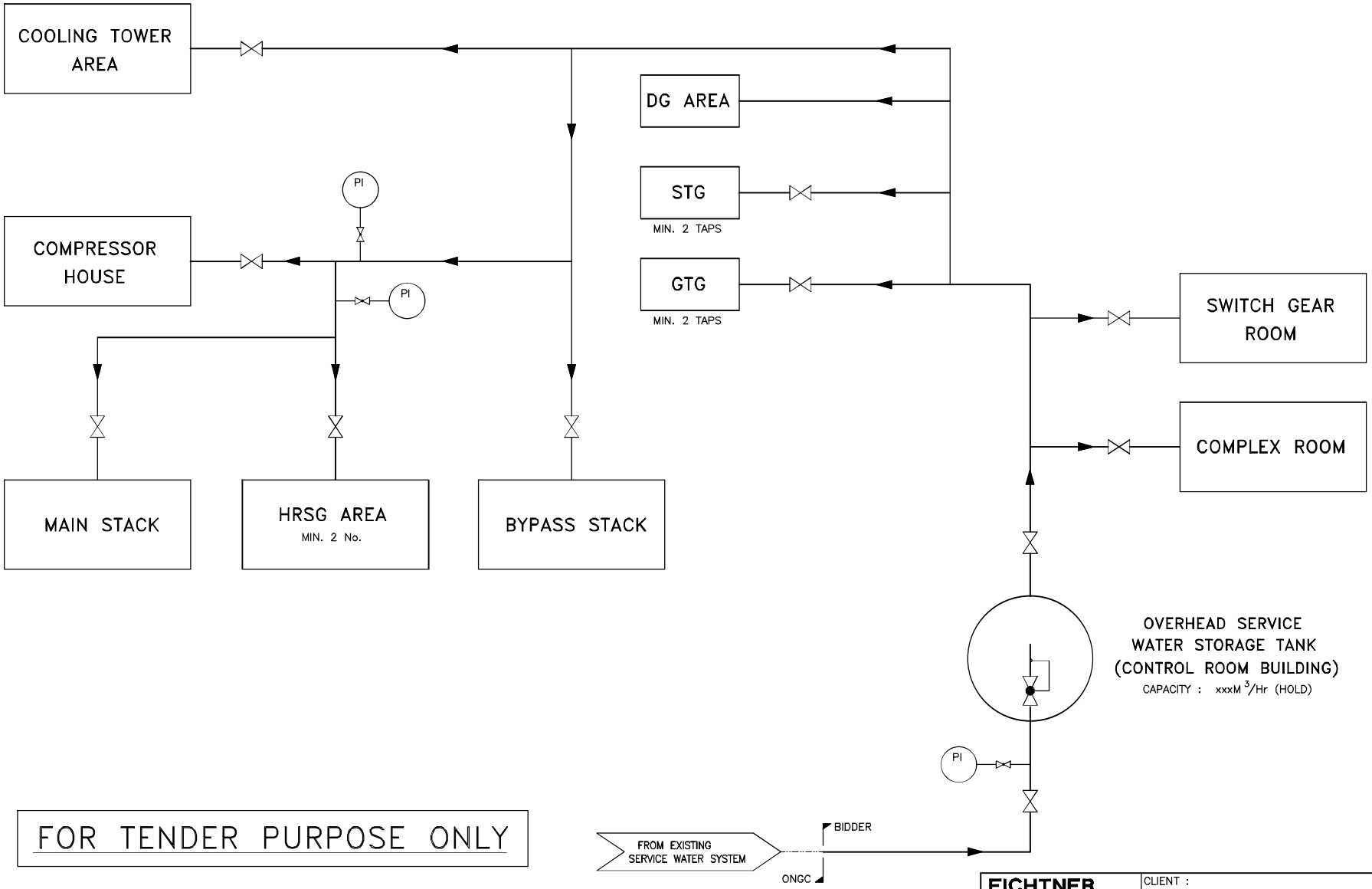


FOR TENDER PURPOSE ONLY

REFERENCE DRAWINGS :-

1. SYMBOLS & LEGEND (EQUIPMENT & PIPING) ——— 10-5111168-M-002
2. SYMBOLS & LEGEND (CONTROL & INSTRUMENTS) ——— 10-5111168-M-003

| REV. | DATE | DESCRIPTION | SIG. |
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| B | 17.05.12 | FOR TENDER PURPOSE ONLY | sd/- |
| A | 19.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | sd/- |

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| MKM | PGT | FWR | 19.04.12 |
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TITLE P & I DIAGRAM FOR SERVICE WATER DISTRIBUTION SYSTEM

DWG. No.:30-5111168-M-018 | SHEET : 1 OF 1 | SCALE : NTS | REV. B

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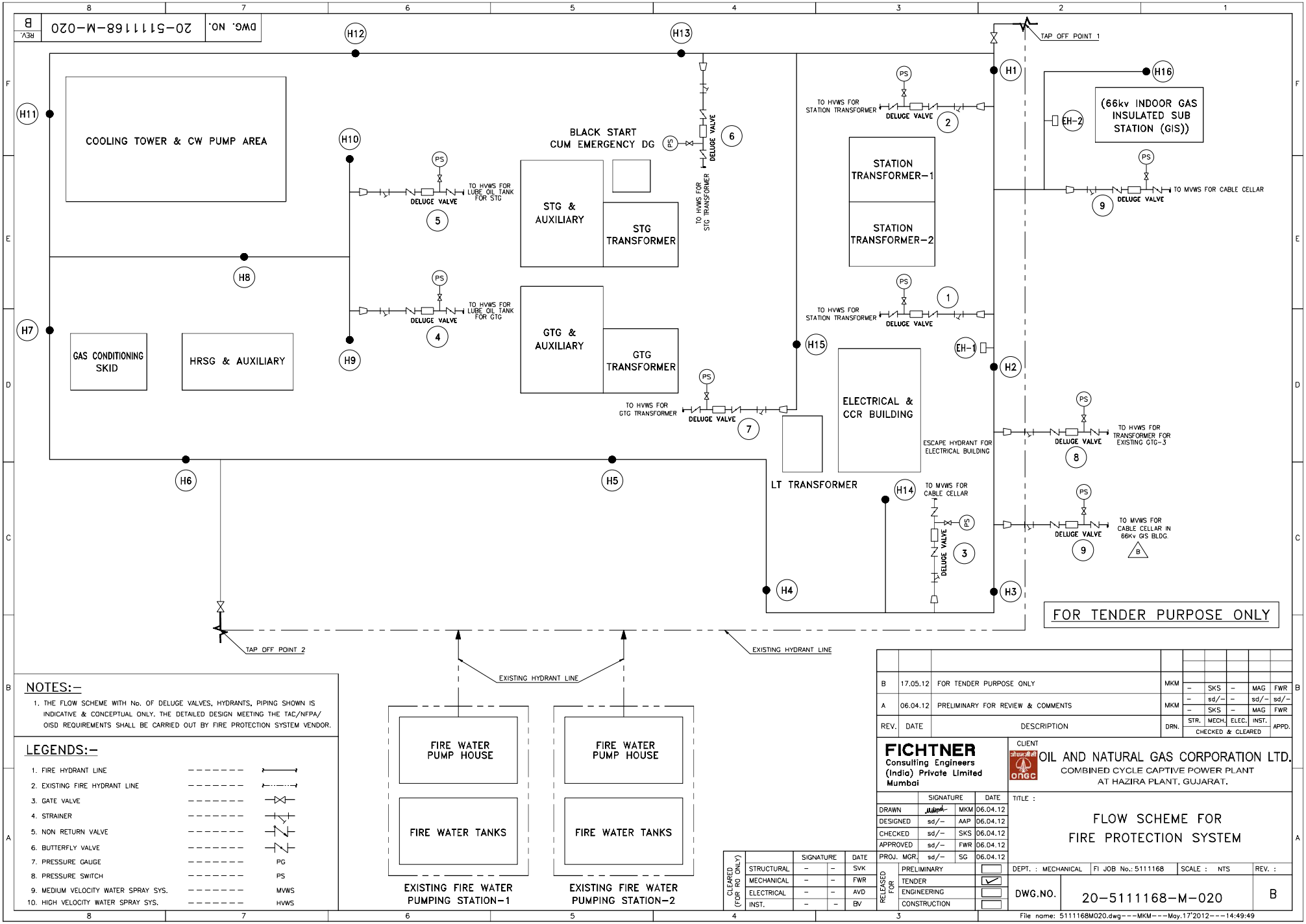


## NOTES:-

1. THE FLOW SCHEME WITH No. OF DELUGE VALVES, HYDRANTS, PIPING SHOWN IS INDICATIVE & CONCEPTUAL ONLY. THE DETAILED DESIGN MEETING THE TAC/NFPA/ OISD REQUIREMENTS SHALL BE CARRIED OUT BY FIRE PROTECTION SYSTEM VENDOR.

## LEGENDS:-

1. FIRE HYDRANT LINE
2. EXISTING FIRE HYDRANT LINE
3. GATE VALVE
4. STRAINER
5. NON RETURN VALVE
6. BUTTERFLY VALVE
7. PRESSURE GAUGE — PG
8. PRESSURE SWITCH — PS
9. MEDIUM VELOCITY WATER SPRAY SYS. — MVWS
10. HIGH VELOCITY WATER SPRAY SYS. — HVWS

| REV. | DATE | DESCRIPTION | DRN. | STR. | MECH. | ELEC. | INST. | APPD. |
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| DRAWN | | MKM | 06.04.12 |
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TITLE :
FLOW SCHEME FOR
FIRE PROTECTION SYSTEM

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| | MECHANICAL | – | – | FWR |
| | ELECTRICAL | – | – | AVD |
| | INST. | – | – | BV |

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| | CONSTRUCTION |

DEPT. : MECHANICAL | FI JOB No.: 5111168 | SCALE : NTS | REV. :

DWG.NO. 20-5111168-M-020 | B

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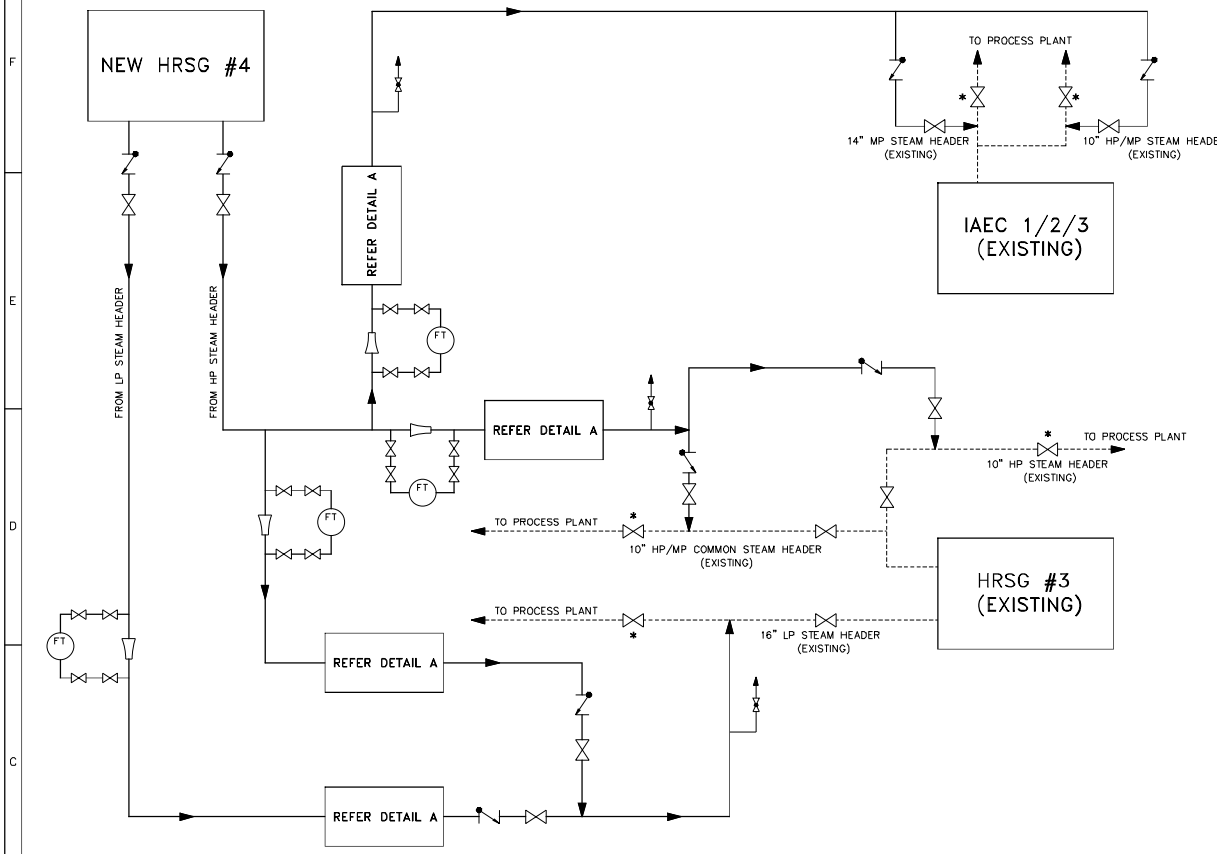


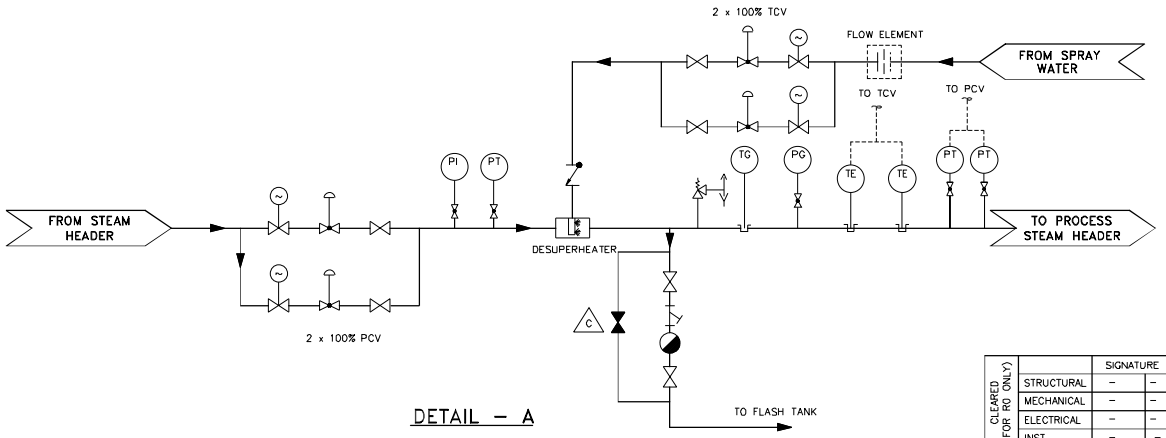


DETAIL – A

## NOTES:–

1. HIGH POINT VENTS AND LOW POINT DRAINS SHALL BE PROVIDED AT SUITABLE LOCATIONS AS PER PIPING LAYOUT.
2. ALL INSTRUMENTS SHALL BE WITH PROCESS ISOLATION VALVE AND AN INSTRUMENT ISOLATION VALVE, WITH PROVISION FOR VENT AND DRAIN.
3. ALL TEMPERATURE INSTRUMENTS SHALL BE PROVIDED WITH THERMOWELL.
4. ALL MOTORIZED VALVES SHALL BE PROVIDED WITH OPEN & CLOSE LIMIT SWITCHES WITH DCS INDICATION AND TORQUE SWITCHES.
5. ALL CONTROL VALVES SHALL HAVE POSITION TRANSMITTER & SMART I/P CONVERTOR WITH DCS INDICATION.
6. DETAILS OF TAPPING POINTS SUCH AS LOCATION, PIPE SIZES, THICKNESS, DESIGN PRESSURE & TEMPERATURE ETC. TO BE FINALIZED/CONFIRMED DURING DETAIL ENGINEERING.
7. TAPPING AT ALL INTERCONNECTIONS ARE IN BIDDER'S SCOPE.
8. ALL VALVES & INSTRUMENTS ARE IN BIDDERS SCOPE, EXCEPT THOSE MARKED *.

## LEGENDS:–

1. * EXISTING VALVE.

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| REV. | DATE | DESCRIPTION | DRN. | STR. | MECH. | ELEC. | INST. | APPD. |
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| B | 17.05.12 | FOR TENDER PURPOSE ONLY | MKM | – | sd/– | – | sd/– | sd/– |
| A | 30.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | MKM | – | SKS | – | MAG | FWR |
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| | SIGNATURE | | DATE |
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| DRAWN | | MKM | 30.04.12 |
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| APPROVED | sd/– | FWR | 30.04.12 |
| PROJ. MGR. | sd/– | SG | 30.04.12 |

TITLE :

# P & I DIAGRAM FOR HP/MP/LP PROCESS STEAM SYSTEM

| CLEARED (FOR RO ONLY) | | SIGNATURE | | DATE |
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| | STRUCTURAL | – | – | SVK |
| | MECHANICAL | – | – | FWR |
| | ELECTRICAL | – | – | AVD |
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| | TENDER | ☑ |
| | ENGINEERING | ☐ |
| | CONSTRUCTION | ☐ |

DEPT. : MECHANICAL | FI JOB No.: 5111168 | SCALE : NTS | REV. :

DWG.NO. 20-5111168-M-022 C

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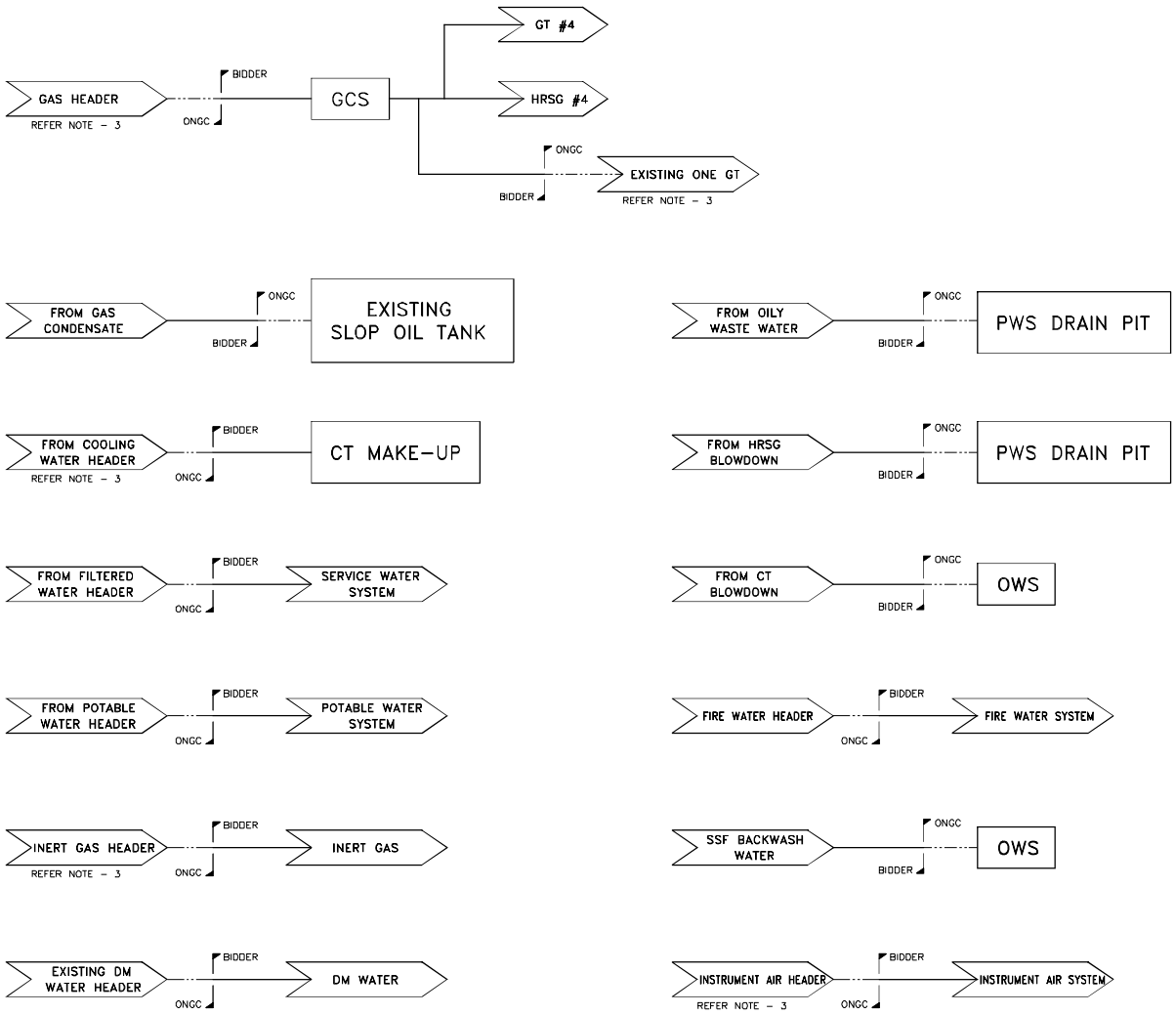


## NOTES:-

1. DETAILS OF TAPPING POINTS SUCH AS LOCATION, PIPE SIZES, THICKNESS, ETC TO BE FINALIZED DURING DETAIL ENGINEERING.
2. TAPPING AT ALL INTERCONNECTIONS AND INTERCONNECTION TO EXISTING SYSTEMS ARE IN BIDDER'S SCOPE.
3. HOT TAPPING IS TO BE CONSIDERED FOR THE INTERCONNECTION.
4. FOR PROCESS STEAM INTERCONNECTION, REFER P&ID No. 20-5111168-M-022.

## LEGENDS:-

1. GCS - GAS CONDITIONING SKID
2. PWS - PROCESS WATER SYSTEM
3. OWS - OTHER WATER SYSTEM

**FOR TENDER PURPOSE ONLY**

| REV. | DATE | DESCRIPTION | DRN. | STR. | MECH. | ELEC. | INST. | APPD. |
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| A | 30.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | MKM | - | SKS | - | MAG | FWR |

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| | SIGNATURE | | DATE |
|---|---|---|---|
| DRAWN | | MKM | 30.04.12 |
| DESIGNED | sd/- | PGT | 30.04.12 |
| CHECKED | sd/- | SKS | 30.04.12 |
| APPROVED | sd/- | FWR | 30.04.12 |
| PROJ. MGR. | sd/- | SG | 30.04.12 |

TITLE :

# HOOK-UP POINTS

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| STRUCTURAL | - | - | SVK |
| MECHANICAL | - | - | FWR |
| ELECTRICAL | - | - | AVD |
| INST. | - | - | BV |

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| TENDER | ☑ |
| ENGINEERING | ☐ |
| CONSTRUCTION | ☐ |

DEPT. : MECHANICAL | FI JOB No.: 5111168 | SCALE : NTS | REV. :

DWG.NO. 20-5111168-M-023 | B

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| | Subject | Dwg. No. | Rev. | Sheet No. |
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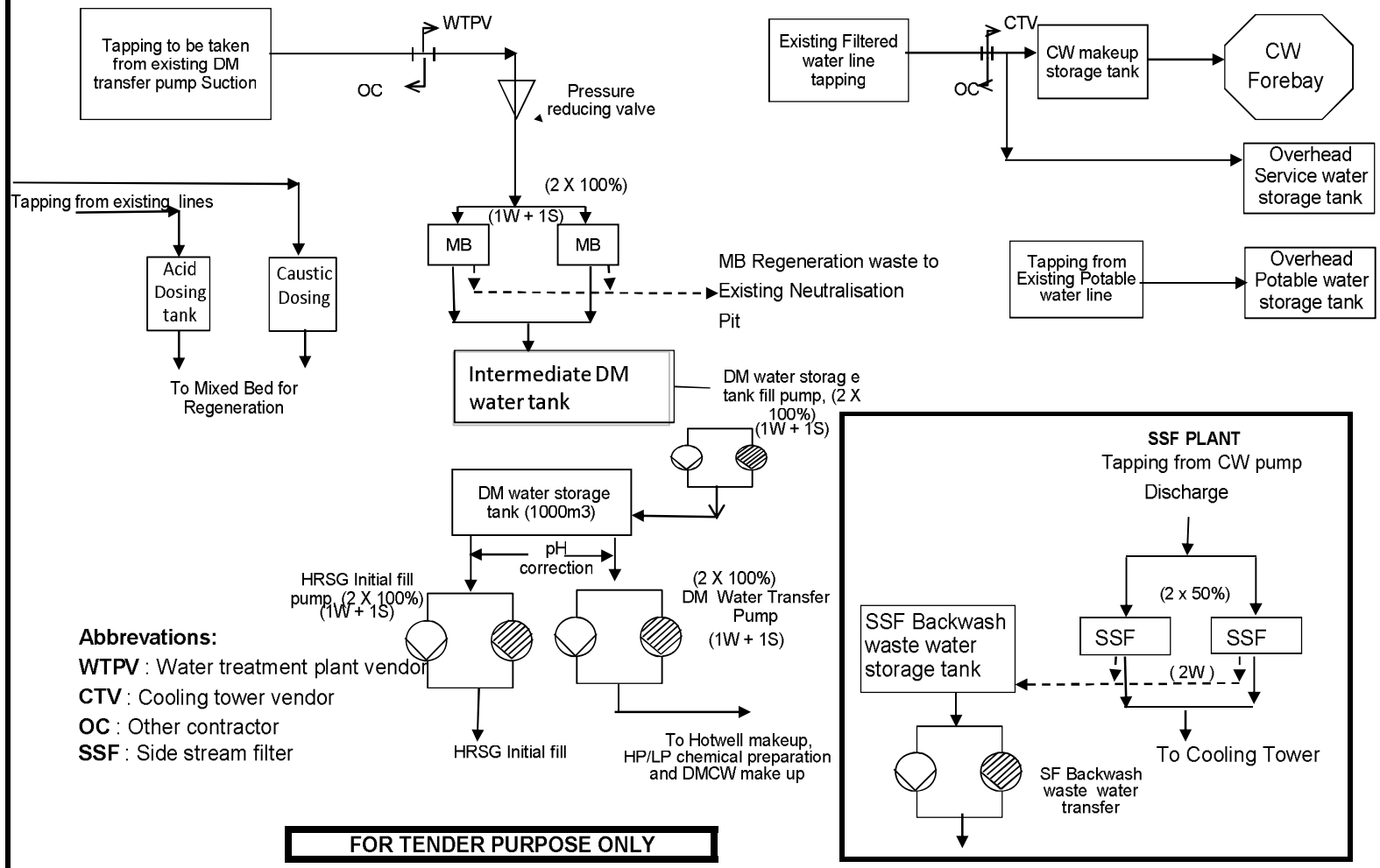
| ONGC | FLOW SCHEME FOR WATER TREATMENT PLANT | 5111168-M-SK-001 | B | 1 of 2 |




**Abbrevations:**

**WTPV** : Water treatment plant vendor
**CTV** : Cooling tower vendor
**OC** : Other contractor
**SSF** : Side stream filter

**FOR TENDER PURPOSE ONLY**

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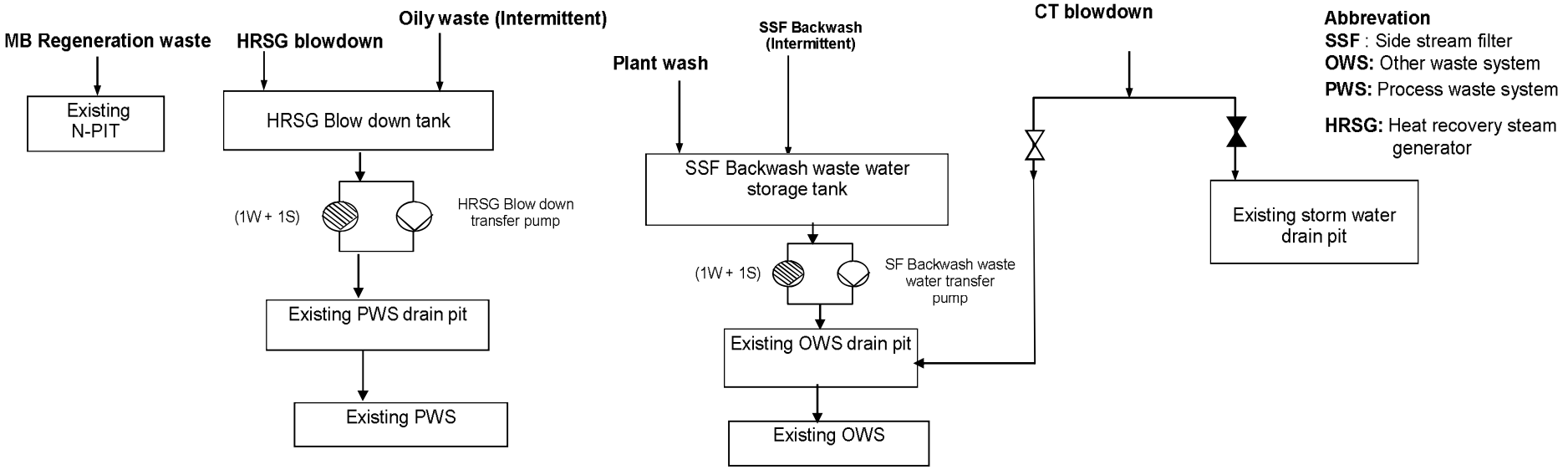
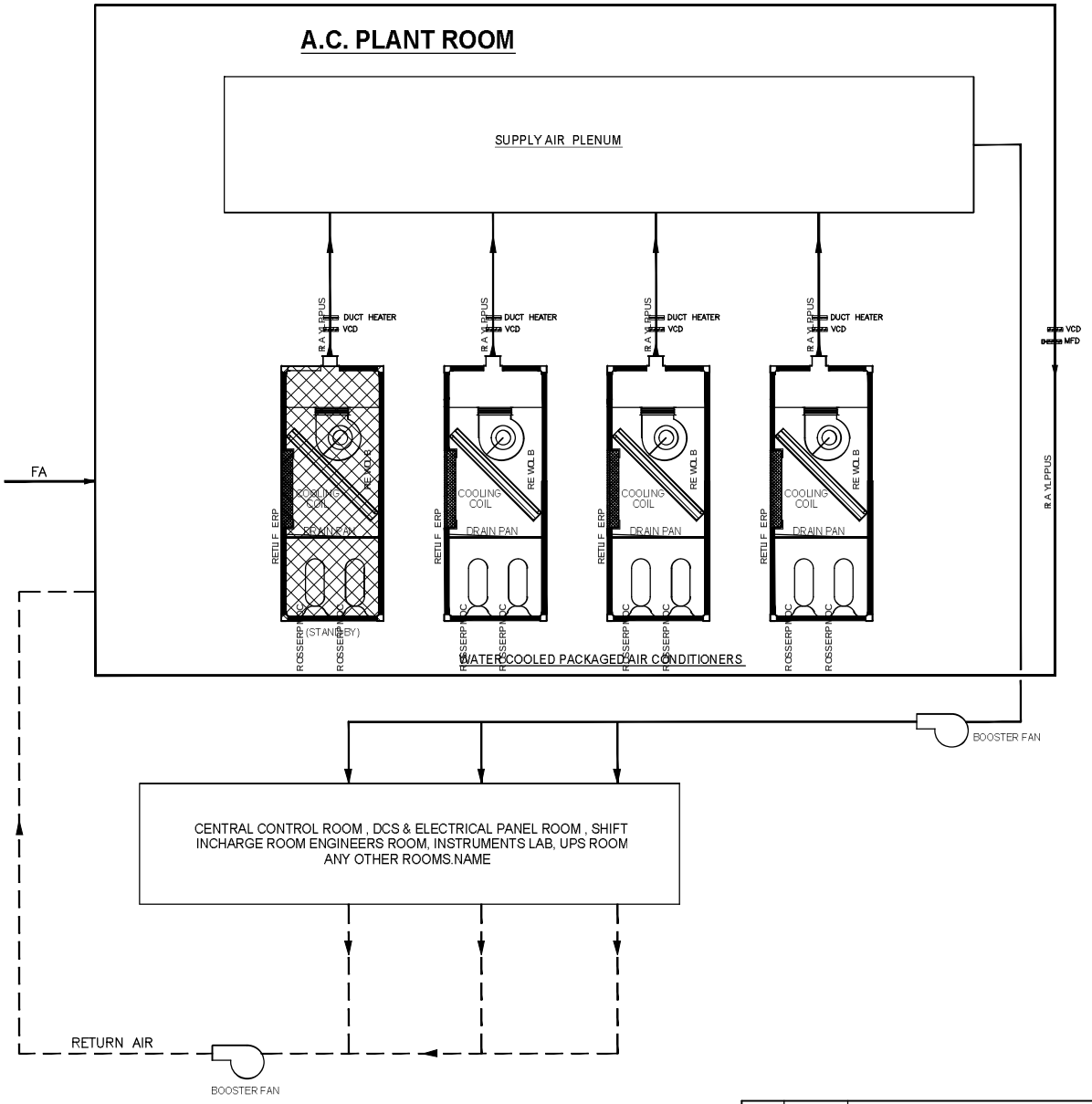
| | Subject | Dwg. No. | Rev. | Sheet No. |
|---|---|---|---|---|
| ONGC | FLOW SCHEME FOR EFFLUENT DISCHARGE | 5111168-M-SK-001 | B | 2 of 2 |




**FOR TENDER PURPOSE ONLY**

NOTE:- NUMBER & CAPACITY OF THE AC UNITS ARE INDICATIVE ONLY.
THE SAME SHALL BE FINALIZED BY HVAC VENDORS.




FOR TENDER PURPOSE ONLY

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | DRN. | CHKD. | APPD. | DATE | |
| B | 17.05.12 | FOR TENDER PURPOSE ONLY | sd/- | GRS | AP | FWR | 13.04.12 | |
| A | 13.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | sd/- | sd/- | sd/- | sd/- | | |
| REV. | DATE | DESCRIPTION | SIG. | DWG. No.: 30-5111168-M-SK-002 | | | SHEET : 1 OF 1 | SCALE : NTS | REV. B |

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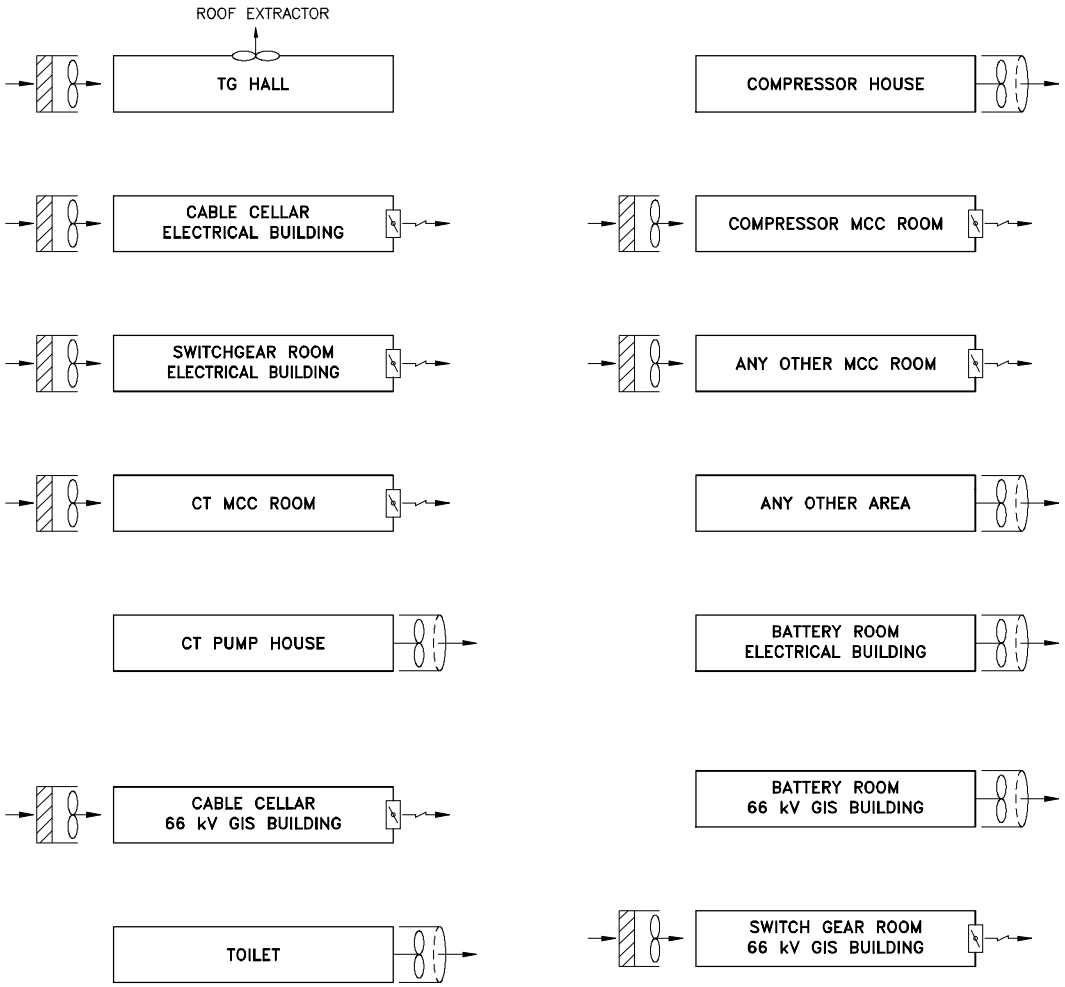
CLIENT :
OIL AND NATURAL GAS CORPORATION LTD.
COMBINED CYCLE CAPTIVE POWER PLANT
AT HAZIRA PLANT, GUJARAT.

TITLE SCHEMATIC LAYOUT OF AC SYSTEM

FILE NAME: 5111168-M-SK-002.dwg---MKM---May 17, 2012---18:23:44




NOTES:

1. THE NUMBER OF FANS ARE INDICATIVE & SHALL BE FINALIZED. THE SAME SHALL BE FINALIZED BY HVAC VENDORS.

LEGEND

1. EXHAUST FAN
2. FAN FILTER UNIT
3. BACK DRAFT DUMPER

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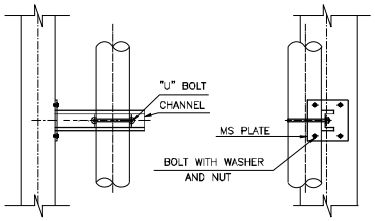
| REV. | DATE | DESCRIPTION | SIG. | DRN. | CHKD. | APPD. | DATE |
|---|---|---|---|---|---|---|---|
| B | 17.05.12 | FOR TENDER PURPOSE ONLY | sd/- | GRS | AP | FWR | 13.04.12 |
| A | 13.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | sd/- | sd/- | sd/- | sd/- | |

TITLE SCHEMATIC LAYOUT OF VENTILATION SYSTEM

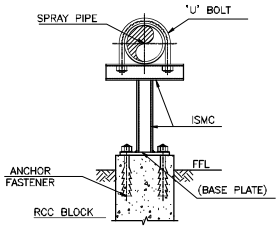
DWG. No.:30-5111168-M-SK-003 | SHEET : 1 OF 1 | SCALE : NTS | REV. B

FILE NAME: 5111168-M-SK-003.dwg---MKM---May 17, 2012---18:24:02

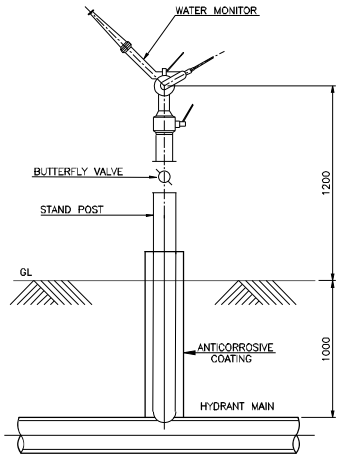
DWG. NO. 20-5111168-M-SK-004 REV. B




TYP PIPE SUPPORT FOR VERTICAL RISER

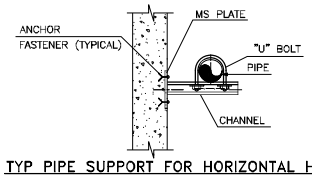



SUPPORT FOR DV

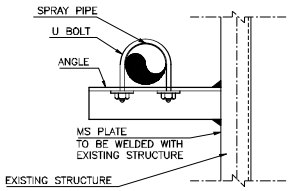



TYPICAL MOUNTING DETAILS OF WATER MONITOR

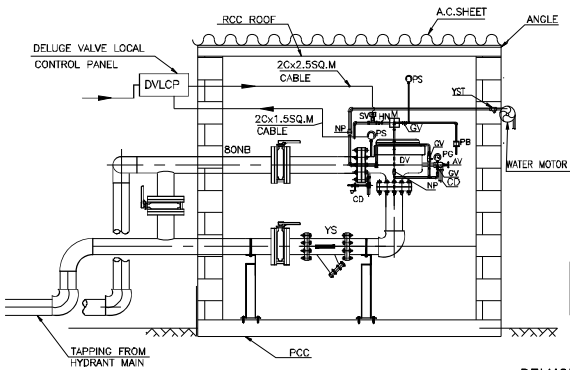
| LEGEND | |
|---|---|
| PS | PRESSURE SWITCH |
| OD | OPEN DRAIN |
| CD | COMMON DRAIN |
| DV | DELUGE VALVE |
| ER | EMERGENCY RELEASE BOX |
| M | SIX WAY MANIFOLD |
| RCN | RESTRICTION NOZZLE |
| PDA | POSITIVE DRAIN ACTUATOR |
| PG | PRESSURE GAUGE |
| G | SPRINKLER ALARM |
| NO | NORMALLY OPEN |
| NC | NORMALLY CLOSED |
| SV | SOLENOID VALVE |

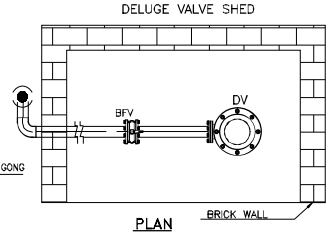



TYP PIPE SUPPORT FOR HORIZONTAL HEADER




TYP PIPE SUPPORT FOR SPRAY PIPE

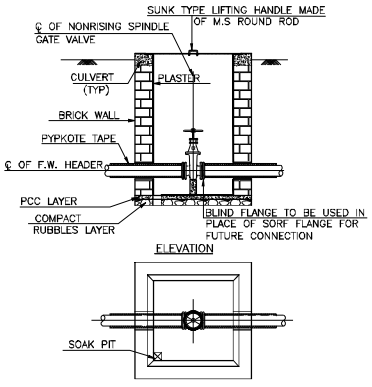



PLAN

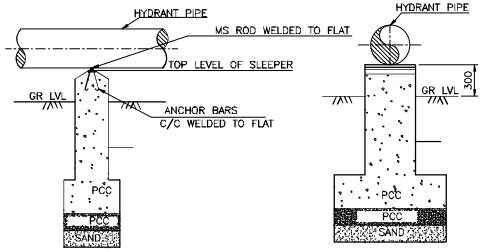
DELUGE SYSTEM ARRANGEMENT

FOR TENDER PURPOSE ONLY




PLAN

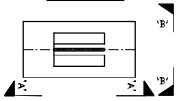
DETAIL OF VALVE CHAMBER



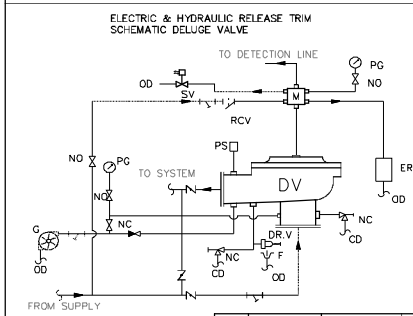

VIEW B–B




VIEW A–A




TYPICAL PIPE SUPPORT FOR ABOVE GROUND PIPE




| REV. | DATE | DESCRIPTION | DRN. | STR. | MECH. | ELEC. | INST. | APPD. |
|---|---|---|---|---|---|---|---|---|
| | | | | CHECKED & CLEARED | | | | |
| B | 17.05.12 | FOR TENDER PURPOSE ONLY | MKM | – | SKS | – | MAG | FWR |
| A | 13.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | GRS | – | sd/– | – | sd/– | sd/– |
| | | | | – | SKS | – | MAG | FWR |

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COMBINED CYCLE CAPTIVE POWER PLANT
AT HAZIRA PLANT, GUJARAT.

| | SIGNATURE | | DATE |
|---|---|---|---|
| DRAWN | sd/– | GRS | 13.04.12 |
| DESIGNED | sd/– | AAP | 13.04.12 |
| CHECKED | sd/– | SKS | 13.04.12 |
| APPROVED | sd/– | FWR | 13.04.12 |
| PROJ. MGR. | sd/– | SG | 13.04.12 |

TITLE :
TYPICAL DETAILS OF FIRE FIGHTING EQUIPMENTS AND SUPPORT

| CLEARED (FOR RO ONLY) | | SIGNATURE | | DATE |
|---|---|---|---|---|
| | STRUCTURAL | – | – | SVK |
| | MECHANICAL | – | – | FWR |
| | ELECTRICAL | – | – | AVD |
| | INST. | – | – | BV |

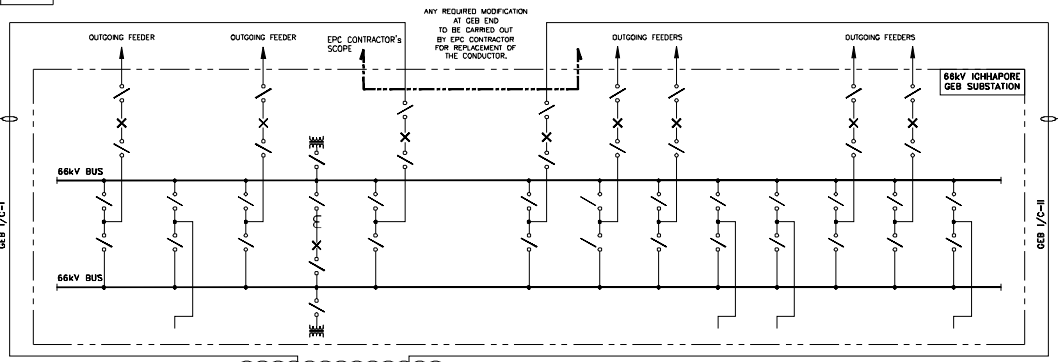
| RELEASED FOR | | |
|---|---|---|
| | PRELIMINARY | |
| | TENDER | ✓ |
| | ENGINEERING | |
| | CONSTRUCTION | |

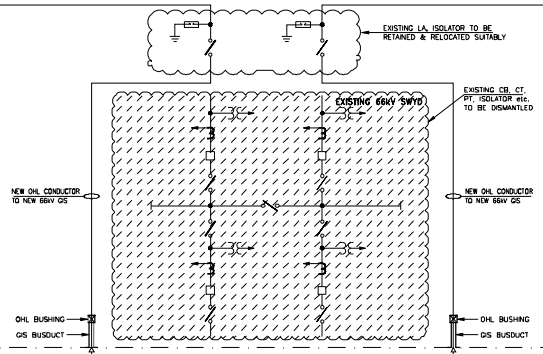
DEPT. : MECHANICAL | FI JOB No.: 5111168 | SCALE : NTS | REV. :

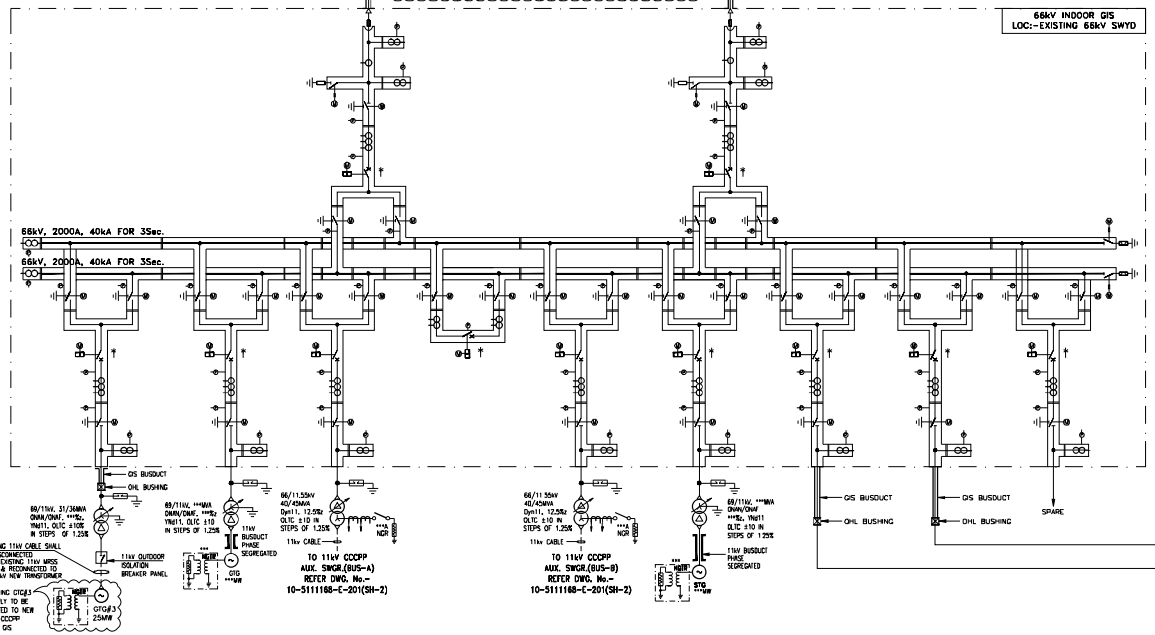
DWG.NO. 20-5111168-M-SK-004 B

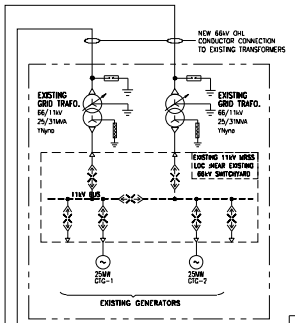
File name: 5111168-M-SK-004.dwg---MKM---May.17'2012---18:57:17

DWG.NO. 10-5111168-E-201 (SHEET - 01 OF 02) REV. C




## LEGEND :-

- : GENERATOR
- : 2 WINDING TRANSFORMER
- : HT CIRCUIT BREAKER (TYPE : AS INDICATED)
- : LT CIRCUIT BREAKER (ACB/MCCB) (TYPE : AS INDICATED)
- : LT LOAD BREAK SWITCH FUSE UNIT
- : DOUBLE BREAK DISCONNECTOR (TYP. AIR BREAK)
- . BATTERY
- : SINGLE BREAK DISCONNECTOR (TYP. AIR BREAK)
- NC . NORMALLY CLOSED
- NO NORMALLY OPEN
- : OUTDOOR CB SF6
- : DRAWOUT TYPE CIRCUIT BREAKER SF6/VCB
- : VOLTAGE TRANSFORMER
- : CABLE CONNECTION
- : ELECTRICAL INTERLOCK
- : MECHANICAL INTERLOCK
- : BUSDUCT
- : CONTACTOR
- : THERMAL O/L RELAY.
- : MOTOR
- : CURRENT TRANSFORMER
- : SYNCHRONIZING FACILITY
- : BOLTED TYPE ISOLATING LINK
- : GROUND LINK FOR EQUIPMENT / SYSTEM EARTHING.
- : DRAWOUT TYPE SWITCHGEAR

## NOTES :-

1. PROTECTION SCHEME FOR STG UNIT SHALL BE FURNISHED IN TYPICAL METERING & PROTECTION FOR GTG/STG DRAWING. (REF. DWG. NO. 30-5111168-E-202)
2. BREAKERS MARKED ' † ' SHALL BE PROVIDED WITH SYNCHRONIZING FACILITY.
3. 66kV OUTDOOR GIS SHALL BE INSTALLED AT NEAR TO EXISTING 66kV SWITCHYARD.
4. "***" MARKED RATING HAS TO BE SIZED BY BIDDER.

## REFERENCE DRAWINGS:-

1.... 10-5111168-E-201 SH-2 :- KEY SINGLE LINE DIAGRAM

**FOR TENDER PURPOSE ONLY**

| REV. | DATE | DESCRIPTION | DRN. | STR. | MECH. | PROC. | ELEC. | INST. | APPD. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | CHECKED & CLEARED | | | | | |
| C | 11.06.12 | RELEASED FOR TENDER PURPOSE ONLY | SDK | -- | -- | -- | -- | -- | AVD |
| B | 17.05.12 | RELEASED FOR TENDER PURPOSE ONLY | DRP | -- | -- | -- | APK | -- | AVD |
| A | 06.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | SDK | -- | -- | -- | -- | -- | sd/- |
| | | | | -- | -- | -- | APK | -- | AVD |
| | | | | -- | -- | -- | sd/- | -- | sd/- |

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CLIENT: GNGC — OIL AND NATURAL GAS CORPORATION LTD.
COMBINED CYCLE CAPTIVE POWER PLANT AT HAZIRA PLANT, GUJARAT.

| | SIGNATURE | DATE |
|---|---|---|
| DRAWN | SAMEER SDK | 05.04.12 |
| DESIGNED | sd/- APK | 05.04.12 |
| CHECKED | sd/- HN | 05.04.12 |
| APPROVED | sd/- AVD | 05.04.12 |
| PROJ. MGR | sd/- SG | 05.04.12 |

TITLE: KEY SINGLE LINE DIAGRAM

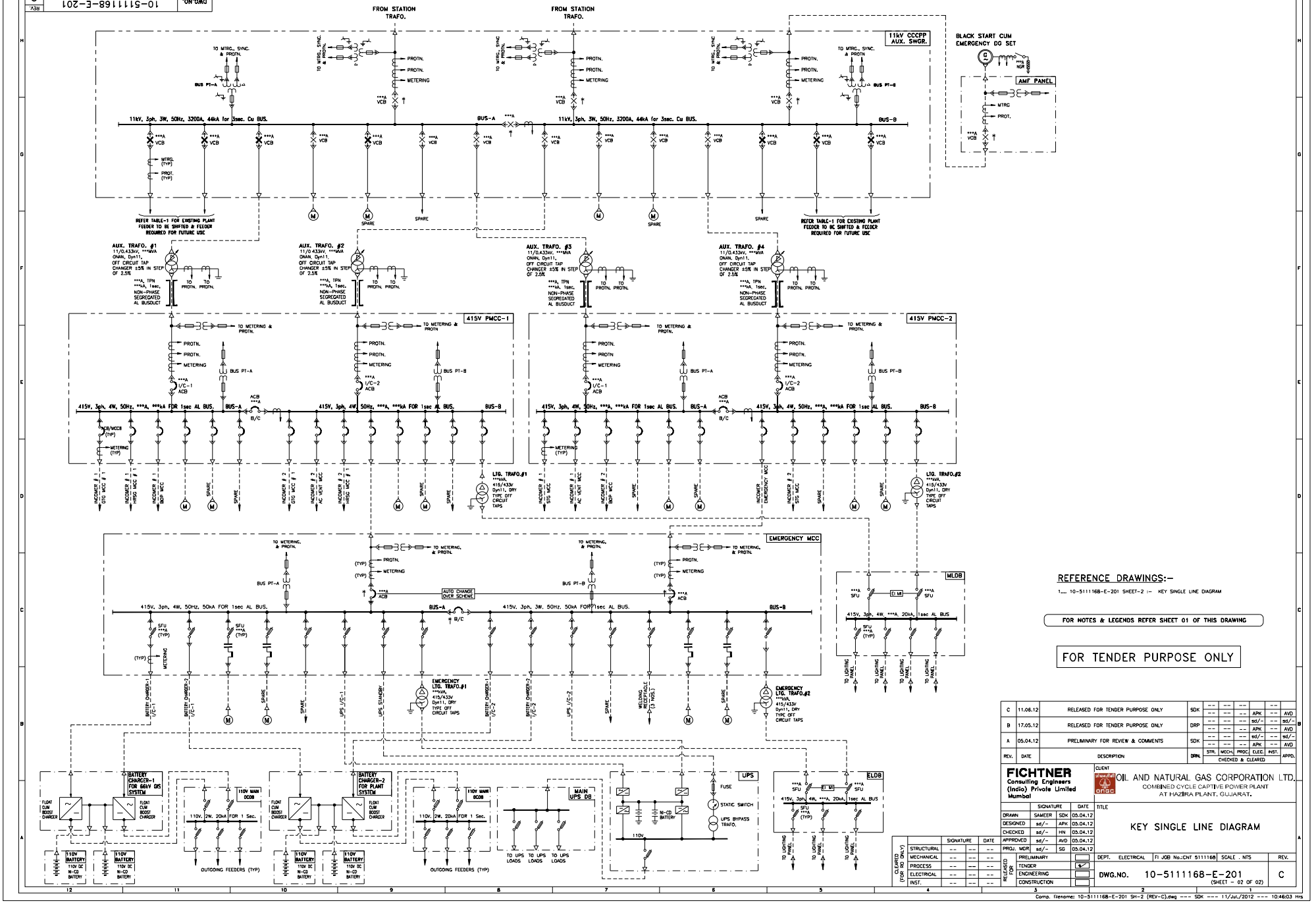
| CLEARED (FOR RD ONLY) | | SIGNATURE | DATE |
|---|---|---|---|
| | STRUCTURAL | -- -- | -- |
| | MECHANICAL | -- -- | -- |
| | PROCESS | -- -- | -- |
| | ELECTRICAL | -- -- | -- |
| | INST. | -- -- | -- |

| RELEASED FOR | | |
|---|---|---|
| | PRELIMINARY | |
| | TENDER | ✓ |
| | ENGINEERING | |
| | CONSTRUCTION | |

DEPT. ELECTRICAL | FI JOB No.:CNT 5111168 | SCALE . NTS | REV.

DWG.NO. 10-5111168-E-201 (SHEET - 01 OF 02) C

Comp. filename: 10-5111168-E-201 SH-1 (REV-C).dwg --- SDK --- 11/Jun./2012 --- 10:51:28 Hrs




DWG.NO. 10-5111168-E-201 (SHEET - 02 OF 02) REV C

## REFERENCE DRAWINGS:-

1.... 10-5111168-E-201 SHEET-2 :- KEY SINGLE LINE DIAGRAM

FOR NOTES & LEGENDS REFER SHEET 01 OF THIS DRAWING

FOR TENDER PURPOSE ONLY

| REV. | DATE | DESCRIPTION | DRN. | STR. | MECH. | PROC. | ELEC. | INST. | APPD. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | CHECKED & CLEARED | | | | | |
| C | 11.06.12 | RELEASED FOR TENDER PURPOSE ONLY | SDK | -- | -- | -- | -- | -- | AVD |
| B | 17.05.12 | RELEASED FOR TENDER PURPOSE ONLY | DRP | -- | -- | -- | APK | -- | sd/- |
| A | 05.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | SDK | -- | -- | -- | APK | -- | AVD |

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COMBINED CYCLE CAPTIVE POWER PLANT AT HAZIRA PLANT, GUJARAT.

TITLE: KEY SINGLE LINE DIAGRAM

| | SIGNATURE | DATE |
|---|---|---|
| DRAWN | SAMEER | SDK 05.04.12 |
| DESIGNED | sd/- | APK 05.04.12 |
| CHECKED | sd/- | HN 05.04.12 |
| APPROVED | sd/- | AVD 05.04.12 |
| PROJ. MGR | sd/- | SG 05.04.12 |

CLEARED (FOR RD ONLY)

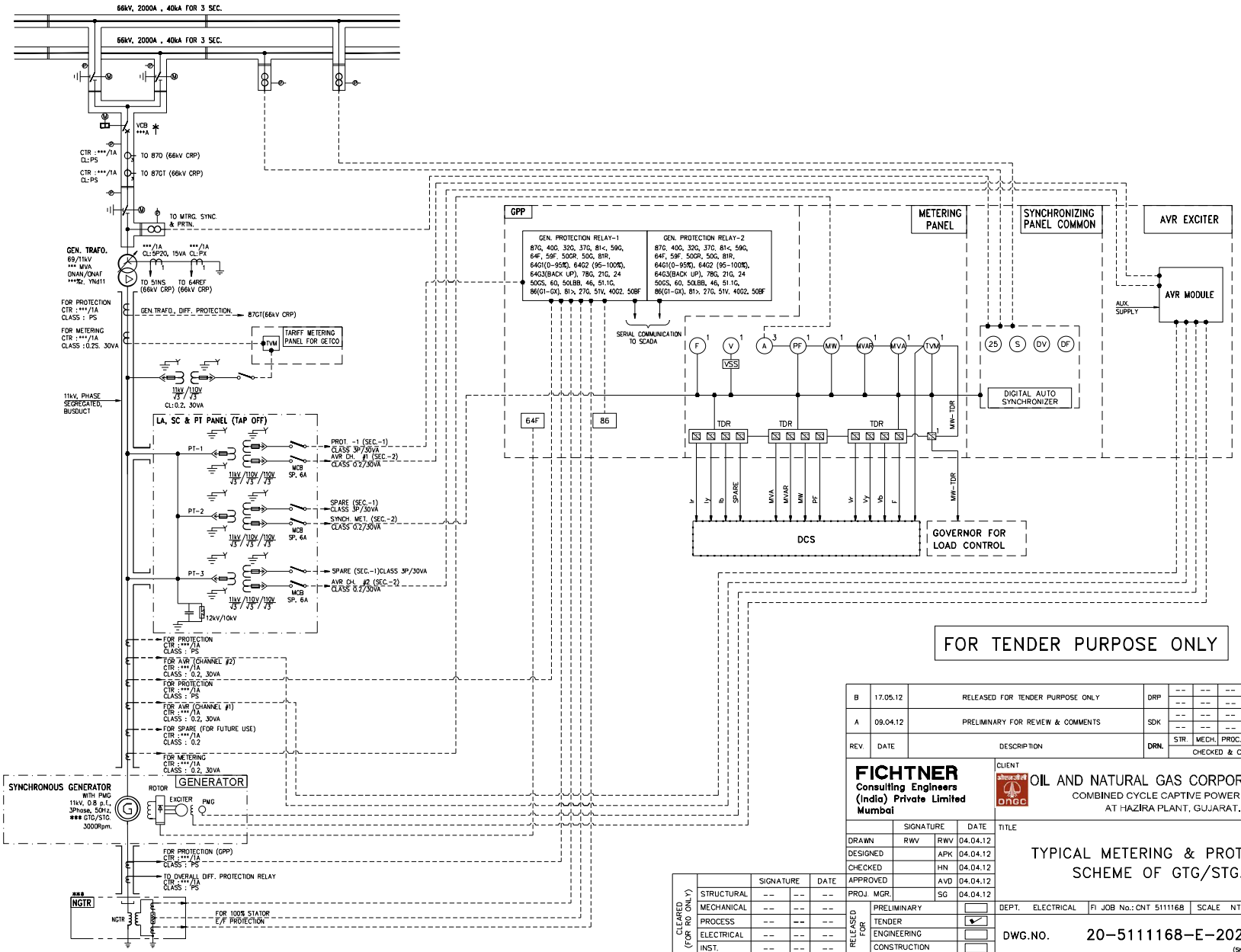
| | SIGNATURE | DATE |
|---|---|---|
| STRUCTURAL | -- | -- |
| MECHANICAL | -- | -- |
| PROCESS | -- | -- |
| ELECTRICAL | -- | -- |
| INST. | -- | -- |

RELEASED: PRELIMINARY ☐ TENDER ☑ ENGINEERING ☐ CONSTRUCTION ☐

DEPT. ELECTRICAL | FI JOB No.:CNT 5111168 | SCALE . NTS | REV.

DWG.NO. 10-5111168-E-201 (SHEET - 02 OF 02) C

Comp. filename: 10-5111168-E-201 SH-2 (REV-C).dwg --- SDK --- 11/Jul/2012 --- 10:46:03 Hrs




FOR TENDER PURPOSE ONLY

| REV. | DATE | DESCRIPTION | DRN. | STR. | MECH. | PROC. | ELEC. | INST. | APPD. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | CHECKED & CLEARED | | | | | |
| B | 17.05.12 | RELEASED FOR TENDER PURPOSE ONLY | DRP | -- | -- | -- | | -- | |
| | | | | -- | -- | -- | APK | -- | AVD |
| A | 09.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | SDK | -- | -- | -- | | -- | |
| | | | | -- | -- | -- | APK | -- | AVD |

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COMBINED CYCLE CAPTIVE POWER PLANT
AT HAZIRA PLANT, GUJARAT.

| | SIGNATURE | | DATE |
|---|---|---|---|
| DRAWN | RWV | RWV | 04.04.12 |
| DESIGNED | | APK | 04.04.12 |
| CHECKED | | HN | 04.04.12 |
| APPROVED | | AVD | 04.04.12 |
| PROJ. MGR. | | SG | 04.04.12 |

TITLE
# TYPICAL METERING & PROTECTION SCHEME OF GTG/STG.

| CLEARED (FOR RO ONLY) | | SIGNATURE | | DATE |
|---|---|---|---|---|
| | STRUCTURAL | -- | -- | -- |
| | MECHANICAL | -- | -- | -- |
| | PROCESS | -- | -- | -- |
| | ELECTRICAL | -- | -- | -- |
| | INST. | -- | -- | -- |

| RELEASED FOR | | |
|---|---|---|
| | PRELIMINARY | |
| | TENDER | ✓ |
| | ENGINEERING | |
| | CONSTRUCTION | |

DEPT. ELECTRICAL | FI JOB No.: CNT 5111168 | SCALE NTS | REV.

DWG.NO. 20-5111168-E-202 (Sh. 1 of 2) | B

Comp. filename: 20-5111168-E-202 Sh. 1 of 2.dwg --- DRP --- 17/May/2012 --- 11:27:40 Hrs

| DWG.NO. | REV. |
|---|---|
| 20-5111168-E-202 (Sh. 2 of 2) | B |

## LEGEND:

MOTORISED ISOLATOR WITH EARTH SWITCH

CURRENT TRANSFOMER

GENERATOR


MCB

TRANSFORMER

EARTHING

BUS DUCT

EHV CIRCUIT BREAKER

POTENTIAL TRANSFORMER

SURGE ARRESTER & SUPPRESSOR

## LEGEND:

| | |
|---|---|
| A | AMMETER |
| AVR | AUTOMATIC VOLTAGE REGULATOR |
| F | FREQUENCY METER |
| V | VOLTMETER |
| MW | ACTIVE POWER METER |
| MVAR | MEGAVAR METER |
| TVM | TRIVECTOR METER |
| LA | LIGHTNING ARRESTOR |
| SC | SURGE CAPACITOR |
| PMG | PERMANENT MAGNET GENERATOR |
| DV | DOUBLE VOLTMETER |
| DF | DOUBLE FREQUENCY METER |
| SYN | SYNCHROSCOPE |
| VSS | VOLTMETER SELECTOR SWITCH |
| NGTR | NEUTRAL GROUNDING TRANSFORMER |
| PF | POWER FACTOR METER |
| SYN ON/OFF | SYNCHROSCOPE ON/OFF SWITCH |
| GPP | GENERATOR PROTECTION PANEL |
| 27G | UNDER VOLTAGE RELAY |
| 51V | VOLTAGE RESTRAINED OVER CURRENT PROTECTION |
| 59G | OVER VOLTAGE PROTECTION |
| 25 | CHECK SYNCHRONISING RELAY |
| 50LBB | LOCAL BREAKER BACK-UP |
| 50BF | BREAKER FAILURE |
| 37G | LOW FORWARD POWER PROTECTION |
| 40G | LOSS OF EXCITATION PROTECTION, TWO STAGE |
| 64 G1 | GENERATOR STATOR 0% TO 95% EARTH FAULT PROTECTION. |
| 64 G2 | GENERATOR STATOR 95% TO 100% STATOR EARTH FAULT PROTECTION. |
| 64 G3 | GENERATOR STATOR BACK-UP EARTH FAULT PROTECTION |
| 46 | NEGATIVE PHASE SEQUENCE PROTECTION |
| 21G | BACK - UP IMPEDANCE PROTECTION. |
| 50 GS | STATOR OVER LOAD ALARM RELAY |
| 60 | GENERATOR VT FUSE FAILURE PROTECTION |
| 32G | REVERSE POWER PROTECTION |
| 64F | ROTOR EARTH FAULT PROTECTION TWO STAGE. (EXCITATION) |
| 59F | FIELD OVER VOLTAGE PROTECTION AUX. EXCITATION. |
| 50 GR | ROTOR OVER CURRENT PROTECTION |
| 24 | OVER FLUXING |
| 86 | MASTER TRIP REALY |
| 27/40 G2 | UNDER VOLTAGE ELEMENT OF LOSS OF EXCITATION PROTECTION |
| 78G | POLE DISCREPANCY PROTECTION. |
| 50G | DEAD MACHINE PROTECTION |
| 51.1G | GENERATOR OVERWARNET WITH TIME DELAY FOR ALARM. |
| 81< | GENERATOR UNDER FREQUENCY PROT. |
| 81> | GENERATOR OVER FREQUENCY PROT. |
| 81R | df/dt PROTECTION. |

## NOTES :-

1) GENERATOR PROTECTION ELEMENTS SHALL BE AS PER THE SPECIFICATION AND PROTECTION SLD.
2) CT RATING WILL BE FINALISED DURING DETAIL ENGINEERING.
3) NGTR NEUTRAL SHALL BE MADE INSIDE THE NGTR PANEL.
4) NECESSARY PROTECTION OTHER THAN THE SPECIFIED SHALL BE PROVIDED BY EPC CONTRACTOR.
5) '***' MARKED HAS TO BE SIZED BY BIDDER.
6) ADEQUATE NO. OF HIGH SPEED TRIPPING RELAY SHALL BE PROVIDED FOR EACH CATEGORY TRIPPING.
7) DUAL OUTPUT TRANSDUCERS SHALL BE PROVIDED FOR 3 PHASE VOLTAGE & FREQUENCY.
8) DUAL OUTPUT TRANSDUCERS SHALL BE PROVIDED FOR 3 PHASE CURRENT, MEGAWATT, MEGAWAR, POWER FACTOR & MEGAWATT HOURS.
9) ALL MAIN PROTECTION RELAYS SHALL BE WITH IEC 61850 PROTOCOL.

**FOR TENDER PURPOSE ONLY**

| REV. | DATE | DESCRIPTION | DRN. | STR. | MECH. | PROC. | ELEC. | INST. | APPD. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | CHECKED & CLEARED | | | | | |
| B | 17.05.12 | RELEASED FOR TENDER PURPOSE ONLY | DRP | -- | -- | -- | | -- | |
| | | | | -- | -- | -- | APK | -- | AVD |
| A | 09.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | SDK | -- | -- | -- | | -- | |
| | | | | -- | -- | -- | APK | -- | AVD |

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**Mumbai**

CLIENT
OIL AND NATURAL GAS CORPORATION LTD.
COMBINED CYCLE CAPTIVE POWER PLANT
AT HAZIRA PLANT, GUJARAT.

| | SIGNATURE | | DATE |
|---|---|---|---|
| DRAWN | RWV | RWV | 04.04.12 |
| DESIGNED | | APK | 04.04.12 |
| CHECKED | | HN | 04.04.12 |
| APPROVED | | AVD | 04.04.12 |
| PROJ. MGR. | | SG | 04.04.12 |

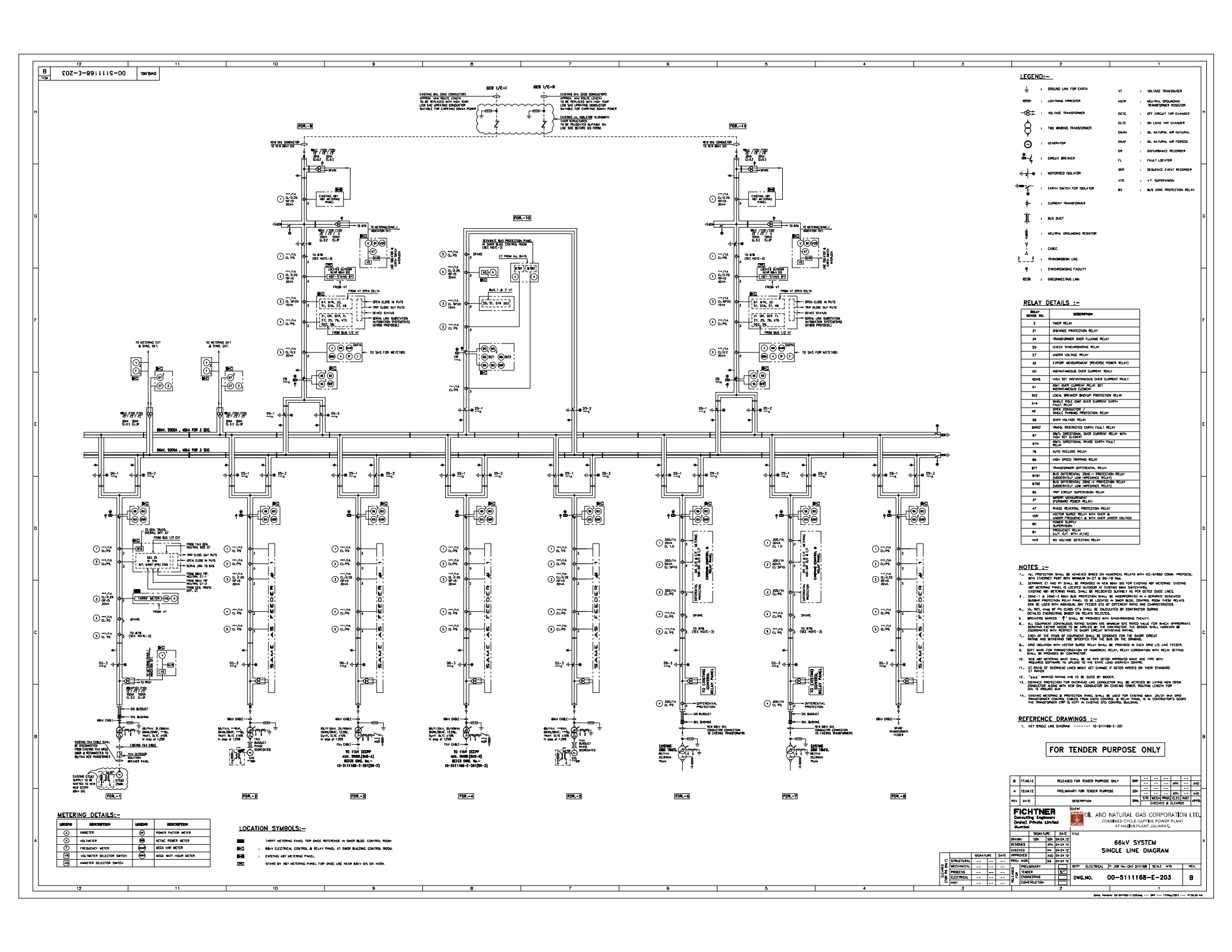
TITLE
TYPICAL METERING & PROTECTION SCHEME OF GTG/STG.

| CLEARED (FOR RO ONLY) | SIGNATURE | | DATE |
|---|---|---|---|
| STRUCTURAL | -- | -- | -- |
| MECHANICAL | -- | -- | -- |
| PROCESS | -- | -- | -- |
| ELECTRICAL | -- | -- | -- |
| INST. | -- | -- | -- |

| RELEASED FOR | |
|---|---|
| PRELIMINARY | |
| TENDER | ✓ |
| ENGINEERING | |
| CONSTRUCTION | |

| DEPT. | ELECTRICAL | FI JOB No.: CNT 5111168 | SCALE | NTS | REV. |
|---|---|---|---|---|---|
| DWG.NO. | 20-5111168-E-202 (Sh. 2 of 2) | | | | B |

Comp. filename: 20-5111168-E-202 Sh. 2 of 2.dwg --- DRP --- 17/May/2012 --- 11.27.07 Hrs




## LEGEND:-

| | | | |
|---|---|---|---|
| : GROUND LINK FOR EARTH | VT | : | VOLTAGE TRANSDUSER |
| : LIGHTNING ARRESTER | NGTR | : | NEUTRAL GROUNDING TRANSFORMER RESISTOR |
| : VOLTAGE TRANSFORMER | OCTC | : | OFF CIRCUIT TAP CHANGER |
| : TWO WINDING TRANSFORMER | OLTC | : | ON LOAD TAP CHANGER |
| | ONAN | : | OIL NATURAL AIR NATURAL |
| : GENERATOR | ONAF | : | OIL NATURAL AIR FORCED |
| : CIRCUIT BREAKER | DR | : | DISTURBANCE RECORDER |
| | FL | : | FAULT LOCATOR |
| : MOTORISED ISOLATOR | SER | : | SEQUENCE EVENT RECORDER |
| : EARTH SWITCH FOR ISOLATOR | VTS | : | V.T. SUPERVISION |
| | BZ | : | BUS ZONE PROTECTION RELAY |
| : CURRENT TRANSFORMER | | | |
| : BUS DUCT | | | |
| : NEUTRAL GROUNDING RESISTOR | | | |
| : CABLE | | | |
| : TRANSMISSION LINE. | | | |
| : SYNCHRONISING FACILITY | | | |
| : DISCONNECTING LINK | | | |

## RELAY DETAILS :-

| RELAY DEVICE NO. | DESCRIPTION |
|---|---|
| 2 | TIMER RELAY |
| 21 | DISTANCE PROTECTION RELAY |
| 24 | TRANSFORMER OVER FLUXING RELAY |
| 25 | CHECK SYNCHRONISING RELAY |
| 27 | UNDER VOLTAGE RELAY |
| 32 | EXPORT MEASUREMENT (REVERSE POWER RELAY) |
| 50 | INSTANTANEOUS OVER CURRENT RELAY |
| 50HS | HIGH SET INSTANTANEOUS OVER CURRENT RELAY |
| 51 | IDMT OVER CURRENT RELAY SET INSTANTANEOUS ELEMENT |
| 50Z | LOCAL BREAKER BACKUP PROTECTION RELAY |
| 51N | SINGLE POLE IDMT OVER CURRENT EARTH FAULT RELAY |
| 46 | OPEN CONDUCTOR / SINGLE PHASING PROTECTION RELAY |
| 59 | OVER VOLTAGE RELAY |
| 64REF | TRAFO. RESTRICTED EARTH FAULT RELAY |
| 67 | IDMTL DIRECTIONAL OVER CURRENT RELAY WITH HIGH SET ELEMENT |
| 67N | IDMTL DIRECTIONAL PHASE EARTH FAULT RELAY |
| 79 | AUTO RECLOSE RELAY |
| 86 | HIGH SPEED TRIPPING RELAY |
| 87T | TRANSFORMER DIFFERENTIAL RELAY |
| 87B1 | BUS DIFFERENTIAL ZONE-1 PROTECTION RELAY (MODERATELY LOW IMPEDANCE RELAY) |
| 87B2 | BUS DIFFERENTIAL ZONE-2 PROTECTION RELAY (MODERATELY LOW IMPEDANCE RELAY) |
| 95 | TRIP CIRCUIT SUPERVISION RELAY |
| 37 | EXPORT MEASUREMENT (FORWARD POWER RELAY) |
| 47 | PHASE REVERSAL PROTECTION RELAY |
| VSR | VECTOR SURGE RELAY WITH OVER & UNDER FREQUENCY & WITH OVER UNDER VOLTAGE |
| 80 | POWER SUPPLY SUPERVISION |
| 81 | FREQUENCY RELAY (U/f, O/f, WITH df/dt) |
| NVR | NO VOLTAGE DETECTION RELAY |

## NOTES :-

1. ALL PROTECTION SHALL BE ACHIEVED BASED ON NUMERICAL RELAYS WITH IEC-61850 COMM. PROTOCOL WITH ETHERNET PORT WITH MINIMUM (4+2)T & (6+1)B NOS.
2. SEPARATE CT AND PT SHALL BE PROVIDED IN NEW 66kV GIS FOR EXISTING ABT METERING. EXISTING ABT METERING PANEL IS LOCATED OUTDOOR AT EXISTING 66kV SWITCHYARD. EXISTING ABT METERING PANEL SHALL BE RELOCATED SUITABLY AS PER GETCO GUIDE LINES.
3. ZONE-1 & ZONE-2 66kV BUS PROTECTION SHALL BE INCORPORATED IN A SEPARATE DEDICATED BUSBAR PROTECTION RELAY PANEL TO BE LOCATED IN SWGR BLDG. CONTROL ROOM. THESE RELAYS CAN BE USED WITH INDIVIDUAL BAY FEEDER CTS OF DIFFERENT RATIO AND CHARACTERISTICS.
4. $V_k$ NOT, Vmag OF PS CLASS CTs SHALL BE CALCULATED BY CONTRACTOR DURING DETAILED ENGINEERING BASED ON RELAYS SELECTED.
5. BREAKERS MARKED '$\Phi$' SHALL BE PROVIDED WITH SYNCHRONISING FACILITY.
6. ALL EQUIPMENT CONTINUOUS RATING SHOWN ARE MINIMUM SITE RATED VALUE FOR WHICH APPROPRIATE DERATING FACTOR NEEDS TO BE APPLIED BY THE CONTRACTOR. THE DESIGN SHALL HOWEVER BE COORDINATED WITH RESPECT TO SHORT CIRCUIT WITHSTAND RATING.
7. EACH OF THE ITEMS OF EQUIPMENT SHALL BE DESIGNED FOR THE SHORT CIRCUIT RATING AND WITHSTAND TIME SPECIFIED FOR THE BUS ON THE DRAWING.
8. GIS ISOLATION WITH VECTOR SURGE RELAY SHALL BE PROVIDED IN EACH GIS I/C LINE FEEDER.
9. SOFT WARE FOR PARAMEETERIZATION OF NUMERICAL RELAY, RELAY COORDINATION WITH RELAY SETTING SHALL BE PROVIDED BY CONTRACTOR.
10. NEW ABT METERING MAKE SHALL BE AS PER GETCO APPROVED MAKE AND TYPE WITH REQUIRED SOFTWARE TO UPLOAD TO THE STATE LOAD DISPATCH CENTRE.
11. CT RATIO OF OVERHEAD LINES MIGHT GET CHANGE IF GETCO INSISTS ON THEIR STANDARD CT RATIOS
12. "###" MARKED RATING HAS TO BE SIZED BY BIDDER.
13. DISTANCE PROTECTION FOR OVERHEAD LINE CONDUCTOR WILL BE ACHEIVED BY LAYING NEW OPGW CONDUCTOR ALONG WITH NEW OHL CONDUCTOR ON EXISTING TOWER. ROUTING LENGTH FOR OHL IS APPROX 4KM
14. EXISTING METERING & PROTECTION PANEL SHALL BE USED FOR EXISTING 66kV 25/31.5MVA SRIE TRANSFORMER CONTROL CABLES FROM GIS TO CONTROL & RELAY PANEL IS IN CONTRACTOR'S SCOPE THE TRANSFORMER CRP IS KEPT IN EXISTING GTG CONTROL BUILDING.

## REFERENCE DRAWINGS :-

1. KEY SINGLE LINE DIAGRAM -------- 10-5111168-E-201

**FOR TENDER PURPOSE ONLY**

## METERING DETAILS:-

| LEGEND | DESCRIPTION | LEGEND | DESCRIPTION |
|---|---|---|---|
| A | AMMETER | PF | POWER FACTOR METER |
| V | VOLTMETER | MW | ACTIVE POWER METER |
| F | FREQUENCY METER | MVAR | MEGA VAR METER |
| VS | VOLTMETER SELECTOR SWITCH | MWH | MEGA WATT HOUR METER |
| AS | AMMETER SELECTOR SWITCH | | |

## LOCATION SYMBOLS:-

- TARIFF METERING PANEL FOR ONGC REFERENCE IN SWGR BLDG CONTROL ROOM.
- : 66kV ELECTRICAL CONTROL & RELAY PANEL AT SWGR BUILDING CONTROL ROOM.
- : EXISTING ABT METERING PANEL.
- : STAND BY ABT METERING PANEL FOR ONGC USE NEAR 66kV GIS ON HIGH.

| REV | DATE | DESCRIPTION | DRN. | CHECKED & CLEARED | APPD. |
|---|---|---|---|---|---|
| B | 17.05.13 | RELEASED FOR TENDER PURPOSE ONLY | DNP | --- --- --- --- | --- --- |
| A | 12.04.12 | PRELIMINARY FOR TENDER PURPOSE | SSK | --- --- --- --- | APN --- AVD |
| | | | STR | MECH PROC ELEC INST | |

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COMBINED CYCLE CAPTIVE POWER PLANT
AT HAZIRA PLANT, GUJARAT.

| | SIGNATURE | DATE |
|---|---|---|
| DRAWN | SSK | SSK 04.04.12 |
| DESIGNED | | APN 04.04.12 |
| CHECKED | | HN 04.04.12 |
| APPROVED | | AVD 04.04.12 |
| PROJ. MGR. | | SG 04.04.12 |

TITLE: **66kV SYSTEM SINGLE LINE DIAGRAM**

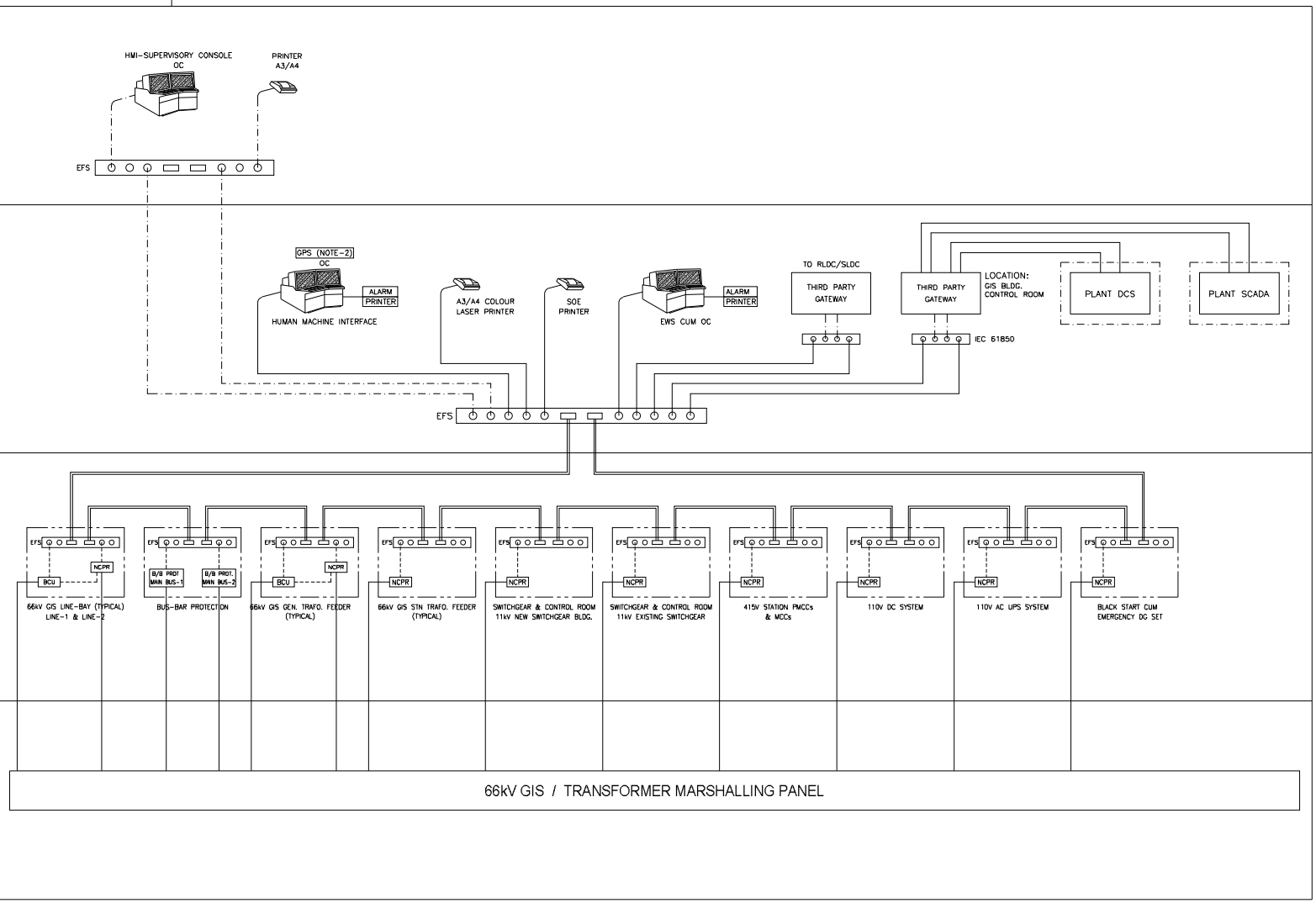
| CLASS OF DOCUMENT (CLIENT USE) | | SIGNATURE | DATE | RELEASED FOR |
|---|---|---|---|---|
| | STRUCTURAL | --- | --- | --- |
| | MECHANICAL | --- | --- | --- |
| | PROCESS | --- | --- | --- |
| | ELECTRICAL | --- | --- | --- |
| | INST | --- | --- | --- |

RELEASED FOR: PRELIMINARY ☐ · TENDER ☑ · ENGINEERING ☐ · CONSTRUCTION ☐

DEPT: ELECTRICAL | FI JOB No : DNT 5111168 | SCALE: NTS | REV.

DWG.NO. 00-5111168-E-203 B

Comp Name= 00-5111168-E-203.dwg --- DRF ---- 17/May/2012 ---- 11:29:35 AM




LEGEND:-

| | |
|---|---|
| ——— | HARDWIRED CABLES |
| ═══ | REDUNDANT FIBRE OPTIC CABLE TCP/IP RING(MULTI MODE) |
| -·-·- | FIBRE OPTIC CABLE (MULTI MODE) |
| - - - - - | UTP CABLE RJ45 ETHERNET LINK |
| ——— | COPPER WIRE. RJ45, 2WIRE LINK |
| EWS | ENGINEERING WORK STATION |
| EFS | ETHERNET FIBER SWITCH |
| OC | OPERATOR CONSOLE |
| HMI | HUMAN MACHINE INTERFACE |
| SOE | SEQUENCE OF EVENTS |
| NCPR | NUMERICAL CONTROL & PROTECTION RELAY |
| BCU | BAY CONTROL UNIT |
| RTU | REMOTE TERMINAL UNIT |
| RLDC | REGIONAL LOAD DESPATCH CENTER |
| SLDC | STATE LOAD DESPATCH CENTER |
| FO | FIBER OPTIC |

NOTES:-

1... THIS DRAWING SHALL BE READ IN CONJUNCTION WITH THE SPECIFICATION
2... GPS RECEIVER SHALL BE PROVIDED AS REQUIRED TO SYNCHRONIZE AND TIME STAMP AT GIS & STATION LEVEL.
3... THE ACTUAL NUMBER OF I/O'S SHALL BE ESTIMATED BY CONTRACTOR / SUPPLIER.
4... ALL NECESSARY SOFTWARE FOR HMI AND CONFIGURATION WITH REQUIRED LICENSE SHALL BE PROVIDED FOR PROTECTION, CONTROL MONITORING AND OPERATING OF SAS FROM HMI.
5... SAS SHALL HAVE THE FOLLOWING REDUNDANCY:
* POWER SUPPLY
* CONTROL PROCESSOR
* COMMUNICATION NETWORK
* HMI SERVER
6... CRITICAL SIGNALS FOR PROTECTION SHALL BE HARDWIRED TO THE SAS, THERE SHALL BE PROVISION IN SAS FOR SYNCHRONIZATION SIGNAL FROM THE MAIN PLANT MASTER CLOCK SYSTEM.
7... EACH ETHERNET FIBER SWITCH (EFS) TO BE PROVIDED WITH 2Nos. SPARE PORTS.

FOR TENDER PURPOSE ONLY

| REV. | DATE | DESCRIPTION | DRN. | STR. | MECH. | PROC. | ELEC. | INST. | APPD. |
|---|---|---|---|---|---|---|---|---|---|
| B | 17.05.12 | RELEASED FOR TENDER PURPOSE ONLY | DRP | -- | -- | -- | | | |
| A | 23.04.12 | PRELIMINARY FOR TENDER PURPOSE | SDK | -- | -- | -- | APK | -- | AVD |
| | | | | -- | -- | -- | APK | -- | AVD |
| | | | CHECKED & CLEARED | | | | | | |

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CLIENT: OIL AND NATURAL GAS CORPORATION LTD.
COMBINED CYCLE CAPTIVE POWER PLANT AT HAZIRA PLANT, GUJARAT.

| | SIGNATURE | DATE |
|---|---|---|
| DRAWN | RMV | 24.03.12 |
| DESIGNED | APK | 24.03.12 |
| CHECKED | HN | 24.03.12 |
| APPROVED | AVD | 24.03.12 |
| PROJ. MGR. | SG | 24.03.12 |

TITLE: SCADA ARCHITECTURE DIAGRAM

| CLEARED (FOR RFI ONLY) | | SIGNATURE | | DATE |
|---|---|---|---|---|
| | STRUCTURAL | -- | -- | -- |
| | MECHANICAL | -- | -- | -- |
| | PROCESS | -- | -- | -- |
| | ELECTRICAL | -- | -- | -- |
| | INST. | -- | -- | -- |

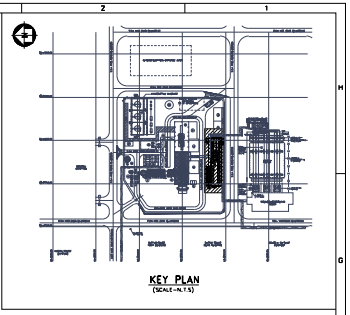
| RELEASED FOR | | |
|---|---|---|
| | PRELIMINARY | |
| | TENDER | ✓ |
| | ENGINEERING | |
| | CONSTRUCTION | |

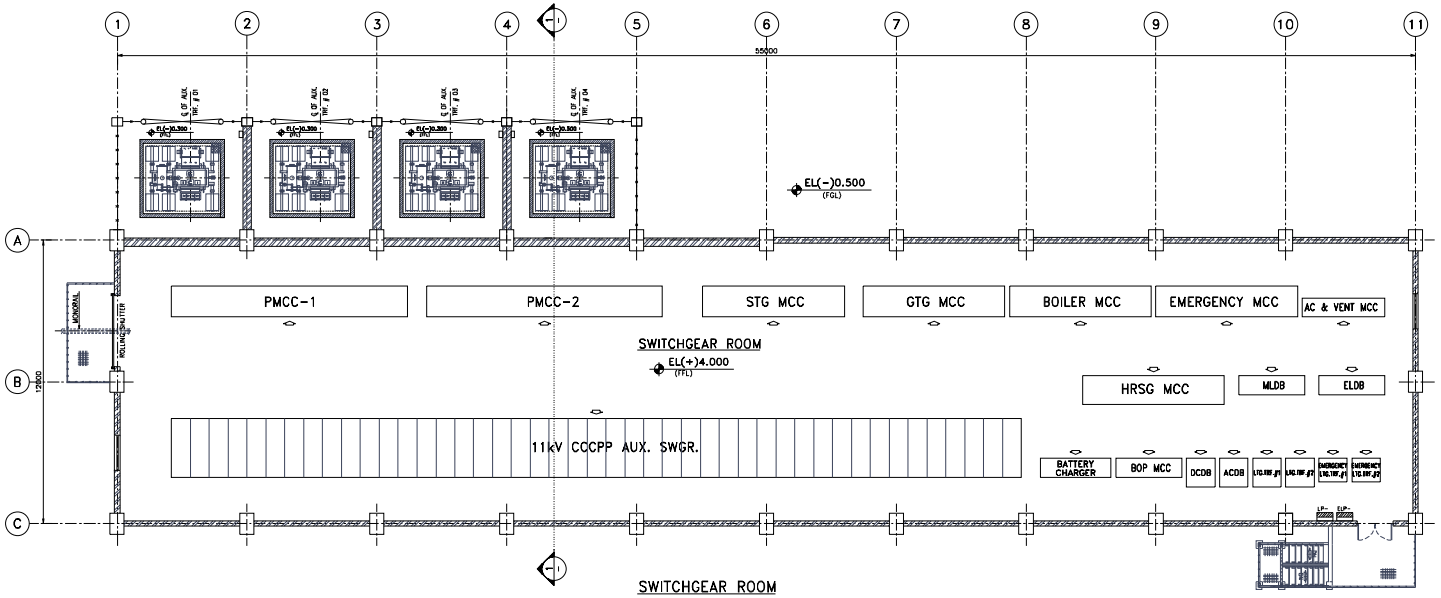
DEPT. ELECTRICAL | FI JOB No.:CNT 5111168 | SCALE: NTS | REV.: B

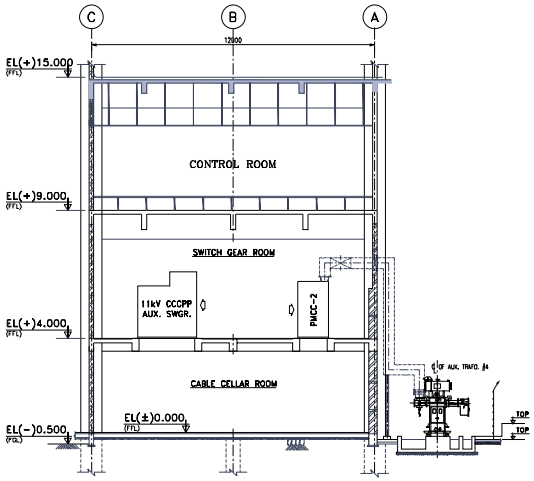
DWG.NO. 10-5111168-E-204

Comp. filename: 10-5111168-E-204.dwg --- DRP --- 17/May/2012 --- 11:26:09 Hrs

DWG.NO. 10-5111168-E-401 REV. B




SECTION 1 (SCALE: N.T.S)

NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETRES AND ELEVATIONS ARE IN METRES.
2. EL(±)0.00 REFERS TO FINISHED FLOOR LEVEL OF PROPOSED STG BLDG.
3. BUILDING & PANEL DIMENSIONS INDICATED ARE TENTATIVE.
4. CONTRACTOR TO SIZE THE BUILDING AS PER ACTUAL PANEL DIMENSIONS DURING DETAILING.
5. FINISH GROUND LEVEL OF THIS AREA EL(-)0.500m AT CONTROL ROOM BLDG. CORRESPONDS TO EL.(+)101.200m FROM MSL.

LEGEND:-

| | |
|---|---|
| EL | ELEVATION |
| FFL | FINISH FLOOR LEVEL |
| FGL | FINISH GROUND LEVEL |
| TOP | TOP OF PAVING |
| TOC | TOP OF CONCRETE |
| ◊ | FRONT |

REFERENCE DRAWING :-

1... PLOT PLAN. : 00-5111168-G-001

FOR TENDER PURPOSE ONLY

| REV. | DATE | DESCRIPTION | DRN. | STR. | MECH. | PROC. | ELEC. | INST. | APPD. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | CHECKED & CLEARED | | | | | |
| B | 17.05.12 | RELEASD FOR TENDER PURPOSE ONLY | DRP | -- | -- | -- | | -- | AVD |
| A | 23.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | SDK | -- | -- | -- | APK | -- | AVD |

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| | SIGNATURE | | DATE |
|---|---|---|---|
| DRAWN | SAMEER | SDK | 18.04.12 |
| DESIGNED | | APK | 18.04.12 |
| CHECKED | | HN | 18.04.12 |
| APPROVED | | AVD | 18.04.12 |
| PROJ. MGR. | | SG | 18.04.12 |

TITLE: EQUIPMENT LAYOUT FOR SWITCHGEAR ROOM

| CLEARED (FOR IND ONLY) | SIGNATURE | | DATE |
|---|---|---|---|
| STRUCTURAL | -- | -- | -- |
| MECHANICAL | -- | -- | -- |
| PROCESS | -- | -- | -- |
| ELECTRICAL | -- | -- | -- |
| INST. | -- | -- | -- |

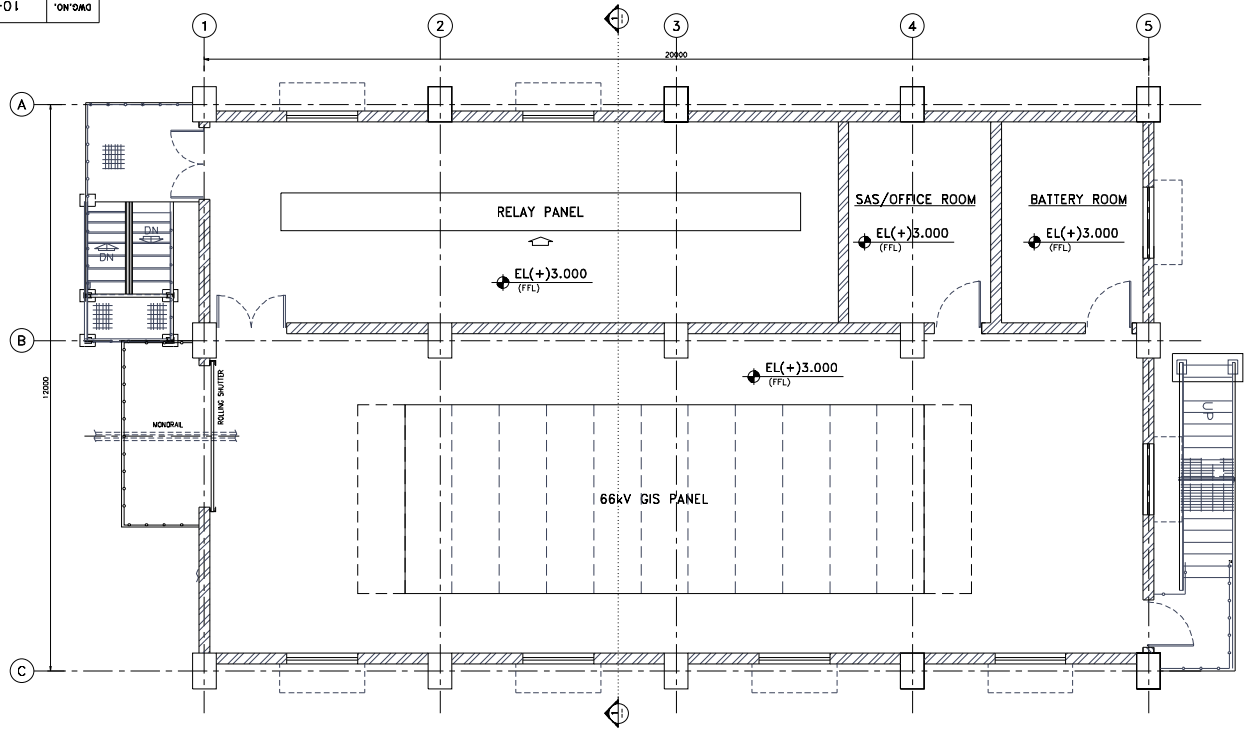
RELEASED FOR: PRELIMINARY ☐ TENDER ☑ ENGINEERING ☐ CONSTRUCTION ☐

DEPT. ELECTRICAL | FI JOB No.: CNT 5111168 | SCALE : 1 : 100 | REV.

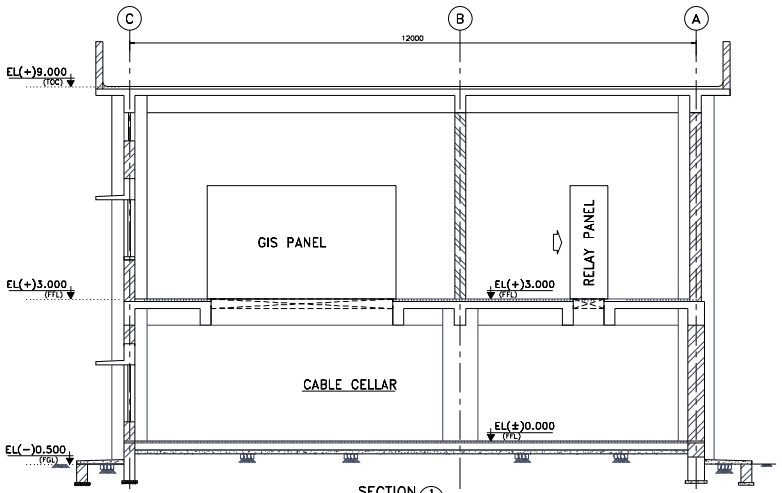
DWG.NO. 10-5111168-E-401 B

Comp. filename: 10-5111168-E-401.dwg --- SDK --- 18/May/2012 --- 14.38.30 Hrs

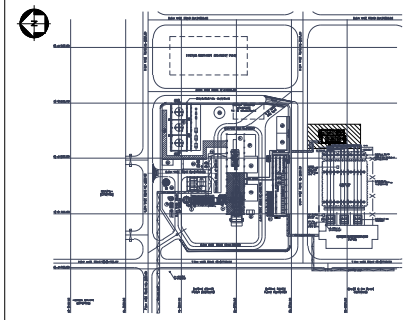
DWG.NO. 10-5111168-E-402 REV. B




PLAN AT EL(+)3.000 M. LEVEL




SECTION 1 (SCALE 1:100)



KEY PLAN
(SCALE-N.T.S)

**NOTES:-**

1... ALL DIMENSIONS ARE IN MILLIMETRES AND ELEVATIONS ARE IN METRES.
2.. EL(±)0.00 REFERS TO FINISHED FLOOR LEVEL OF PROPOSED STG BLDG.
3... BUILDING & PANEL DIMENSIONS INDICATED ARE TENTATIVE.
4.. CONTRACTOR TO SIZE THE BUILDING AS PER ACTUAL PANEL DIMENSIONS DURING DETAILING.

**LEGEND:-**

| | |
|---|---|
| EL | ELEVATION |
| FFL | FINISH FLOOR LEVEL |
| FGL | FINISH GROUND LEVEL |
| TOP | TOP OF PAVING |
| TOC | TOP OF CONCRETE |
| ◊ | FRONT |

**REFERENCE DRAWING :-**

1... PLOT PLAN. : 00-5111168-G-001

FOR TENDER PURPOSE ONLY

| REV. | DATE | DESCRIPTION | DRN. | STR. | MECH. | PROC. | ELEC. | INST. | APPD. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | CHECKED & CLEARED | | | | | |
| B | 17.05.12 | RELEASED FOR TENDER PURPOSE ONLY | DRP | -- | -- | -- | -- | -- | AVD |
| A | 23.04.12 | PRELIMINARY FOR REVIEW & COMMENTS | SDK | -- | -- | -- | APK | -- | AVD |

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AT HAZIRA PLANT, GUJARAT.

| | SIGNATURE | | DATE |
|---|---|---|---|
| DRAWN | SAMEER | SDK | 18.04.12 |
| DESIGNED | | APK | 18.04.12 |
| CHECKED | | HN | 18.04.12 |
| APPROVED | | AVD | 18.04.12 |
| PROJ. MGR. | | SG | 18.04.12 |

TITLE: EQUIPMENT LAYOUT FOR 66kV GIS BUILDING AREA

| CLEARED (FOR IND ONLY) | | SIGNATURE | | DATE |
|---|---|---|---|---|
| | STRUCTURAL | -- | -- | -- |
| | MECHANICAL | -- | -- | -- |
| | PROCESS | -- | -- | -- |
| | ELECTRICAL | -- | -- | -- |
| | INST. | -- | -- | -- |

| RELEASED FOR | | |
|---|---|---|
| | PRELIMINARY | |
| | TENDER | ✓ |
| | ENGINEERING | |
| | CONSTRUCTION | |

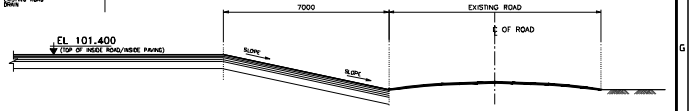
DEPT. ELECTRICAL | FI JOB No.: CNT 5111168 | SCALE : 1 : 50 | REV.

DWG.NO. 10-5111168-E-402 B

Comp. filename: 10-5111168-E-402.dwg --- SDK --- 18/May/2012 --- 14:27:36 Hrs

DWG. NO. 10-5111168-C-002

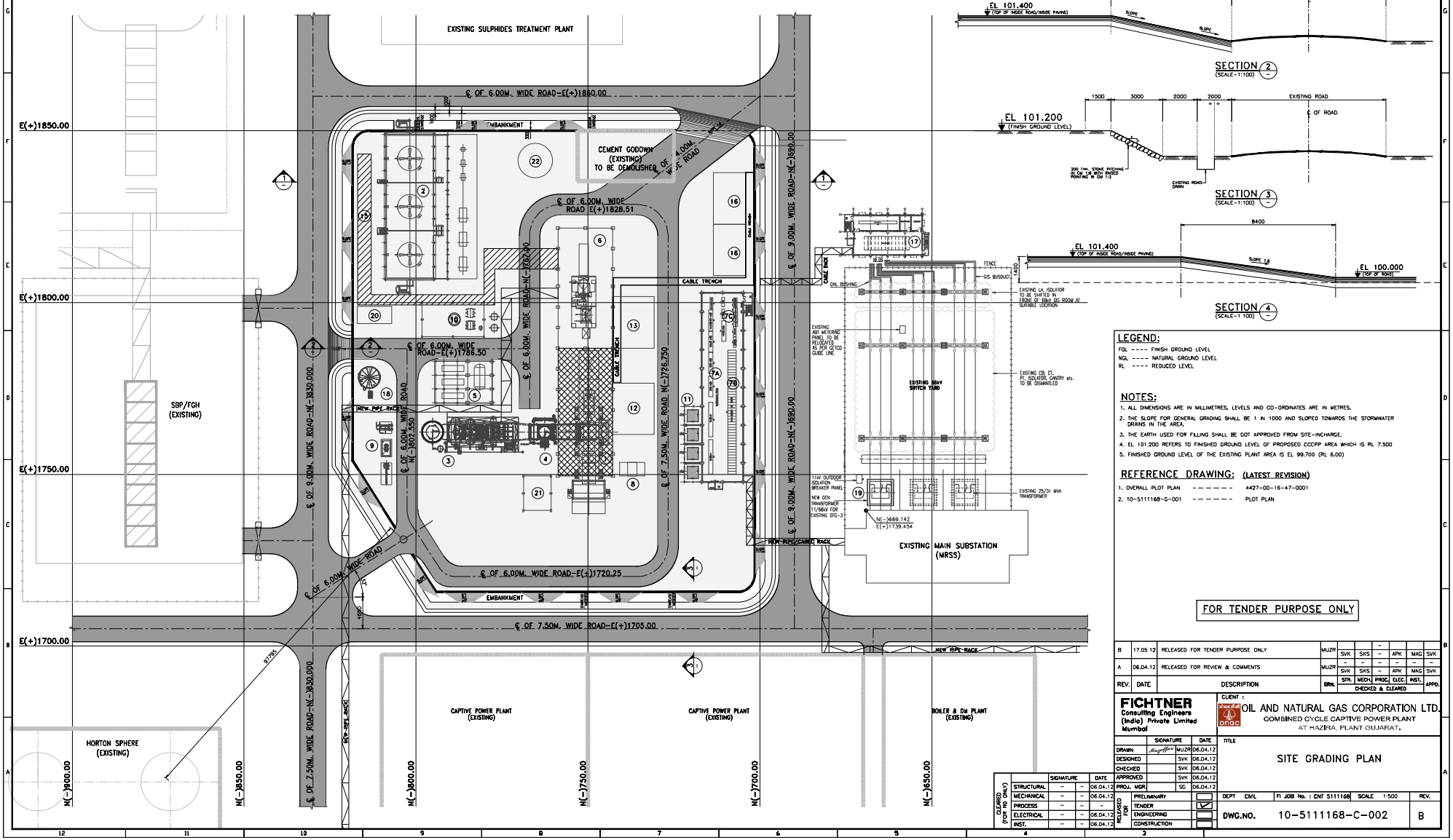
REV. B










## LEGEND:

FGL ---- FINISH GROUND LEVEL
NGL ---- NATURAL GROUND LEVEL
RL ---- REDUCED LEVEL

## NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES. LEVELS AND CO-ORDINATES ARE IN METRES.
2. THE SLOPE FOR GENERAL GRADING SHALL BE 1 IN 1000 AND SLOPED TOWARDS THE STORMWATER DRAINS IN THE AREA.
3. THE EARTH USED FOR FILLING SHALL BE GOT APPROVED FROM SITE-INCHARGE.
4. EL 101.200 REFERS TO FINISHED GROUND LEVEL OF PROPOSED CCCPP AREA WHICH IS RL 7.500
5. FINISHED GROUND LEVEL OF THE EXISTING PLANT AREA IS EL 99.700 (RL 6.00)

## REFERENCE DRAWING: (LATEST REVISION)

1. OVERALL PLOT PLAN ------ 4427-00-16-47-0001
2. 10-5111168-G-001 ------ PLOT PLAN

**FOR TENDER PURPOSE ONLY**

| REV. | DATE | DESCRIPTION | DRN. | STR. | MECH. | PROC. | ELEC. | INST. | APPD. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | CHECKED & CLEARED | | | | | |
| B | 17.05.12 | RELEASED FOR TENDER PURPOSE ONLY | MUZR | SVK | SKS | – | APK | MAG | SVK |
| A | 06.04.12 | RELEASED FOR REVIEW & COMMENTS | MUZR | SVK | SKS | – | APK | MAG | SVK |

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Mumbai

CLIENT :
ONGC
OIL AND NATURAL GAS CORPORATION LTD.
COMBINED CYCLE CAPTIVE POWER PLANT
AT HAZIRA, PLANT GUJARAT.

| | SIGNATURE | | DATE |
|---|---|---|---|
| DRAWN | | MUZR | 06.04.12 |
| DESIGNED | | SVK | 06.04.12 |
| CHECKED | | SVK | 06.04.12 |
| APPROVED | | SVK | 06.04.12 |
| PROJ. MGR. | | SG | 06.04.12 |

TITLE
SITE GRADING PLAN

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| MECHANICAL | – | – | 06.04.12 |
| PROCESS | – | – | – |
| ELECTRICAL | – | – | 06.04.12 |
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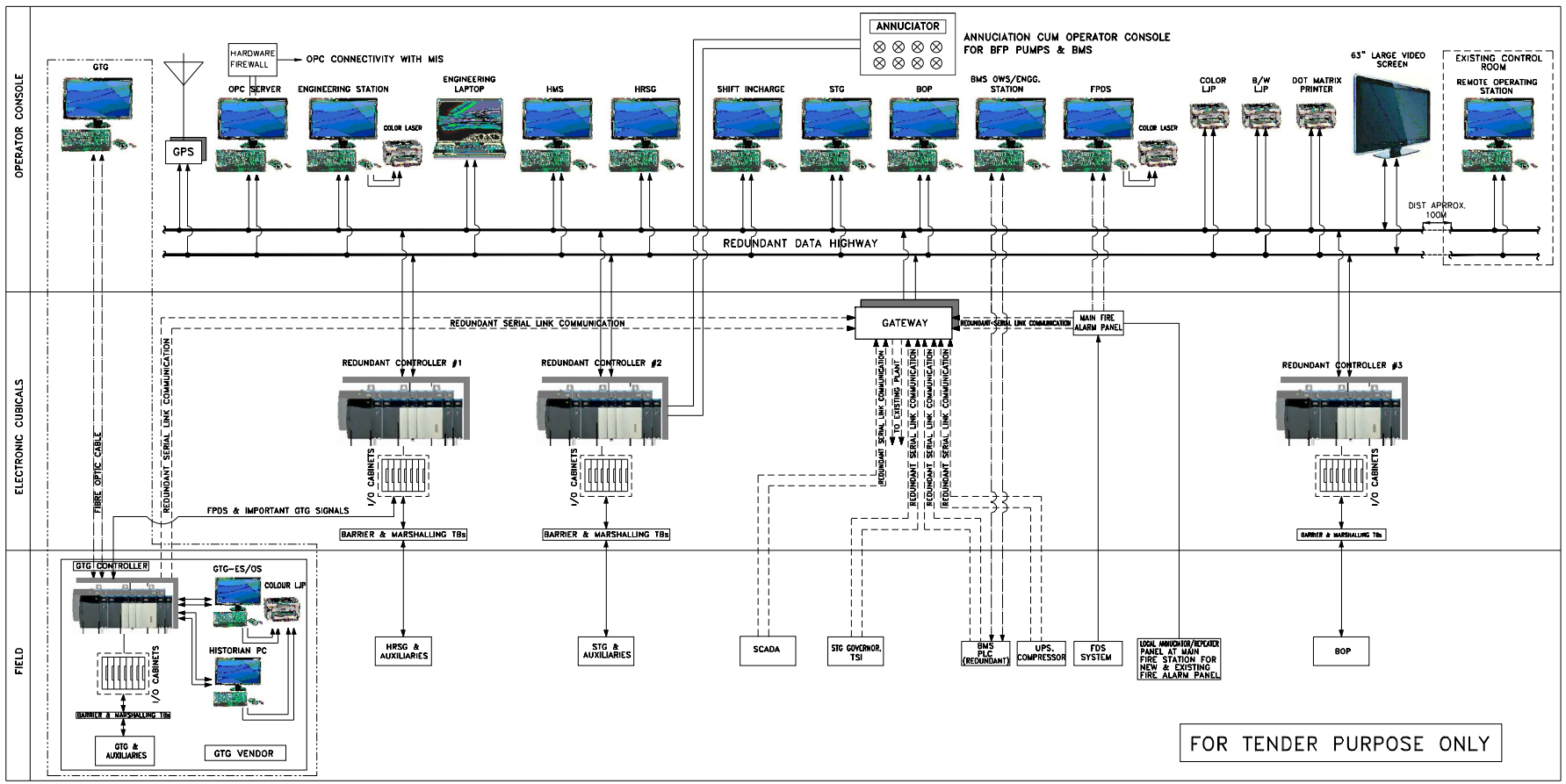
REV. B

DWG. NO. 20-5111168-I-351




FOR TENDER PURPOSE ONLY

## NOTES:–

01) REDUNDANCY SHALL BE PROVIDED AT CONTROLLER, POWER SUPPLY & COMMUNICATION LEVEL, SERVER (IF APPLICABLE).
02) MONITOR SIZE OF ALL OPERATOR STATION SHALL NOT BE LESS THAN 24".
03) SEQUENCE OF EVENT RECORDING SHALL BE PART OF THE DCS.
04) ALL OPERATOR STATIONS SHALL HAVE LATEST VERSION OF MMI SOFTWARE.
05) No. OF CONTROLLERS ARE INDICATIVE. ACTUAL No. OF CONTROLLER WILL BE DECIDED DURING DETAIL ENGINEERING KEEPING 60% LOADING PER CONTROLLER.
06) TURBO SUPERVISORY INSTRUMENT (TSI), WTP, AIR COMPRESSOR, GTG CONTROL SYSTEM, UPS, SHALL COMMUNICATE TO DCS THROUGH REDUNDANT SERIAL COMMUNICATION LINK. HOWEVER, IMPORTANT SIGNALS OF COMPRESSOR, GOVERNOR CONTROL SYSTEM, & UPS SHALL BE HARDWIRED TO DCS.
07) FIREWALL SHALL BE PROVIDED WITH REQUIRED HARDWARE & SOFTWARE (ANTIVIRUS)
08) REQUIRED HARDWARE & SOFTWARE SHALL BE PROVIDED FOR GPS SYSTEM.
09) ALL THE SOFTWARE'S SHALL BE PROVIDED WITH LICENSE VERSION (COPY) SOFTWARE.

## LEGEND :–

OS : OPERATOR STATION
TSI : TURBO SUPERVISORY INSTRUMENTS
GCS : GOVERNOR CONTROL SYSTEM
GPS : GLOBAL POSITIONING SYSTEM
WTP : WATER TREATMENT PLANT
HMS : HART MANAGEMENT SYSTEM WORKSTATION
– – – : SERIAL COMMUNICATION LINK
——— : HARDWIRED SIGNAL
—.—.— : FIBER OPTICS CABLE

ES : ENGINEERING STATION.
SOE : SEQUENCE OF EVENTS RECORDER
BMS : BURNER MANAGEMENT SYSTEM
DMP : DOT MATRIX PRINTER
LJP : LASERJET PRINTER
FDS : FIRE DETECTION SYSTEM

GPS MASTER CLOCK SYSTEM
→ PROPOSED DCS SYSTEM – CCPP
→ GTG CONTROL SYSTEM
→ OTHER PLC SYSTEMS IN POWER PLANT
→ SPARE 1
→ SPARE 2
→ SPARE 3

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| B | 17.05.12 | FOR TENDER PURPOSE ONLY | HNA | PMB SKS --- APK MAG BV |
| A | 06.04.12 | FOR REVIEW & COMMENTS | HNA | PMB SKS --- APK MAG BV |

FICHTNER Consulting Engineers (India) Private Limited Mumbai

CLIENT: OIL AND NATURAL GAS CORPORATION LTD.
COMBINED CYCLE CAPTIVE POWER PLANT AT HAZIRA PLANT, GUJARAT.

| | SIGNATURE | DATE |
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| DRAWN | HNA | 28.03.12 |
| DESIGNED | MAG | 27.03.12 |
| CHECKED | MAG | 06.04.12 |
| APPROVED | BV | 06.04.12 |
| PROJ. MGR. | SG | 06.04.12 |

TITLE: DCS CONFIGURATION DIAGRAM

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| | STRUCTURAL | -- | SVK | -- |
| | MECHANICAL | -- | FWR | -- |
| | PROCESS | -- | --- | -- |
| | ELECTRICAL | -- | AVD | -- |
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DEPT. INSTRUMENTATION | JOB No.: CNT 5111168 | SCALE N.T.S | REV.

DWG.NO. 20-5111168-I-351 | B

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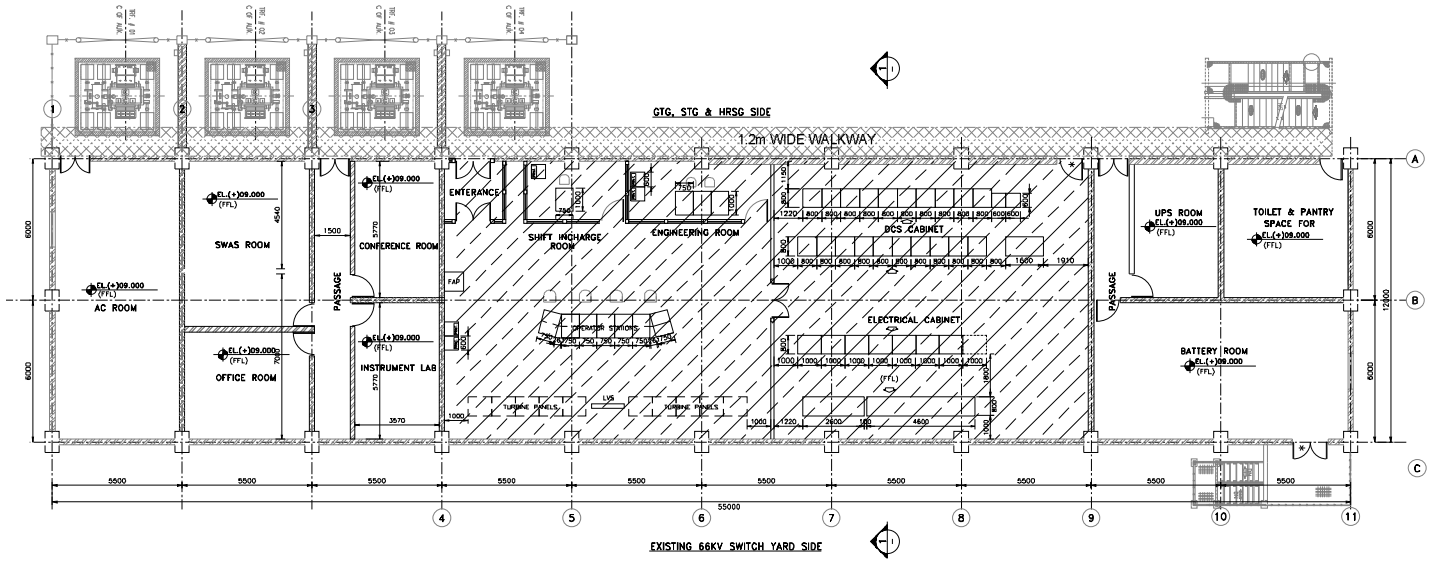
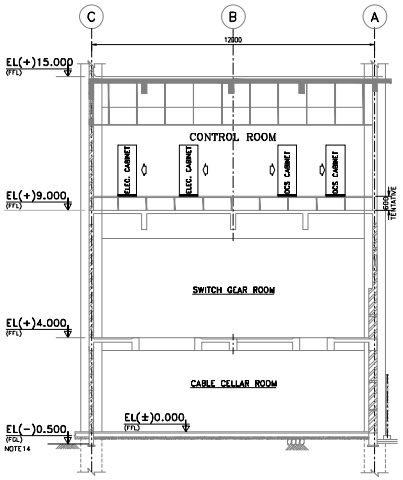



CONTROL ROOM AT EL(+ 9.000M)

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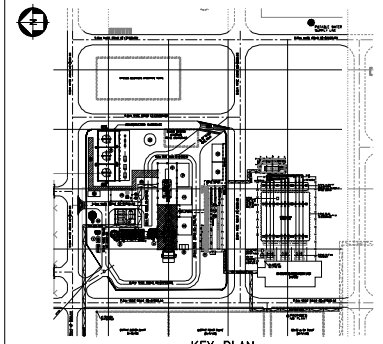

KEY PLAN

## NOTES:-

01) ALL DIMENSION ARE IN MM & ELEVATION IN METERS.
02) FALSE FLOORING SHALL BE PROVIDED ONLY FOR THE SHADED AREA.
03) FALSE CEILING SHALL BE PROVIDED FOR ENTIRE CONTROL ROOM.
04) ALL ROOMS SHOWN IN THIS DRAWING SHALL BE AIR CONDITIONED, EXCEPT UPS BATTERY ROOM. UPS BATTERY ROOM SHALL HAVE INDEPENDENT SPLIT AC.
05) ANTISTATIC FLOORING (PVC FLOOR) TO BE PROVIDED FOR ENTIRE CONTROL ROOM.
06) GLASS PANELS SHALL BE CONSTRUCTED AFTER ALL PANELS ARE TAKEN INSIDE THE CONTROL ROOM.
07) CLEAR GAP BETWEEN TOP OF FALSE FLOOR AND BOTTOM OF FALSE CEILING SHALL BE 3.0 Mtrs.
08) GLASS PANELS INSIDE THE CONTROL ROOM SHALL BE 2 Mtrs. HEIGHT.
09) THE Nos. OF PANELS & CONTROLLERS ARE TENTATIVE CONSIDERING 60% LOADING - VARIES FROM VENDOR TO VENDOR.
10) THE PANEL DIMENSIONS MARKED ARE TENTATIVE.
11) + NORMALLY CLOSED. TO BE USED AS AN EMERGENCY EXIT
12) BUILDING & PANEL DIMENSIONS INDICATED ARE TENTATIVE.
13) EPC CONTRACTOR TO SIZE THE BUILDING AS PER ACTUAL PANEL DIMENSIONS DURING DETAILING.
14) FINISH GROUND LEVEL OF THIS AREA EL(-)0.500m AT. CONTROL ROOM BLDG. CORRESPONDS TO EL.(+)101.200m FROM MSL.
15) GLASS WINDOW SHALL BE PROVIDED TOWARDS SWITCH YARD & GT-STG HALL, HRSG.

## LEGEND:-

| | |
|---|---|
| EL. | ELEVATION |
| FFL. | FINISH FLOOR LEVEL |
| FGL. | FINISH GROUND LEVEL |
| LVS | LARGE VIDEO SCREEN |
| FAP | FIRE ALARM PANEL |
| | FRONT |
| | FALSE FLOOR |

## REFERENCE DRAWING:-

1... PLOT PLAN. : 00-5111168-G-001 (REV B)
2.. SITE GRADING PLAN. : 10-5111168-C-002 (REV B)

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FICHTNER
Consulting Engineers (India) Private Limited
Mumbai

CLIENT: OIL AND NATURAL GAS CORPORATION LTD.
COMBINED CYCLE CAPTIVE POWER PLANT AT HAZIRA PLANT, GUJARAT.

| | SIGNATURE | | DATE |
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| DRAWN | sd/- | HNA | 07.05.12 |
| DESIGNED | sd/- | MAG | 07.05.12 |
| CHECKED | sd/- | MAG | 11.05.12 |
| APPROVED | sd/- | BV | 11.05.12 |
| PROJ. MGR. | sd/- | SG | 11.05.12 |

TITLE: EQUIPMENT LAYOUT FOR CONTROL ROOM AT EL.(+)9.000m

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# GENERAL SCOPE

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1) These Specifications establish and define the material and constructional requirements for civil, structural and architectural works.
2) Method of measurement are indicated in these specifications. Where not so specified, latest version of IS: 1200 shall be applicable.
3) Providing and operating necessary measuring and testing devices and materials including all Consumables are included in the scope of work. No separate measurement or payment for testing the work shall be made but rates quoted for various items shall be deemed to include the cost of such tests which are required.
4) All materials shall be standard quality, manufactured by renewed concerns, conforming the Indian standards or equivalent and shall have "IS" mark as far as possible unless other wise approved by engineer in-charge prior to procurement and use. The contractor shall furnish manufacture's certificates, for the materials tested from an approval test house, if asked for by the engineer-in-charge. The costs of all test and the test certificates, shall be borne by the contractor. No separate payment shall be made for the testing. The Engineer –in-charge shall have the right to determine whether all or any of the materials are suitable. Any materials procured or brought to sight and not conforming the specifications and satisfaction of the Engineer-in-charge shall be rejected and the contractor shall have to remove the same immediately from sight at his own expenses and with out any claim for compensation due to such rejection.
5) Where ever referred to in third tender document, only the latest revision which shall be enforced in the completion of work of specifications, codes of practice and other publications of the Bureau of Indian Standards shall be applicable.
6) Wherever contractor executes civil and structural works involving building and equipment foundations, structural work or building pipe etc the following works are deemed to have been included in the quoted rates for various works.

    1. Mark of center lines or foundations

    2. Marking of top levels of foundations, floors etc and establishment of reference lines, bench marks on various floors, plat forms etc.

    3. Preparation of "as built" scheme of structural foundation and indicating designed and achieved levels, center line and dimensions of pockets, position and level of anchor bolt etc.

7) In case of conflict amongst the provisions of schedule of rate specifications and drawings, all of them shall be read in conjunction with other and clarification shall be obtained from the Engineer-in- charge whose decision shall be final and binding.
Following procedure may generally followed

    7.1 Description of items in schedule of rates shall be followed when provisions therein are different from those in specifications
    7.2 Where the description of items doesn't call out for some specific requirement but the same are given in specifications, the specifications shall be followed, in addition to the requirements given in description of items
    7.3 Where drawings call out for requirements different from or additional to those given item description and specifications, the decision of the Engineer-In-Charge shall be obtained as to what to shall be followed.

# PROPERTIES, STORAGE & HANDLING OF COMMON BUILDING MATERIALS

| REV. NO. | PRAPARED | APPROVED | DATE |
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## 1.00.0 Scope

The scope for this section is to specify the properties, storage and handling of Common building materials unless otherwise mentioned in drawings or schedule items.

## 2.00.0 MATERIALS

**a) Bricks**

Bricks for general masonry work shall be conform to IS: 1077 and for face Bricks work shall conform to the specifications in IS: 2691.

Bricks for general masonry work shall be of first class (Class A) quality, Well Burnt, of uniform size, shape and colour free cracks, flaws or nodules Or free lime and emit clear ringing sound when struck. Fractured surface shall show uniform texture free from grits, lumps holes etc. Compressive Strength shall be 75kg/cm$^2$ minimum for common bricks and 150/kg/cm$^2$ Minimum for face bricks. Water for common bricks absorption after 24 Hours Immersion shall not exceed 15% by weight for common bricks and 12%For Face bricks. Dimensional tolerance shall not exceed 8% of the size shown in Drawing for common bricks and 3% for face bricks. All bricks shall have Rectangular faces and shape bricks shall be 6mm at the edges and 10mmFor Corners. The bricks shall show no effluences after socking in water and in shade. Each bricks shall have manufacturer's identification marks clearly marked on the frog. Representative samples shall be submitted by the contactor and approved samples shall be retained by the engineer for comparison of bulk supply. Any brick not found the specification should be removed immediately from site at the contractor's own cost.

**b) Stone**

All stones shall be from approved quarries. Hard, tough, durable compact Drained, uniform in texture and colour and free from decay, flaws, veins, Cracks and sand holes. The surface of freshly broken stone shall be bright, Clean and sharp and shall show uniformity of texture, without loose grains and free from any dull, chalky or earthy appearance. Stone showing mottled colours shall not be used for face works. A stone shall not absorb more than 5 present of its weight of water after 24 hours immersion. The type of stone shall be as specified on drawings and/or instructed by Engineer. Samples shall be submitted by the contactor and approved samples shall be retained by the engineer for comparison of bulk supply.

**c) Lime**

Lime shall be stone lime and conform to the specification Building lime IS: 712. Lime putty may be prepared from hydrated lime or quick lime. Hydrated lime shall be mixed with water to from putty and stored with Reasonable care to prevent evaporation for at least 24 hours before use. Quick Lime shall be shacked with

enough water to make a cream passed through a No. O Sieve and then stored with reasonable care to prevent evaporation for at least 7 days before use.

**d) Cement**

Cement used shall be ordinary Portland cement conforming to Code for Ordinary cement in IS: 8112 and shall be fresh when delivered. The contractor shall submit the anufacture's certificate for each consignments of cement procured to the contractor, the Contractor shall satisfy himself at the time of taking delivery that the quality, quantity and freshness of cement are up to the Specified standards No. shall be entertained and all rectification work on Account shall be done by the contractor at his own expense. If at any time, the Engineer feels that the work and send the samples of the cement to a testing Laboratory for standard tests and all expenses incurred thus shall be borne by the Contractor. The contractor shall else have no claim for this type of Suspension of work.

**e) Coarse Aggregates**

Coarse aggregates shall be as per IS: 383 latest editions, consisting of hard, Strong and durable pieces of crushed stone and shall and be free organic or clay coatings and other impurities like disintegrated stone. Soft flaky particles etc. and any other materials liable to affect the strength durability or appearance of Concrete. Aggregates other than crushed stone conforming to the provisions of specification may be used if permitted by the Engineer. Washing of aggregates by approved means shall be carried out, if desired by the Engineer. Grading of coarse aggregates shall generally conform to IS: 383 and shall be Such as produce dense concrete of the specified proportions and strength and of Consistency that will work readily into position without segregation.

**f) Sand**

Sand shall be hard, durables, clean and free from adherent coating or organic matter and shall not contain clay balls or pellets, the sand shall be free from impurities such as iron pyrities. Alkalise, salts, coal, mica, shale or other laminated materials in such forms or quantities as to affect adversely the Harding, strength, durability or appearance of mortar. Plaster or concrete or to cause corrosions to any metal in contact with such mortar, plaster or concrete. All sand shall be properly graded. Unless otherwise directed by the Engineer all sand shall pass through IS Sieve NO< 240 and 15 to 30% of and for masonry mortar and 5 to 50% of sand for plaster shall pass through IS Sieve No 30. Sand for concrete shall conform to IS: 383.

**e) Water**

Water shall be clean, fresh and free from organise matters, acids or soluble salts and other deleterious substances which may cause corrosion, discolouration, Efflorescence etc.

**g) Reinforcement**

Reinforcement steel shall be clean and free from loose mill scales, dust, loose Rust, oil and grease or other coatings, which may impair proper, bond Structural Steel shall conform to

IS: 226. Mild steel and medium tensile steel and medium Tensile steel bars and hard-drawn steel wire for concrete reinforcement shall conform is IS: 432 Cold twisted steel bars shall conform to IS: 1786 Hexagonal Wire netting shall conform toIS: 3150. All steel bars including and above 10mm Diameter shall be of tested quality. All wire netting shall be galvanised.

3.00.0 **STORAGE AND HANDLING OF MATERIALS.**

**a) Bricks**

Bricks shall not dumped at sits. They shall be stacked in regular tires. Even as they are unloaded, to minimise breakage and defacement of bricks. Bricks selected for different situation of use in the work shall be stacked separately.

**b) Stones**

Stones shall be stored at site in manner approved by the Engineer. Dressed stone For wall facing, paving etc. shall be stored with special care to avoid Defacement of faces and edges or damp and rust stains.

**c)Lime**

Lime shall be in weatherproof sheds.

**d) Cement**

The cement shall be stored above the ground level in perfectly dry and watertight sheds. The bags shall be stacked in a manner so as to facilitate removal or first in first out basis. Any material considered defective by the Engineer shall not be used by the contractor and shall be removed from the Site immediately.

**e) Coarse and Fine Aggregates**

Aggregates shall be stored on brick soiling or an equivalent platform so that they do not come in contact with dirt. Grass or any other injurious substances at any stage. Aggregate of different size shall be kept in separate stacks. If so desired by the Engineer aggregate from different sources shall be stacked separately with proper care to prevent intermixing.

**f) Reinforcement**

Reinforcement bars shall be stored off the ground and under cover if so desired by the Engineer. If necessary. A coat of cement wash shall be given to the bars to guard against rusting.

# EARTHWORK IN EXCAVATION AND BACKFILLING

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**1.0.0 SCOPE**

This specification covers excavation in all types of soil, soft and decomposed rock not requiring blasting and rocks requiring blasting, shoring, dewatering, filling around foundations and to grade, compaction of fills and approaches, protective fencing, lighting, etc relevant to structures and locations covered under the scope of this contact.

2.00.0 **GENERAL**

2.1.0 **WORK TO PROVIDED FOR BY THE CONTRACTOR**

The work to provided for by the contractor, unless specified otherwise. Shall include but not be the following.

a) Furnish all labour, supervision, services including facilities as required under statutory labour regulations, materials, equipment, tools and plants, transportation, etc, required by the Engineer
b) Prepare and submit working drawing showing the approaches, slope, beam, shoring, sumps for dewatering, including drains and outfall for drainage, space for temporary stacking of spoil, disposal area, fencing, etc and all other details as may be required by the Engineer.
c) To carry out sampling and testing and submit to the Engineer, results of soil compaction tests if required by the Engineer to assess the degree of compaction.
d) Construction, maintenance and removal after completion of Magazine of proper capacity as well as design for storing of explosives required for blasting work to be carried out scope of this tender.

2.2.0 **WORK TO PROVIDED FOR BY OTHERS.**

No work under this specification will be provided by any agency other than the Contractor unless specifically mentioned elsewhere in the Contract

2.3.0 **CODES AND STANARDS**.

All works under this specification, unless specified otherwise shall conform to the Latest revision and /or replacement of the following or any other Indian Standard Specifications and codes of practice. In case any particular aspect of work is no Covered specially by Indian Standard Specification any other standard practice as May be specified by the Engineer shall be followed: -

IS: 3664: Indian Standard for Safety Code for Excavation work.

IS: 1200: Indian standard Method of Measurement of Building and Civil Engineering Work, (Part-I): Earthwork.
IS: 4701: Indian standard Code of Practice for Earthwork on Canals

2.4.0 **CONFORMITY WITH DESIGNS.**

The Contractor is to carry out the work as per the drawings issued to him and/ or Contractor's drawings which are approved by the Engineer and/or
Engineer's instructions.

2.5.0 **MATERIALS TO BE USED**

2.5.1 **GENERAL**

All material required for the work shall be of best commercial variety and approved By the Engineer.

2.5.2 **BORROW METERIAL.**

Borrow material required for back-filling shall be excavated from approved locations and levels and shall consist of material, approved by the Engineer, free roots, Vegetations, decayed organic matter, harmful salts and chemicals, free from lumps and codes. If specified, clean graded sand free from harmful and deleterious Material from approved quarries, shall be as fill material.

2.6.0 **QUALITY CONTROL**

The contractor shall establish and maintain quality control for the various aspects of the work, method, materials and equipment used. The quality control operation shall Include but not be limited to the following items of work: -

a) Lines, Levels and Grades: I) periodic surveys
II) Establishment of markers, boards etc.

b) Back- filling: I) Checking the quality of fill material
II) Checking moisture content of the backfill
III) Checking the degree of compaction

3.3.0 **EXECUTION**

3.1.0 **SETTING OUT**

Within 15 days of award of Contract, the contractor will prepare and submit to the Engineer, detailed drawings of the excavation work as proposed to be executed by The Showing the diminutions as per drawings and specification adding his proposals of Slopes, shoring, approaches, dewatering sumps, beams, etc. On Receiving, approval From the engineer with modifications and corrections, if necessary, the Contractor Will set out the work from the control points furnished by the Engineering and fix Permanent point s furnished by the Engineer and fix permanent point and markers for case of future checking. These permanent points and markers for case of furnished by the engineer and fix permanent points and markers will be fixed at intervals prescribed by the Engineer and checked by the Engineer and certified by him after which the Contractor will proceed with the work. It should be noted that this checking by the Engineer prior to start of the carrying work will in no way

absolve the Contractor of responsibility of carrying out the work to true lines and levels and grades as per drawing and subsequent corrections. If necessary, free of cost to the Owner in case any errors are noticed in the Contractor's work at any stage.

## 3.2.0 INITIAL LEVELS

Initial level of the ground either in a definite grid pattern or as directed by the Engineer will be taken by the Contractor jointly with the Engineer over the original Ground prior to starting actual excavation work and after setting out. These initial Level will be used for preparing cross-sections for volume measurement or for Crosschecking the depths obtained from tape measurement.

All records of levels, measurements etc. and also any drawing, cross section etc. Made there from, shall be jointly signed by the authorised representative of the Contractor and the engineer before the commencement of and they shall from the Basis of all payments in future.

## 3.3.0 CLEARING AND GRUBBING, ETC.

The area to be excavated shall be cleared out of fences, trees, logs, stumps, bush, Vegetation, rubbish, slush, etc. and levelled up. Trees unto 300mm girth shall be Uprooted. Trees above 300mm girth to be cut, shall be approved by the engineer And then Marked. Felling of trees shall include taking out roots up to 600mm below ground level or 150mm below formation level whichever is lower. After the tree is cut and roots taken out the pot–holes formed shall be filled with good earth in 250mm layers and consolidated unless directed by the Engineer otherwise. The trees shall be cut in suitable pieces as instructed by the Engineer.

Before earthwork is started, all the spoil and unserviceable materials and rubbish Shall be burned or removed from the site to approved disposal areas as may be Specified. Ash shall be spread or removed. Useful materials, saleable timber, Firewood, etc, shall be the property of the Owner and shall be stacked properly at the worksite in a manner as directed by the Engineer.

## 3.4.0 CLASSIFICATION

All earthworks shall be classified under the following categories:

### a) ORDINARY SOIL

This shall comprise vegetable or organic soil, turf, sand, loam, clay, mud, peat, black Cotton soil, soft shale or loose moorum, a mixture of these and similar material which Yields to the ordinary application of pick and shovel, rake or other ordinary digging implement. Removal or any other modular material having diameter in any one direction not exceeding 75mm occurring in such strata shall be covered under this category.

**b) HARD SOIL.**

This shall include

i) Stiff heavy clay, hard shale, or compact mooruum, requiring grafting tool or pick or both and chovel, closely applied,
ii) Gravel and cobble stone having maximum diameter in any one direction between 75 and 300mm,
iii) Soiling of roads, paths, etc, and hard core,
iv) Macadam surface such as water bound, and bitumen/ tar bound,
v) Lime concrete, stone masonry in lime mortar and brick work in lime/cement Mortar, below ground level,
vi) Soft conglomerate, where the stones may be detached from the matrix with Picks, and

vii) Generally any material, which requires close application of picks, or scarifies to loosen and not affording resistance to digging greater than the hardest of any soil mentioned in (i) And (vi) above.

**c) SOFT AND DECOMPOSED ROCK**

This shall include:

i) Limestone, sandstone, late rite, hard conglometerate or other soft or Disintegrated rock which may be quarried or spilt with crowbar,

ii) Unreinforced cement concrete, which may be broken up with crowbars or picks And stone masonry in cement mortar belowground level.

iii) Boulders, which do not require blasting having maximum diameter in any Direction of more than 300mm, found laying loose on the surface or embedded In river bed, soil, talus, slope wash and terrace material of dissimilar origin, and

iv) Any rock which in dry state may be hard, requiring blasting, but which when Wet becomes soft and manageable by means other than blasting.

**d) HARD ROCK (requiring blasting)**

This shall include:

i) Any rock or cement concrete for the excavation of which the use of mechanical plant or blasting is requiring.
ii) Reinforced cement concrete (reinforcement cut trough but separated from the concrete) below ground level, and

iii) Boulders requiring blasting.

**c) HARD ROCK (blasting prohibited)**

Hard rock requiring blasting as described under (d) but where blasting is Prohibited for any reason and excavation has to be carried out by chiselling, Wedging or other agreed method.

In case any dispute regarding classification, the decision of the Engineer shall be final.

3.4.0 **EXACAVATION FOR FOUNDATIONS AND TRENCHES**

3.5.1 **GENERAL**

All excavations shall be done to the minimum dimensions as required for safety and Working facility. Prior approval of the Engineer shall be obtained by the Contractor, In each individual case, for the method he proposes to adopt for the Excavations including dimension, side slopes, shoring, dewatering, disposal, etc. This approval, however, shall not in any way make Engineer responsible for any Consequent loss Damage. The excavation must be carried out in the most Expeditious and efficient Manner.

All excavation in open cuts shall made true to line, slopes and grades shown on the Drawing or directed by the Engineer. No material shall project within the dimension Of minimum excavation lines marked. Boulders projecting out of the excavated Surfaces shall be removed, if in the opinion of the Engineer they are likely to be a Hindrance to the workers.

Method of excavation shall be in every case subject to the approval of the Engineer And the Contractor shall ensure that stability and safety of the excavation, adjacent Structures, to be works.

The Contractor shall be in every case subject to the approval of the excavation and Safety of the workmen. If any slip occurs, the Contractor shall remove all slipped Material from the excavated pit.

All loose boulders, semi-detached rocks, not directly in excavation but so close to The Area to be excavated as to be liable, in the opinion of the Engineer, to fall or Otherwise endanger the workmen, equipment of the work, etc, shall be stripped Off Removed away from the areas of excavation. The method used shall be such as Not to Shatter or render unstable or unsafe the portion which was originally sound And safe any materials not requiring removal as contemplated in the work, but Which In the Option of the Engineer, is later to become loose or unstable shall Also be Promptly and satisfactory directed by the Engineer.

Prior starting the excavation, the ground level at the location shall be checked Jointly With the Engineer.

The rough excavation may be carried unto a maximum depth of 150mm above the

Final level. The balance shall be excavated with special care. If directed by the Engineer, soft and undesirable spots shall be removed even below the final level. The extra excavation shall be filled up as instructed by the Engineer and the Contractor shall be paid for the extra excavation and the filling appropriate item Rates.

If the excavation is done to a depth greater than shown on the drawing, or directed By The Engineer, due to the Contractor's fault, the excess shall be filled unto the Required level at the latter's cost (with cement concrete not leaner than 1:4:8 Ordinary Concrete or richer) as directed by the engineer in each individual case.

Information of rock requiring blasting, those over cuts which are unavoidable will be Made unto ordinary cement concrete 1:2:4 which will be paid for under appropriate rate, provided this over cut is not due to negligence of the contractor. The decision of the Engineer as to the admissibility of such over cut for payment will be final. All excavated materials such hard rock, boulders, bricks, dismantled concrete blocks, etc. Shall be stacked separately as directed by the Engineer and shall be the property of the Owner.

### 3.5.2 EXACAVATION IN ORDINARY SOIL, HARD SOIL AND SOFT AND DECOMPOSED ROCK

The excavation in ordinary soil, soft and decomposed rock will be carried out as per the approved proposal, modified and corrected where necessary by the Engineer. The work will be carried out in a workman like manner without endangering the safety of nearby structure/ services or works wnd without causing hindrance to other activates in the area. As the excavation reaches the required dimensions, lines, levels and the grades, the work will be carried out carefully to avoid any over- excavation. On completion, the work will be finally checked and approved by the Engineer. In certain cases, where deterioration of the ground, upheaval, slips etc. are expected the engineering may order to suspend the at any stage and instruct the Contractor to carryout the balance work just before the foundation work of the structure can be started. No extra will be paid to the Contractor for such unviable temporary suspension of work.

### 3.5.3 EXCAVATION IN HARD ROCK

In case where excavation, both in ordinary soil and hard rock, are involved, the Ordinary soil comprising of soft, hard and dense soil (including literate formation) And rock including weathered rocks, lateritic rocks, etc. Which can be excavated Without blasting, shall be completely stripped off and the levels of the hard rock Wall be taken to be enable measurements. Further work in hard shall be resumed Clearance from the Engineer. Personal deployed for track excavation shall be Protected from all hazards such as loose rock/boulder rolling down and from general Slips of excavated surfaces. Where the excavated surface is such that it is not stable Against sliding, necessary from the excavated surfaces is such that it is not stable Against sliding, necessary supports, props, bracing or bulkheads shall be provide and Maintained .

In case where blasting, though otherwise required, is prohibited for any reasons, the

Excavation shall be carried out by chiselling, wedging or any other approved Method and payment appropriate to blasting shall be made, unless otherwise Mentioned in the Schedule.

3.5.4 **BLASTING**

3.5.4.1 **GENERAL**

Storage, handling and use of explosives shall be governed by the current explosive Rules laid down by the state Governments. The Contractor shall ensure that these Rules are strictly adhered to. The following instruction, wherever found in variance With the variance with the above rules, shall be considered as superseded by the Above rules.

No child under the age of 16 and no person who is in a state of intoxication shall be allowed to enter the premises where explosives are stored not they Be allowed to handle the explosives.

3.5.4.2. **STORAGE OF EXPLOSIVE**:

Storage of explosive shall be governed by the current explosive rules. Explosive shall be stored in aclean, dry, well ventilated magazine to be specially built for the purpose. Under no circumstances should a magazine be erected within 400mm of the actual work site or any source of fire. A space surrounding the magazine shall be fenced in. the ground inside the fence shall be kept class and free from tress, bushes etc. the admission ti this fence without permission of the officer-in-charge. The clear space between the fence and the magazine shall. shall not be less than 90m. The magazine shall be perfectly well drained.

Two lightning conductors shall be provided to the magazine, one at each end. The Lightning conductors shall be once in every year.

Fuses and detonators shall be stored in separate magazines. However, detonators can be kept in an annexe adjoining the magazines. However, provided that their number does not exceed 25,000 and that the annexe is so constructed that not less than 60cm masonry and 100cm of air space shall intervene between any detonators in such annexe and not to be opened in a magazine. Cases containing explosives are not to be opened in a magazine. Explosives in open cases are not to be received into a magazine. Explosives which appear to be in damaged or dangerous condition are not to be kept in any magazine, but must be removed without delay to a safe distance and destroyed.

Artificial light is to be allowed in any magazine. No smoking shall be allowed within 100m of a magazine.

Magazine shoes without nails shall be used while entering the magazine.

The mallets, levers, wedges etc, for opening barrels or cases are to be of wood. Inside a magazine the cases of explosives are to be carried by hand and shall not be rolled or dragged. Explosives, which have been issued and returned to the magazine are to be issued first, otherwise those which have been longest of cases in store are to be issued first.

Cases of explosives must be kept clear of the walls and floors for free circulation of air on all sides, special care is to be taken to kept the floor free from grains of powder of portions of explosive matter fallen on the floors due to leakage of cases etc.

The magazine shall not be opened during any dustsorm or thunderstorm nor any person shall be allowed in the vicinity of the magazine.

All magazines shall be officially inspected at definite intervals and a record kept of the results of such inspections.

3.5.4.3. **Carriage of Explosive**

Detonators and explosives shall be transported separately to the blast site. Explosives shall be kept dry and away from the direct rays of the sun, naked lights, steam pipes or heated metal and other sources of heat. Before explosives are removed, each cage or package is to be carefully examined to ascertain that it is properly closed and shows no sign of leakage.

No persons expect the driver shall be allowed to travel on a vehicle conveying Explosives. No carriage or vessel shall be used for transporting explosives unless all all iron or steel therein with which a package containing any explosive is likely to Come or other suitable material. No lights shall be carried on the vehicle carrying Explosives.

No operation contracted with the leading, unloading and handling of explosives Shall be conducted after sunset.

3.5.4.4 **USE OF EXPLOSIVES**

The contractor shall appoint an agent who shall personally superintend the firing And All operations connected therewith. The contractor Shall Satisfy himself that the person so appointed is fully acquainted with the Responsibilities imposed on him.

Holes for charging explosives shall be drilled with Pneumatic drills, the drilling Pattern being so planned that the rock pieces after blasting will be suitable for Handling.

The hole diameter shall be of such a size that cartridges can easily pass down them And undue force is not required during charging. Charging operations shall be Carried out by or under the personal supervision of the shot firer. Wrappings shall neve be removed from explosive cartridges. Only wooden rods shall be used for

Loading and steaming shot holes. Only one cartridge at a time shall be inserted and gently passed home with the wooden tamping rod.

Only such quantities of explosives as are required for the particular amount of work To be done shall be brought to the works. Should any surplus remain when all the holes have been charged, it shall be carefully removed to a point at least 300m from the firing point.

The explosives shall be fired by means of an electric detonator placed inside the cartridge. For simultaneous firing of a number of charges the electric detonators shall be connected with the exploder through the shot firing able in a simple series circuit. Due precautions shall be taken to keep the firing circuit insulated from the ground., bare wires, rails pipes or any other path of stray current and to keep the lead wires short circuited until ready to fire. Any kinks in detonator leading wire shall be avoided.

For simultaneous firing of a large number of shot holes, use of cordtex may be done. Cordtex shall be initiated by electric detonator attached to its side with adhesive tape, connecting wire or string.

All connection shall be made by authorised shot firer himself. The shot firing cable shall not be dragged along the ground to avoid possible damage to the insulation. The shot firing cable shall be tested for continuity and possible short circuiting be fore it is used each time.

The shot firer shall always carry the exploder handle on his person until he is ready to fire shots. The number or shots fired at a time shall not exceed the permissible limits.

Blasting shall is carried out at certain specified times to be agreed jointly by the Contractor and the Engineer.

Before any blasting is carried out. It shall be censured that all workmen, vehicles and equipment on the site are cleared from an area of minimum 300 meters radius from the firing point, or as required by statutory regulation, at least ten minutes before the time or firing by sounding a warning siren. The area shall be encircled by red flags.

At least five minutes after the blast has been fired in case of electric firing or as stipulated in the regulations the authorised shot firer shall return to the blast area and inspect carefully the work and satisfy himself that all charged holes have exploded. Cases of misfired unexploded charges shall be employed by drilling a
Parallel fresh holes hot less than 600mm from the misfired hole and by exploding new charges. The authorised shot fire shall be present during removal of the debris liable to contain unexploded explosive near the misfired hole. The workmen shall not return to the site of firing until at least half an hour after firing.

When blasting is conducted in the neighbourhood of roads, structures, buildings etc. controlled blasting has to be carried out by drilling shallow shot holes and filling the same with light charge of explosives.

Adequate safety precautions as per building bye-laws, safety code, statutory regulations etc. shall be taken during blasting operations.

3.5.5 **DISPOSAL**

The excavated spoil will be disposed of in any or all the following manners.

a) By using it for backfilling straightway.
b) By stacking it temporarily for use in back filling at a later date during execution of the Contract.
c) I) By either spreading, or
ii)Spreading and compacting at designated disposal areas.
d) By selecting the useful material and stacking it neatly in areas designated by the Engineer for use in backfilling by some other agency.

3.5.6 **DISPOSAL OF SURPLUS**

All surplus material from excavation shall be carried away from the excavation site to designated disposal area selected by Engineer.

All good and sound rock excavated from the pits and all assorted materials of dismantled structures shall be the property of the owner and if the Contractor wants to use it, he shall have to obtain it from the Engineer at a mutually Agreed rate for the same.

All sound rock and other assorted materials like excavated bricks, etc shall be stacked separately and shall be measured in stacks deducting 50% volumetric
Measure for voids.

3.5.7 **PROTECTION**

The Engineer shall be notified by the contractor as soon as the excavation is Expected to the completed within a day so that it may be inspected by him at the Earliest. Immediately after approval of the engineer, the excavation must be Covered up in the shortest possible time. But, in no case the excavation shall be Covered up or worked On before approval and measurement by the Engineer. Excavated material shall be placed beyond 1.5 metres from the edge of the pit or Trench or half the depth of the pit or trench whichever is more or further away if Directed by the Engineer.

Excavation shall not be carried out below the foundation level of structure close by until required precautions have been taken.

Adequate fencing is to be made enclosing the excavation.

The Contractor shall protect all under- ground services exposed by excavation. The

Contractor shall also divert all surface drains, etc. affected by the excavation to Maintain the working area neat and clean.

3.5.8 **DEWATERING**

All excavations shall be kept free of water and slush. Grading in the vicinity of Excavations shall be controlled to prevent surface water running into excavated Areas. The Contractor shall remove by pumping or other means approved by the Engineer any water inclusive of rainwater and subsoil water accumulated in Excavation and keep the trench dewatered until the construction of foundation Structure and backfilling are complete in all respects. (Expect where such separate Payment will be made.) Sumps made for dewatering must be kept clear of the Foundations. Method of pumping shall be approved by the Engineer but in any Case, the pumping arrangement shall be no movement of subsoil or blowing in due To Differential head of water during pumping.

If necessary, the Engineer may the contractor to Contractor to continue dewatering Beyond his original or extended contract period in which case will be paid Separately for dewatering as terms mentioned elsewhere under payment and Measurement, provided the contractor has completed all the work satisfactorily

3.5.9.**TIMBER SHORING**

Timber shoring made out of approved quality of timber shall be 'close' or 'open' Type, depending on the nature of soil and the depth of pit or trench and the type of The contractor to take all necessary steps to prevent the sides of Trenches and pits from collapsing.

3.5.9.1 **CLOSE TIMBERING**

Close timbering shall be done by completely covering the sides of the trenches and Pits generally with short, upright members called 'polling board'. These shall be of Minimum 250x40 mm sections as directed by the Engineer. The boards shall generally be placed in pairs, one board on each side of cutting ,and shall be apart by Horizontal walers of strong wood at maximum 1.2 metres spacing, cross struts shall depend of the trench or pit.

In case where the soil is very soft and loose, the boards shall be placed horizontally against the sides of the excavation and supported by vertical walers, which shall be strutted to similar timber piece on the opposite face of the ground. No portion of the sides shall be taken into the ground. No portion of the vertical side of the trench or pit shall remain exposed, so that the earth is not libel to slip out.

The withdrawal of the timber shall be done very carefully to prevent the collapse of

the pit or trench. It shall be started at one end and proceeded systematically to the other end. Concrete or masonry shall not be damaged during the removal of the timber. No claim shall be entertained for any timber which cannot be withdrawn and is lost or buried.

3.5.9.2 **OPEN TIMBERING.**

In the case of open timbering, the entire surface of the side of trench pit is not required to be covered. The vertical board of minimum 250mm width and minimum 40mm depth shall be spaced sufficiently apart to leave unsupported strips of maximum 500 mm average width. The detailed arrangement, sizes of the timber and the distances apart shall be subject to the approval of the Engineer. In all other respects, specification for close timbering shall apply to open timbering.

3.10.0 **TREATMENT OF SLIPS**

The Contractor will take all precautions to avoid high surcharges and provide proper surface drainage drainage to prevent flow of water over the sides. These precautions along with proper slopes, berms, shorting and control of ground water should cause no slips to occur. If however slips do occur due to causes beyond the control of the contractor, the same shall be removed by him and payment shall be made to him on appropriate item rate of earthwork. Slips caused due to negligence of the Contractor will be cleared and back-filled later by him at his own expenses.

3.7.0 **BACK FILLING**

3.7.1 **GENERAL**

The material used for backfilling shall consist of material, approved by the Engineer obtained directly from nearly areas where excavation work by the same agency is in Progress, from temporary stacks of excavated spions or from borrow pits from Lumps and clods, roots and vegetations, harmful salts and chemicals, organic Materials, etc.

In certain locations, the Engineer may direct sand fillings. The sand should be Cleaned, well graded and be of quality normally acceptable for use in concrete.

3.7.2 **FILLING AND COMPACTION IN PITS AND TRENCHES AROUND STRUCTURES**

As soon as the work in foundations has been accepted and measured, the spaces Around The foundations structures in pits and trenches shall be cleared of all debris, brick bats,Mortar droppings etc, and filled with earth in layers not exceeding 250mm in loose Thickness each layer being watered, rammed and properly compacted to the Satisfaction of the Engineer. Earth shall be rammed with approved mechanised. Usually, no manual compaction shall be allowed unless specifically permitted by

the Engineer. The final surface shall be trimmed and levelled to proper profile as Desired by the Engineer.

Since the degree of compaction depends on the moisture content of the soil, a close watch should be kept on it and corrections to optimise the moisture content.

3.7.3 **PLINTH FILLING**

The plinth shall be filled with earth in layers not exceeding 250mm in loose Thickness, watered and compaction machine or manually, if specifically permitted By the Engineer. When the filling reaches the finished level, the surface shall be Flooded with water for at least 24 hours, allowed to dry and the rammed and Compacted, in order to avoid any settlement at a later stage. The finished level of The following shall be trimmed to the slope intended to be given to the floor.

3.7.4 **FILLING IN TRENCHES FOR WATER PIPES AND DRAIIN**

Earth used for filling shall be free from salts, organic or other foreign matter. All Clods of earth shall be broken or removed. Where excavated material is mostly Rock, the boulders shall be broke into pieces not bigger than 150mm size in any Direction, mixed with fine material consisting of disintegrated rock, moorum or Earth as available, so as to fill up the voids as far as possible and then the mixture Used for filling.

Filling in trenches for pipes and drains be commenced as soon as the joints of pipes And drains have been tested and passed.

Where the trenches are excavated in soil, the filling shall be done with earth on the Sides and top of pipes in layers not exceeding 150mm, watered, rammed and Compacted taking care that no damage is caused to the pipe below.

In case of excavation of trenches in rock, the filling unto a depth of 300mm or the Diameter of the pipe whichever is more, above the crown of pipe or barrel shall be Done with fine material such as earth, moorum, disintegrated rock or ash according To the availability at site. The remaining filling shall be done with rock filling of Boulders of size not exceeding 150mm mixed with fine material as available to fill Up the voids, watered, rammed and compacted.

3.7.5 **FILLING IN DISPOSAL AREA**

Surplus material from excavation which is not required for backfilling will be Disposed of in disposal areas. The spoil shall not be dumped haphazardly but Should be spread in layers approximately 250mm thick when loose and compacted With the help of compacting equipment. In wide areas rollers will be employed and Compaction done to the satisfaction of the Engineer as the optimum moisture Content, which shall be checked and controlled by the Contractor.

In certain cases the Engineer may direct disposal without compaction which can be Done by typing the spoils from a high bench neatly maintaining always a proper Level and grade of the bench.

3.8.0 **APPROCHES AND FENCING**

The Contractor should provide and maintain approaches for workmen and for Inspection, the roads and approaches around the excavation pits should be kept Clear at all times so that there is no hindrance to the movement of men, material And equipment of various agencies connected with the project. Sturdy and elegant Fencing is to be provided around the top edge of excavation as well as the bottom Of the filling at the surplus disposal area where dumping from a high bench is in Progress.

3.9.0 **LIGHTING**

Full-scale area lighting is to be provided if night work is permitted or directed by The Engineer. If no night work is in progress, red warning lights should be provided At the corners of the excavated pit and the edges of the fill.

## 4.0.0 TESTING AND ACCEPTANCE CRITERIA

4.1.0 **EXCAVATION**

On completion of the excavation, the dimensions of the pits will be checked as per The drawings after the pits are completely dewatered the work will be accepted After all undercuts have been set right and all over excavations filled back to Required lines, levels and grades by compacted earth, as directed by the Engineer At the Contractor's cost. The choice of grade of concrete will be a matter of unfettered discretion of the Engineer. Over excavation of sides will be made good free of cost by the contractor while carrying out the back filling. The excavation work will be accepted after the above requirements are fulfilled and all temporary Approaches encroaching inside the required dimension of the excavation have been Removed.

4.2.0 **BACK FILLING**

The degree of compaction required will be as the per the stipulation laid down in IS: 4701, if not otherwise mentioned in the Schedule and the actual method of Measuring the compaction achieved will be as decided by the Engineer. Is Satisfied With the degree of compaction achieved.

5.0.0 **INFORMATION TO BE SUBMITTED**

5.1.0 **WITH TENDER**

Detail of equipment proposed to be used for excavation, back filling and Compactions have to be submitted along with the tender.

5.2.0 **AFTER AWARD**

After award of the Contractor the successful tender shall submit the following for Approved and adoption

a) Within 30days of award of the Contractor, the Contractor shall submit a detailed Programme of the work as proposed to be executed giving completion dates of Excavation of the various foundations and the time required for back-filling and Compaction after completing the foundation for structure. In case the earthwork Contractor is also the agency for the foundation work, the Earthwork programme is To be contracted with the foundation programme. The programme should also show How the excavation and back-filling quantities will be balanced, minimising Temporary stacking of spoils. It is to be noted that Engineer even after initial Approval of the programme, may instruct to enhance or retard the progress of Foundations without attracting any claims from the Contractor. The initial Programme being submitted by the Contractor should have sufficient flexibility to Take care of such reasonable variations.

b) Within 15days of award, the Contractor shall submit showing details of slopes, Shorings, approaches, sump pits, dewatering lines, fencing etc, for approval of the Engineer for adoptions.

6.00 **RATES**

The rates for the items shall include cost of all materials consumed in the works, Hire Charges of materials, tools and plant, cost of labour, insurance, all transport, Taxes, Royalties, security and safety arrangements, supervision, profit etc. The rates of Excavation shall be also include the cost of dewatering and stacking the Excavated Spoils properly within a lead of 30 m unless otherwise mentioned in the Schedule of items.

The Contractor will have to give a rebate if the excavated earth is directly used for Back-filling.

Where back- filling is to be done with sand, it shall be of good quality from quarries Approved by the Engineer. The rate shall include all operations including the cost Of sand.

In cases the Contractor is required to continue dewatering of the excavated pits Beyond of the contract, original or extended, he will be paid separately for it as the Schedule of items only for the period beyond the final terminal date of the contact. The rate will be complete in all respects including the cost all respect including the cost of consumables, if any.

**7.**0.0 **MEASUREMENTS**

7.1.0 **CLEARING AND GRUBBING**

No separate measurement shall be done for this item for the purpose of payment in General except for cutting of trees having girth more than 30cms and works Connected to this.

7.2.0 **EXCAVATION**

Actual quantity of excavation required and approved by the Engineer shall be Measured in Cu.M.No extra shall be paid for keeping the excavations dewatered as Required for completion of the structure to come in. Necessary disposal of the spoil As described in the schedule of items shall be included in the quoted rate.

7.3.0 **SHORING**

The actual efficient area of shoring as approved by the Engineer, shall be measured In Sq.m.All planks, walling, verticals, struts, props and all other materials as Required for the shoring and subsequent safe dismantling and removal shall be Included in the rates quoted.

7.4.0 **BACK-FILLING**

7.4.1 **WITH ASSORTED EARTH FROM EXCAVATIONS, TRENCHES ETC**

Actual quantity of consolidated backfill shall be measured in Cu.M. The cost of Lead, Lift, etc. shall be as per schedule of items and included in the rate quoted.

7.4.2 **WITH EARTH FROM BORROW PITS AND STACKS**

Actual quantity of consolidated back-filling or actual quantity of excavation in the Borrow pits, or the excavated volume of the stack with a deduction of 30% for Voids, in case filling is done by earth from stack, whichever is less, shall be paid in Cu. M. The lead, lift, etc. as mentioned in the Schedule of item shall be included in The rates Quoted.

**7.4.3 SAND FILLING**

Actual quantity of consolidated sand filling shall be measured in Cu. M. The rate shall include cost of sand and all necessary works for execution of the item.

7.5.0 **LEADS AND LIFTS**

The leads for excavation and/or back filling will be measured between the centroid of the actual disposal area and that of the plan of pit. The distance between these Two points will two points will be measured along the shortest practicable haulage

Path as decided by the Engineer.

Lift will be measured vertically between the average ground level from where the Pit Excavation was started and the bottom level of the excavated pit. Level lines Corresponding to the stages where lifts become payable will be drawn on the cross Section of the pit and the volumes of excavation contained between these horizontal Planes will be computed and paid according to the corresponding rates.

7.6.0 **DEWATERING**

Dewatering for work beyond the contract period original or excavated will be Measured on the basis of horse power –hour which will be obtained by multiplying The estimated requirement of horse power required to run the pumps or actually Employed, whichever is less, by the actual hours run, approximated to the nearest Half hour.

7.7.0 **TRANSPORTATION OF SURPLUS EARTH**

7.7.1 Payment shall be made only for the lead beyond initial 100M from construction Area. Rate shall include reexcavation, loading, transportation, dumping, stacking or Spreading (as per directions of the engineer-in-charge) the surplus earth and the soil In the area demarcated by the Engineer-in – charge. Payment shall be made on Cubic Meter ($M^3$ ) basis on the difference of measurements of the volumes of the Excavated Pits and the measurement of the back filling. Quantity generated due to Voids in back Filled volume of earth, shall also be removed by the Contractor at no Extra cost and This disposal of earth shall not measured and paid under any item.

7.7.2 In exceptional circumstances the Engineer- in-charge may direct the Contractor to Remove surplus earth, concrete of debris or any other material from site to the area Of disposal on the basis of truck measurement. In such cases volume of material Shall be calculated on the basis of truck volume reduce by 30% for voids in case of Soft/hard soil sand 50% for soft/hard rock. All other provisions of disposal such as Spreading, levelling, grading shall apply in this case also.

**ANNEXXURE F3.1- VERY BROAD SPECIFICATIONS FOR SOIL TO BE CONSIDERED AS CNS MATERIAL**

| SL.NO. | PROPERTY | VERY BROAD SPECIFICATION RANGE |
|---|---|---|
| 1. | Grain size analysis | |
| | (i) Clay | 15-25% |
| | (ii) Silt | 35%-50% |

| | | |
|---|---|---|
| | (iii) Sand | 30-40% |
| | (iv) Gravel | < 10% |
| 2. | Consistency limits | |
| | (i) Liquid limits | 30-50% |
| | (ii) Plastic limit | 20-25% |
| | (iii) Plasticity index | 10-25% |
| | (iv) Shrinkage limit | 15% and above |
| 3. (a) | Swelling pressure when compacted to Maximum dry density corresponding to Standard proctor compaction with zero Initial compaction moisture constant, for No volume charge condition. | Less than 0.1kg/cm$^2$ 10kN/m$^2$ |
| (b) | Swelling pressure when compacted to Maximum corresponding to standard Proctor compaction and initial compaction Moisture corresponding to optimum moisture Content for no volume change condition | less than 0.05kg/cm$^2$ |
| 4. | Clay minerals | Preferable kaolinite Illite |
| 5. | Shear strength of/ compacted to maximum dry Density correspond to standard proctor compaction And initial moisture content corresponding to Optimum moisture content, but sample test on Saturation. | |
| | (a) From unconfined compression | Cu0.15- 0.35 Kg/cmsq. |
| | (b) From consolidated undrained direct Shear test | Cu0.0.1-0.3 kg/cmsq. (10-30 kN/m sq) |

## ADDENDUM TO SPECIFICATION NO. PEDC/STD.SPEC/032 REV 00 FOR EARTHWORK

Add under clause 3.70 back filling.

If it is required to use clayey soil exhibiting swelling properties for filling Around foundations and under pavement and floor slabs due to non Availability of suitable filling material nearby, then the back filled clayed Swelling soil should be well compacted and a layer of not less than 250m Thick cohesive non-swelling (CNS) soil shall be placed on top of the clayey soil and well compacted. Very broad specifications for soil to be Considered as CNS material is given in Annexure F3:1 enclosed at the end of the section.

# CEMENT CONCRETE
# PLAIN AND REINFORCED

| REV. NO. | PRAPARED | APPROVED | DATE |
|---|---|---|---|
| | | | |
| 00 | MARINA | PMISHRA | 00 |

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3.13 Construction Joints and Cold Joints……..

3.13.1 Construction Joints……..

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3.14 Repairs, Finishes and Treatment Of Concrete Surfaces……....

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3.16.4 Placing In Position……

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3.17 Cold Weather Concreting…….

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3.20.2 Cleaning and Treatment of Forms……..

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3.22 Anchor Bolts, Anchors, Sleeves, Inserts,
Hangers /Conduits/Pipe and Other Misc.
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3.23 Expansion And Isolation Joints…….

3.23.1 General……

3.23.2 Bitumen Board /Expended Polystyrene Boards……

3.23.2.1 Bitumen Boards……..

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3.23.3 Joint Sealing Strips……..

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3.23.3.1 Metal Sealing Strips…….

3.23.3.2 Non- Metallic Sealing Strips……

3.23.4 Joint Sealing Strips…….

3.23.5 Isolation Joints……..

3.23.6 Rubber Pad…….

3.24 Grouting Under Machinery Or
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3.26 Waterproofing Of Concrete Structure……..

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7.0 MATHOD OF MEASUREMENT……

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7.3 Reinforcement……..

7.4 Formwork ……

7.5 Anchor Bolts, Anchor Sleeve, Inserts, Hangers, Conduit Pipes and Other Miscellaneous Embedded Fixtures……..

7.6 Expansion and Isolation Joints……

7.7 Joins Seals: G.I. Copper, Aluminium, Rubber or P.V.C ……

7.8 Rubber Pad…….

7.9 Grouting Under Base Plates Etc……

7.10 Waterproof Plaster……

7.11 Bitumen Coating /Tar Coating……..

7.12 Bitumen Felt ……

7.13 Polyethylene Film ……

7.14 Tests …….

8.0 LIST OF I. S. CODES AND STANDARDS FOR

REFERENCE……

## SCOPE

1.1 **General**

This specification covers all the requirements described hereinafter for general use of plain and reinforced cement concrete work in structures and locations, cast-in-situ or precast, and shall include all incidental items of work not shown or specified but reasonably implied or necessary for the completion of the work.

1.2 This specification shall also supply to the extent it has been referred to or applicable with the special requirements of structures covered in scope of is: 456.

1.3 IS: 456 shall from a part of these specifications and shall be complied with unless permitted otherwise. for any particular aspect not covered by these code, appropriate is code, specifications and/ or replacement by an international code of practices as may be specified by the engineer shall be followed. all code and standards shall conform to its latest revisions. a list of is codes and standards is enclosed hereinafter for reference.

## 2.0 General

2.1 **Work to provided for by the contractor**

The work to be provided for by the contractor, unless otherwise specified shall include but not be limited to the following:-

a) Furnish all labour, supervision, services including facilities as may be required under statutory labour regulations, materials, forms, templates, supports, scaffolds, approaches, mids construction equipment, tools and plants, transportations- etc. required for the work.

b) Except where it is excluded from the scope of contract, contractor shell prepare progressively and submit for approval detailed drawing and bar bending schedules for reinforcement bars showing the positions and details of spacers, supports, chairs, hangers etc.

c) Design and prepare working drawing of formworks, scaffolds supports, etc. and submit for approval.

d) Submit for approval shop drawing for various inserts, anchors, anchor, bolts. pipe sleeves, embodiments, hangers opening, frames etc.

e) Submit for approval detailed drawing of supports, templates hangers etc. required for installation of various embedments like inserts, anchor bolts, pipe sleeves, frames, joint seals, frames, openings etc.

f) Submit for approval detailed schemes of all operation required for executing the work, e. g. material handing, concrete mixing, placement of concrete, compaction, curing , services, approaches , etc.

g) Design and submit for approval concrete mix designs required to be adopted on the job.

h) Furnish samples and submit for approval results of tests of various properties of the following: -

i) The various ingredients of concrete

ii) Concrete

iii) Embedment

iv) Joint seals

i) Provide all incidental items not shown or specified in particular but reasonably implied or necessary for successful completion of the work in accordance with the drawings, specifications and schedule of items.

j) For supply of certain materials normally manufactured by specialist firms, the contractor may have to produce, if directed by the engineer, a guarantee in approved, perform for satisfactory performance for a reasonable period as may be specified , binding the manufactures and the contractor, jointly and severally.

**2.2 work by others**

No work under this specification will be provided by any agency other then the contractor unless specifically mentioned elsewhere in the contract.

**2.3 Information to be submitted by the tenderer**

**2.3.1 With tendered**

The following technical information are required with the tender.

a) Source and arrangement of processing of aggregates proposed to be adopted.
b) Type of plant and equipment proposed to be used.
c) Names of firms with which association is sought for to execute the specia items of work in the contract.
d) Types of formwork proposed to be used.

**2.3.2 After award**

The contractor shall submit the following information and dada including samples where necessary, progressively during the execution of the contract.

**a) Programme of execution and requirement of materials**

within 30 days of the award of contract, the contractor will submit a master programme for completion of the work giving month wise requirements of materials, particularly mentioning in details the materials witch are to be supplied by the owner, and for the procurement of which the help of the of the owner is required as per the terms and conditions of the contract. in case the contractor proposes to take on hire any machineries or tools and plants from the owner, the detailed phased out programme of such hire is also to be submitted.
this master programme may have to be reviewed and updated by the contractor, quarterly or at more frequent intervals as may be directed by the engineer depending on the exigencies of the work.
detailed day-to-day programme of every month is to be submitted by the contractor before the end of the previous month.

**b) Samples**

Samples of the following materials and any other materials proposed to be used, shall be submitted as directed by the engineer, insufficient quantities free of cost, for approval. Approved samples will be preserved by the engineer for future reference. the approval of the engineer shall not, in any way , relieve the contactor of his responsibility of supplying materials of specified qualities:-

i) Coarse and fine aggregates
ii) admixtures
iii) Plywood for from work.
iv) Embedded and anchorage materials as may be desired by the engineer.
v) Joint sealing strips and other water proofing materials.
vi) Joints filling compounds
**vii)** Foundations quality rubber pads

**c) Design mix**

Design mix as per clauses 2.1 (g) & 3.4 of this specification giving proportions of the ingredients. sources of aggregates and cement. along with accompanying test results of trial mixes as per relevant i. s. .is be submitted to the engineer for his approval before it can be used on the works.

**d) Detail drawing and bar bending schedules**

Detailed working drawings and bar bending schedules in accordance with clause 2.1 (b) and 3.16.1 of this specification.

**e) Detailed drawing and designs of formworks to be used**

Detailed design data and drawings of standard formworks to be used as per clauses 2.1 (c).

**Detailed drawing for templates &temporary supports for embodiments**

As per clause 2.1(e).

**g) Mill test report for cement &reinforcing steel**

mill test report for cement and reinforcing steel in case these Materials are supplied by the contractor.

**H) Inspection reports**

Inspection reports in respect of from work and reinforcement and any other item of work as may be desired by engineer in accordance with clause 2.4 of this specification.

i) **test reports**

Reports of tests of various materials and concrete as required under clause 4.0: sampling & testing of this specification.

j ) any other data which may be required as this per this specification

2.4 **Conformity With Design**

The contractor will prepare check in approved Performa, which will be called pour cards. These pour cards will list out all items of work involved the contractor will inform the engineer, sufficiently in advance, whenever any particular pour is ready for concreting he shall accord all necessary help and assistance to the engineer for all checking required in the pour. On specification, the engineer will give written permission on the same poured card allowing the contractor to commence placement of concrete. Details of all instruction issued by the engineer and any other relevant information will be written on accompany sheets,

termed as progress cards, will be prepared by the contractor on approved Performa. The pour cards along with accompaniments will be handed over to the engineer before starting placement of concrete. One of the mix designs developed by the contractor as per the I. S. specifications and established the satisfaction of the engineer by trial mixes shall be permitted to be used by the engineer, the choice being dictated by the requirements of designs and workability. The methods of mixing, of concrete will be as approved or directed by the engineer.

**2.5 Materials to be used**

2.6 **General Requirement**

2.7 All materials whether to be incorporated work or used temporarily for the construction shall conform to the relevant IS specifications unless stated otherwise and be of best-approved quality.

**2.5.2 Cement**

Generally,cement shall be ordinary Portland cement conforming to IS :8112. In special case, rapid hardening Portland cement, low heat cement etc. May be permitted or directed to be used by the engineer.

**2.5.3 Coarse Aggregate**

Aggregate of size ranging between 4.75 mm and 150mm will be termed as coarse aggregate. only coarse aggregate from approved quarries and conforming to is: 383 will be allowed to be used on the works.

**2.5.4 Fine Aggregate**

Aggregate smaller than 4.75 mm and within the grading limits and other requirement set in is:383 is termed as fine aggregate or sand. only fine aggregate from approved sources and conforming to the above is specification will be allowed to be used on works.

**2.5.5 Water**

Water for use in concrete shall be clear and free from injurious oils, acids, alkalis, organic matter, salt, silts or other impurities. Normally potable water is found to be suitable. generally, is:3550 will be followed for routine tests. in

case of doubt, the acceptance test for water shall be as per is: 3025, and table-i of is: 456.

**2.5.6 Admixture**

Only admixture of a quality will be used when directed or permitted by the engineer. the admixture shell conform to is: 9103.

**2.5.7 Reinforcement**

Reinforcement shell be as per relevant is specification as mentioned in the contract/drawing/instruction. all bars above 10mm dia. shall be tested quality.

**2.6.0 Storage of materials**

**2.6.1 General**

All materials shall be so as to prevent deterioration or intrusion of
Foreign matter and to ensure the preservation of their quality and fitness for the work. Any material, which has deteriorated or has been damaged or is otherwise considered defective by the engineer, shell not be used for concrete and shell be removed from site immediately, failing which, the engineer shall be at liberty to get the materials removed from site immediately, failing which, the engineer shall be at
Liberty to get the materials removed and the cost incurred there of shall be realised from the contractors dues. The contractor shall maintain up to- date

**2.6.2 Cement:**

1) Sufficient space for storage, with open passages between stacks, shall arranged by the contractor to the satisfaction of the engineer.
2) Cement shall be stored off the ground in dry, leak proof, well-ventilated ware-houses at the works in such in such a manner as to prevent deterioration due to the moisture or intrusion of foreign matter.
Cement shall be stored in easily countable stacks with consignment identification marks.
3) Consignment shall be used in the order of their receipts at site. Sub – standards or partly set cement shall be removed from the site, with the knowledge of the engineer, as soon as it is detected
.

**2.6.3 Aggregate:**

Aggregate shall be stored on planks or steel plates or on concrete or masonry surface. Each size shall be kept separated with wooden or steel or concrete or masonry bulk-heads or in separate stacks and sufficient care shall be taken to prevent the material at the edges of the stock piles from getting intermixed. Stacks of fine and coarse aggregates shall be kept sufficiently apart with proper arrangement of drainage. The aggregates shall be stored in easily measurable stacks of suitable depths as may be directed by the engineer.

**2.6.4 Reinforcement:**

Reinforcement steel shall be stored consignment-wise and size wise off the ground and under cover, if desired by the engineer, it shall be protected from rusting, oil, grease and distortions. If necessary, the reinforcing steel may be coated with cement wash before stacking to prevent scale and rust at no extra cost to the owner. The stacks shall be easily measurable. Steel needed for immediate use shall be removed from storage.

**2.7 Quality Control:**

Contractor shall be establish and maintain quality control for different items of work and materials as may be directly by the engineer to assure compliance with contract requirement and maintain and submit to the engineer records of the same. The quality control operation shall include.

a) Admixture : Type, quantity, physical and properties that affect Strength, workability and durability of concrete. For air entraining admixtures, dosage to be adjusted to Maintain air contents within desirable limits.

b) Aggregate : physical, chemical and mineralogical qualities. Grading, Moisture content and impurities.

c) Water : Impurities tests.

d) Cement : Test of satisfy relevant IS specification (only association With Owner s tests, if the supply is made by Owner).

e) formwork : material , shapes dimensions, lines elevation , surface Finish, adequacy of form , ties, bracing and shoring and Coating.

f) Reinforcement : shapes, dimensions, length of splices, clearances, items and supports . Quality and requirement of welded splices.

g) Grades of concrete : Usage and mix design, testing of all properties.

h) Batching & mixing : Types and capacity of plant, concrete mixers and transportation equipment.

i) joints : Location of joints, water stops and filler materials.

Dimension of joints, quality and shape of joint material and Splices.

j) Embedded and

Anchorage items : Material, shape, location, setting.

k) Placing : preparation, rate of pouring weather limitations, time intervals between mixing and placing and between two successivelifts, covering over dry or wet surfaces, cleaning and proper bond , prevention of cold joint, types of chutes or conveyors.

1) Compaction : numbers of vibration, their prime mover, frequency and amplitude of vibration , diameter and weight of vibrators, duration of Vibration, hand – spreading, rodding and tamping.

m) Setting of base & Beaming plates : Lines, elevations and bedding mortar.

n) Concrete finishes : Repairs of surface defects, screening, floating, steel trowel ling and Booming, special finishes.

o) Curing : Methods and length of time.

Copies or records and tests for the items noted above, as well as, records of corrective Action taken shall be submitted to the engineer for approval as may be desired.

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## 3.0 INSTALLATION

All installation requirements shall be in accordance with IS: 456 and as supplemented or modified herein or by other best possible standards where the specific requirement Mentioned in this section of the specification do not cover all the aspects to the full Satisfaction of the Engineer.

### 3.1 Washing and screening of Aggregates

Washing and screening of coarse and fine aggregates to remove fines, dirt or other deleterious materials shall be carried out by approved means as desired by the Engineer.

### 3.2 Admixture

All concrete shall be designed for normal rate of setting and hardening at normal temperature. Variations in temperature and humidity under different climatic conditions will affect the rate of setting and hardening, which will, in turn, affect the workability and quality of the concrete. Admixtures may be permitted to be used in accordance with IS: 456 to modify the rate of hardening, to improve workability or as an aid to control concrete quality. The Engineer reserves the right to require laboratory test or use test data, or other satisfactory reference before granting approval. The admixture shall be used strictly in accordance with the manufacture s directions and /or as directed by the Engineer.

### 3.3 Grades of Concrete

Concrete shall be in any of the grades designated in IS: 456.Grade of concrete to be used in different parts of work shall be as shown on the drawing or as per the Engineer's instruction. In case of liquid retaining structures, IS: 3370 will be followed.

### 3.4 Proportioning and Works Control

#### 3.4.1 General

Proportioning of ingredients of concrete shall be made by any of the two following Methods as directed by the Engineer.

a) With preliminary tests by designing the concrete mix. Such concrete shall be called "Design Mix Concrete"

b) Without preliminary tests adopting nominal concrete mix. Such concrete shall be called "Nominal mix Concrete.

As far as possible, design mix concrete shall be used on all concrete works. Ordinary concrete, in grades permitted in accordance with IS: 456 may be used if shown on drawing or approved by the Engineer. In all cases the proportioning of ingredient and works control shall be in accordance with IS: 456 and shall be adopted for use after the Engineer is satisfied regarding its adequacy and after obtaining his approval in writing.

#### 3.4.2 Mix Design Criteria

Concrete mixing will be designed by the Contractor to achieve the strength, durability and workability necessary for the job, by the most economical use of the various ingredients. In general, the design will keep in view the following considerations: -

a) Consistent with various other requirements of the mix , the quantity of water should be kept at the lowest possible level.

b) The nominal maximum size of coarse aggregate shall be as large as possible within the limits specified.

c) The various fractions of coarse and fine aggregates should be mixed in such a proportion as to produce the best possible combined internal grading giving the densest and most workable mix.

d) The finished concrete should have adequate durability in all conditions to withstand satisfactorily the weather and other destruction agencies which it is expected to be subjected to in actual services.

The requirement of adequate structural strength is catered for by the choice of proper grade of concrete by the Engineer. The Contractor will strictly abide by the same in his design of concrete mix installation.

Not withstanding anything mentioned in various tables given in IS:456 giving specific values and degrees of workability for different condition of concrete placing, minimum cement content and maximum water cement ratio for concrete exposed to sulphate attack and for concrete to ensure durability under different condition of exposure , strength requirement for different grades of concrete, proportion for nominal mix concrete, the following tables in the specification are included. For identical condition is values given in the tables shown herein below are different from those mentioned in IS:456, the values as indicated in the table shown herein below shall prevail.

TABLE – 1

STRENGTH REQUIREMENT OF CONCRETE

| Grade of Concrete | Specific Characteristic Compressive Strength of 15cm cubes at 28 days conducted in accordance with IS: 516(All values in N/Sq.mm) |
|---|---|
| M – 10 | 10 |
| M –15 | 15 |
| M – 20 | 20 |
| M – 25 | 25 |
| M – 30 | 30 |
| M – 35 | 35 |
| M – 40 | 40 |

Note: 1.Notwithstanding anything mentioned above, the cement/total aggregate ratio is not be increase beyond 1:9.0 without specific permission of the Engineer

Note: 2. It should be noted that such high aggregate cement ratio will be required for concretes of very low slump and high water – cement ratio which may be required to be used in mass concrete work only .

Note: 3. The above figures are guidance only , the actual cement /aggregate ratios are to be worked out from the specific gravities of coarse aggregates and sand being used and from trial mixes.

**3.5 Strength Requirements**

Strength Requirements of both design mix and nominal mix concrete where ordinary Portland Cement or Portland Blast furnace slag cement is used, shall be as per IS: 456. All other relevant clauses of IS: 456 shall also apply.

3.6 **Minimum Cement Content**

The minimum cement content for each grade of concrete shall be as shown below unless specified in schedule of items: -

**TABLE –III**

**Minimum Cement CONTENT, Maximum Water Cement Ratio and Minimum Grade of Concrete for Different Exposures with Normal Weight Aggregates of 20 mm nominal maximum Size**

| SI No. | Exposure | Plain Concrete | | | Reinforced Concrete | | |
|---|---|---|---|---|---|---|---|
| | | Minimum Cement Concrete Kg/m3 | Maximum Free Water Cement Ratio | Minimum Grade of Concrete | Minimum Cement Concrete Kg/m3 | Maximum Free Water Cement Ratio | Minimum Grade of Concrete |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| i) | Mild | 220 | 0.60 | | 300 | 0.55 | M20 |
| ii) | Moderate | 240 | 0.60 | M15 | 300 | 0.50 | M25 |
| iii) | Severe | 250 | 0.50 | M20 | 320 | 0.45 | M30 |
| iv) | Very severe | 260 | 0.45 | M20 | 340 | 0.45 | M35 |
| v) | Extreme | 280 | 0.40 | M25 | 360 | 0.40 | M40 |

Note: 1.Cement content prescribed in this table is irrespective of the grades of cement and it is inclusive of additions mentioned in 5.2. The additions such as fly ash or ground granulated blast fumace slag may be taken into account in the concrete composition with respect to the cement content and water – cement ratio if the suitability is established and as long as the maximum amounts taken in to account do not exceed the limit of pozzolona and slag specified in IS 1489 (part I) and IS 455 respectively.

2. Minimum grade of plain concrete under mild exposure condition is not specified.

**TABLE - II**

**MIX PROPORTIONS (BY WEIGHT) EXPECTED TO GIVE DIFFENT DEGREES OF WORKABILTY WITH DIFFERENT VALUES OF WATER – CEMENT RATIO**

(FOR GUIDANCE)

CEMENT/TOTAL AGGREGATE RATIOS

| WORKABILTY | WATER/ CEMENT RATIO | RATIO BY WEIGHT OF CEMENT TO GRAVEL AGGREGATE | | RATIO WEIGHT OF CEMENT TO CRUSHED STONE AGGREGTE | |
|---|---|---|---|---|---|
| | | 20mm size | 30mm size | 20mm size | 38mm size |
| Very low slump<br>0-25 mm | 0.4<br>0.5<br>0.6<br>0.7 | 1:4.8<br>1:7.2<br>1:9.4<br>1:10 | 1: 5.3<br>1: 7.7<br>1: 10<br>1: 12 | 1: 4.5<br>1: 6.5<br>1: 7.8<br>1: 8.7 | 1: 5.0<br>1: 7.4<br>1: 9.6<br>1: 10.6 |
| Low slump<br>25-50 mm | 0.4<br>0.5<br>0.6<br>0.7 | 1:3.9<br>1:5.5<br>1:6.8<br>1:8.0 | 1: 4.5<br>1: 6.7<br>1: 7.4<br>1: 8.5 | 1: 3.5<br>1: 5.0<br>1: 6.3<br>1: 7.4 | 1: 4.0<br>1: 5.5<br>1: 7.0<br>1: 8.0 |
| Medium slump<br>50-100 mm | 0.4<br>0.5<br>0.6 | 1:3.5<br>1:4.8<br>1:6.0 | 1: 3.8<br>1: 5.7<br>1:7.3 | 1: 3.1<br>1: 4.2<br>1: 5.2 | 1: 3.6<br>1: 5.0<br>1: 6.2 |

| | | | | | |
|---|---|---|---|---|---|
| High slump<br>100-175 mm | 0.4<br>0.5<br>0.6<br>0.7 | 1:3.2<br>1:4.4<br>1:5.4<br>1:6.2 | 1: 3.5<br>1: 5.2<br>1: 6.7<br>1: 7.4 | 1: 2.9<br>1: 3.9<br>1: 4.7<br>1: 5.5 | 1: 3.3<br>1: 4.6<br>1: 5.7<br>1: 6.5 |

Note: 1- notwithstanding anything mentioned above, the cement/ Total aggregate ratio is not be increased be yond 1; 9.0 without specific permission of the Engineer

Favourable conditions, on of better quality of cement control, then the Engineer may instruct lower cement content, and Contractor shall abide by the stipulations laid down hereunder:

a) The contractor shall design the mixes for 10% (ten percent) higher strength over and above those specified in table-I under Clause 3.4, for the various grades of concrete and different slump requirement.

b) Sufficient number of trial mixes (to be decided by the Engineer) will be taken at the laboratory for the various designs and graphs of w/c ratio Vs crushing strengths at various ages will be plotted.

c) All tests will be done in presence of the Engineer who shall be the final authority to decide upon the adoption of any revised minimum cement content. The contractor will always be responsible to produce quality concrete of the required grade as per the acceptance criteria of IS 456.

d) The Engineer will always have the unquestionable right to revise the minimum cement content as decided above, if in his opinion, there is any chance of deterioration of quality on account of use of lower cement content or any other reason.

In case there is a downward revision of the minimum cement content from that specified in the contract, the particular unit rate of concrete will be reduced by an amount equal to the cost of cement saved, calculated at the issue rate. The relevant cost of wastage and handling on the cement saved, which is inherent in the total cost of structure, will not be deducted from the unit rate and will thus pass on the Contractor.

### 3.7 Water Cement Ratio

The choice of water-cement ratio is designing a concrete mix will depend on

a) The requirement of strength

b) The requirement of durability.

3.7.1 Strength Requirement

In case of "Design Mix Concrete", the water-cement ratio of such value as to Give acceptable test results as per IS: 4 56, will be selected by trial and error. The values of water – cement ratio for different grade and mix designs will have to be established after conducting sufficiently large number of preliminary test laboratory to the satisfaction of Engineer. Frequent checks on test will have to be carried out and the water – cement ratio will be revised if the tests produce unsatisfactory results. Notwithstanding anything stated above all the consequences in case of default remains unaltered.

In case of ordinary concrete, the maximum water – cement ratio for different grades of concrete is specified in table –III of IS: 456 and no tests are necessary. The acceptance test criterion for nominal mix concrete shall be as per IS: 456.

**3.7.2 Durability Requirement**

Tables 19 & 20 of IS: 456 give the maximum water – cement ratio permissible from the point of view of durability of concrete subjected to adverse exposure to weather, sulphate attacks, and contact with harmful chemical. Impermeability may also be an important consideration.

Whenever the water – cement ratio dictated by Durability consideration is lower then that required from strength criterion, the form shall be adopted.

However, water – cement ratio, from the point of durability as well as from strength consideration, should meet the requirement given in Table No.IV.

**TABLE IV**

MAXMIUM PERMISSIBLE WATER / CEMENT RATIOS FROM DURABILITYCONSIDERATIONS FOR DIFFEREN TYPES OF STRUCTURES AND DEGREES OF EXPOSURE USING ORDINARY PORT LAND CEMENT

| | Exposure Conditions | | | | | |
|---|---|---|---|---|---|---|
| | Severe wide range of Temperature. Frequent alterations of freezing and thawing (use Air Entrained concrete only) | | | Mild Temperature rarely below Freezing or rainy or arid | | |
| Type of structure | At the water line or within the range of fluctuating water level or spray. | | | At the water line or within the range of fluctuating water level or spray. | | |
| | In air | | | In air | | |

| | | In Fresh water | In sea water or in contact with sulphate (concentration more then 0. 2p.c) | | In fresh water | In sea water or in contact with sulphate (concentration more then 0. 2p.c) |
|---|---|---|---|---|---|---|
| Thin sections such as railing kerbs, sills ledges, ornamental or Architectural concrete reinforced concrete piles, pipes and all sections with less then I" concrete cover to reinforcement | 0.49 | 0.44 | 0. 40 | 0.53 | 0.49 | 0.40 |
| Moderate sections such as Retaining Walls, abutments, piers, girders, beams | 0.53 | 0.49 | 0.40 | * | 0.53 | 0.44 |
| Exterior portions of heavy mass sections | 0.58 | 0.49 | 0.44 | * | 0.53 | 0.44 |
| Concrete deposited by Tremie under water | - | 0.44 | 0.44 | - | 0.44 | 0.44 |
| Concrete slabs laid on ground | 0.53 | - | - | * | - | - |
| Concrete which will later be protected by enclosure or backfill but which may be exposed to freezing & thawing for several years before such protection is offered | 0.53 | - | - | * | - | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| Concrete protected from the water, interiors of building concrete below ground which is free from sulphate attacks | * | - | - | * | - | - |

Note: * Water/Cement ratios be selected on basis of strength and workability requirements.

### 3.8 Workability

The degree of workability necessary to allow the concrete to be well consolidated and to be worked into the corners of formwork and around the reinforcement and embodiments and to give the required surface finish shall depend on the type and nature of structure and shall be based on experience and tests. The usual limits of consistency for various types of structures are given below: -

**TABLE - V**
**LIMITS OF CONSISTENCY**

| **D**egree of Workability | Slump in mm with standard Cone as per IS: 1199 | | Use for which concrete is suitable |
|---|---|---|---|
| | Min | Max | |
| Very low | 0 | 25 | Large mass concrete structure with heavy compaction equipments, roads and like |
| Low | 25 | 50 | Uncontested wide and shallow R.C.C. Structures |
| Medium | 50 | 100 | Deep but wide R.C.C. Structures with congestion or reinforcement and inserts |
| High | 100 | 150 | Very narrow and deep R.C.C. structures with congestion due to reinforcement and inserts**.** |

(Note: Notwithstanding anything mentioned above, the slump to be obtained for work in professes shall be as per direction of the engineer)

With the permission of the engineer, for any grads of concrete, if the water has to be increased in special cases, cement shall also be increased Proportionately to keep the ratio of water to cement same as adopted in trial mix design for each grade of concrete. No extra payment will be made for this additional cement.

Workability of concrete shall be checked at frequent intervals by slump tests. Alternative where facilities exist or if required by the engineer, the compacting factor test in accordance with IS: 1199and Clause 6 of IS: 456 shall be carried out.

### 3.9 Size of Coarse Aggregates

The maximum size of coarse aggregates for different locations shall be as follows unless otherwise directed by the Engineer: -

| | | |
|---|---|---|
| Very narrow space | - | 12mm |
| Reinforced concrete except foundation | - | 20mm |
| Ordinary plain concrete and Reinforced | - | 40mm |
| Mass concrete | - | 80mm |
| Mass concrete very large structure | - | 150mm |

Grading of coarse aggregates for a particular size shall concrete to relevant I.S. Codes and shall also be such as to produce a dense of the specified proportion, strength and consistency that will work readily into position without segregation.

Course aggregate will normally be separated in to the following size and stacked separately in properly designed stockpiles ; 150mm to 80mm, 80mmto 40mm, 40mm to 20mm and 20mm to 5mm. In certain it may be necessary to further spilt the 20mm to 5mm fraction into 20mm to 10mm and 10mm to 5mm fractions.

This separation of aggregates in different size fraction is necessary so that they may be remixed in the desired proportion to arrive at a correct internal grading to produce the best mix.

### 3.10 Mixing of Concrete

Concrete shall always be mixed in mechanical mixer unless specifically approved by the Engineer for concrete be used in unimportant out of the way locations in small quantities. Water shall not normally be charged into
the drum of the mixer until all the cement and aggregates consisting the batch are already in the drum and mixed for at least one minute. Mixing of each batch shall be continued until there is a uniform distribution of the materials and the mass is uniform in color and consistency, but in no case shall mixing be done for lass then 2

(two) minutes and at least 40 (forty) revolutions after all the material and water are in the drum. When absorbent aggregates are used or when the mix is very dry, the mixing time shall be extended as may be directed by the Engineer. Mixers shall not be loaded above their rated capacity as this prevents thorough mixing.

The entire contents of the drum shall be discharged before the ingredients for the next batch are fed into the drum. No partly set of remixed or excessively wet concrete shall be used. Such concrete shall be immediately removed from site. Each time the work stops, the mixes, shall be thoroughly cleaned & when the next mixing commences, the first batch shall have 10% additional cement at no extra cost to the Owner to allow for loss in the drum.

Regular checks on mixer efficiency shall be carried out as directed by the engineer as per IS: 4634 on all mixers employed at site. Only those mixers whose efficiencies are within the tolerances specified in IS: 1791 will be allowed to be employed.

Batching plant where used shall conform to IS: 4925.

When hand mixing is permitted by engineer, it shall be carried out on a water – tight platform and care shall be taken to ensure that mixing is continued until the mass is uniform in colour and consistency. In case of hand –mixing, 10% extra cement shall be added to each batch at no extra cost to the Owner.

3.11 **Conveying concrete**

Concrete shall be handled and conveyed from the place of mixing to the place of laying as rapidly as practicable by approved means and placed and compacted in the final position –before the Initial settings of the cement starts. Concrete should be conveyed in such a way as will prevent segregation of loss of any of the ingredients. For long distance haulage, agitator cars of approved design will be used.If in spite of all precautions, segregation does occur during transport, the concret shall be properly remixed before placement. During hot or cold weather, if directed by the Engineer, concrete shall be transported in deep containers which will reduce the rate of loss of water evaporation or loss of heat. If equipments for concrete shall be well maintained and thoroughly cleaned before commencement of concrete mixing. Such equipments shall be kept free from set concrete.

A layer of mortar of thickness 12mm of the same or less w/c ratio and the same proportion as that of the concrete being placed and cement slurry will be spread thoroughly on the rock foundation or construction joint just prior to placement of concrete. The cost of application of such cement slurry and mortar will be deemed to be included in the unit rate of concrete.

After concrete has been placed, it shall be spread, if necessary and thoroughly compacted by approved mechanical vibration to maximum subsidence without segregation and thoroughly worked around shape. Vibrators shall not be used for pushing concrete into adjoining areas. Vibrators must be operated by experienced

workmen and the work carried out as per relevant IS Code of Practice. In thin members with heavy congestion of reinforcement or other embedments, where effective use of internal vibrator is, in the opinion of the Engineer, doubtful, in addition to immersion vibration the contractor may have to employ form vibrators conforming to IS: 4656. For slabs and other similar structures, the contractor will additionally employ screed vibrator as per IS:2506. Hand tamping may be allowed in rare cases, subject to the approval of the Engineer. Care must be taken to ensure that the inserts, fixtures, reinforcement and formwork are not displaced or distorted during placing and consolidation of concrete.

The rate of placement of concrete shall be such that no cold joint is formed and fresh concrete is placed always against green concrete which is still plastic and workable. No concrete shall be placed in open, during rains. During rainy season, no placement in the open is to be attempted unless sufficient tarpaulins or other similar protective arrangement for completely covering the still green concrete from rain is kept at the site of placement. If there has been any sign of washing of cement and sand, the entire affected concrete shall be removed immediately. Suitable precautions shall be taken in advance to guard against rains before leaving the fresh concrete unattended. No accumulation of water shall be permitted on or around freshly laid concrete,.

Slabs, beams and similar members shall be poured in one operation, unless otherwise instructed by the Engineer. Moulding, throating, drip course, etc. shall be poured as shown on the drawings or as directed by the Engineer. Holes shall be provided and bolts, sleeves, anchor's fastenings or other fixtures shall be embedded in concrete as shown on the drawings or as directed by the engineer. Any deviation there from shall be set right by the Contractor at his own expense as instructed by the Engineer.

In case the forms or supports get displaced during or immediately after the placement and bring the concrete surface out of alignment beyond tolerance limits, the Engineer may direct to remove the portion and reconstruct or repair the same at the Contractor's expense.

3.12 **Placing and Compacting Concrete**

Where specifically covered the relevant IS Code will be followed for the procedure of surface preparation, placement, consolidation, curing, finishes, repairs and maintenance of concrete. If, however, there is no specific provision in the relevant IS Code for any particular aspect or work, any other standard Code of Practice, as may be specified by the Engineer, will be adopted. Concrete may have to be placed against the following types of surfaces:-

a) Earth foundations

b) Rock foundations

c) Formwork

d) Construction joint in concrete or masonry.

The surface on or against which concrete is to be placed has to be cleaned thoroughly. Rock or old construction joint has to be roughened by wire brushing, chipping sand blasting or any other approved means for proper bond. All cutting's dirt, oil, foreign and deleterious material, laitance, etc., are to be removed by the air water jetting or water at high pressure. Earth foundation on which direct placement of concrete is allowed, will be crumble and consolidated as directed by the Engineer such that it does not crumble and get mixed up with the concrete during or after placement, before it has sufficiently set and hardened.

Formwork, reinforcement, preparation of surface, embodiments, joint seals etc., shall be approved in writing by the Engineer before concrete is placed. As far as possible, concrete shall be placed in the formwork by means approved by the Engineer and shall not be dropped from a height or handled in manner which may cause segregation. Any drop over 1500 mm shall have to be approved by the Engineer.

Rock foundation or construction joint will be kept moist for at least 72 hours prior to placement. Concrete will be placed always against moist surface but never on pools of water. In case the foundation cannot be dewatered completely, special procedure and precaution, as directed by the engineer will have to be adopted.

Formwork will be cleaned thoroughly and smeared lightly with form oil or grease of approved quality just prior to placement.
The Engineer shall decide upon the time interval between two placements of concrete of different ages coming in contact with each other, taking in consideration the degree of maturity of the older concrete, shrinkage, heat dissipation and the ability of the older concrete to withstand the load imposed upon it by the fresh placement.

Once the concrete is deposited, consolidated and finished in its final position., it shall not be distributed.

## 3.13 Construction Joints and Cold Joint

### 3.13.1 Construction Joints

It is always desirable to complete any concrete structure by continuous pouring in one operation. However, due to practical limitation of methods and equipment and certain design considerations, construction joints are formed by discontinuing concrete at certain predetermined stages. These joints will be formed in a manner specified in the drawings/Instruction. Vertical construction joints will be made with rigid stop-board forms having slots for allowing passage of reinforcement rods and any other embodiments and fixtures that may be shown. For water retaining structures and leak proof buildings suitable and approved water stops may be installed at the construction joints as per clause12.4 of IS: 456.

Where the location of the joints are not specified, it will be in accordance with the following: -

a) In a column, the joint shall be formed 75 mm below the lowest soft of the beam framing into it.

b) Concrete in a beam shall preferably be placed without a joint, but if provision of a joint is unavoidable, the joint shall be vertical and it the middle of the span.

c) A joint in a suspended floor slab shall be vertical and at the middle of the span and at right angles to the principal reinforcement.

d) Feather-edges in concrete shall be avoided while forming a joint.

e) A construction joint should preferably be placed in a low-stress zone and at right angles to the direction of the principal stress.

f) In case the Contractor proposes to have a construction joint anywhere to facilitate his work, the proposal should be submitted well in advance to the Engineer for study and approval with which no construction joint will be allowed.

**3.13.2 Cold joint**

An advancing face or a concrete pour, which could not be covered by fresh concrete before expiry of initial setting time (due to an unscheduled stoppage or delay on account of breakdown in plant, inclement weather, low rate of placement or any other reason), is called a cold joint. The Contractor should always remain vigilant to avoid cold joints.

If, however, a cold joint is formed due to unavoidable reasons, the following procedure shall be adopted for treating it:-

a) If the concrete is so green that it can be removed manually and if vibrators can penetrate the surface without much effort, fresh concrete can be placed directly against the old surface. The old concrete should be covered by fresh concrete as quickly as possible and the joint thoroughly and systematically vibrated.

b) In case concrete has hardened a bit more than (a) but can still be easily removed by a light hand pick, the surface will be raked thoroughly and the loose concrete removed completely without disturbing the rest of the concrete in depth. A rich mortar layer 12 mm in thickness, will be placed on the cold joint. fresh concrete shall be placed on the mortar layer and the joint will be thoroughly and systematically vibrated penetrating the vibrator deep into the old layer of concrete.

c) In case the concrete at the joint has become so stiff that it cannot be remoulded and mortar or slurry does not rise in spite of extensive vibration,

the joint will b3ee left to harden for at least 12 – 24 hrs. It will then be treated as a regular construction joint, after cutting the concrete to required shape and preparing the surface as described under clause 3.12.

**3.14 Repairs, Finishes and Treatment of Concrete surfaces**

3.14.1 Adequate and sound concrete surfaces, whether formed or unformed, can be obtained by employing a concrete mix of proper design, competent formwork, appropriate methods of handling, placing and consolidation by experience workmen.

Unsound concrete resulting from improper mix design, incompetent methods, equipment and formwork poor workmanship and protection will not be accepted and will have to be dismantled, removed and replaced by sound concrete at the Contractor's cost. The Engineer may, at his sole discretion, allow to retain concrete with minor defects provided the Contractor is able to repair it by approved methods at no extra cost to the Owner. All concrete work shall be inspected by the Contractor immediately after the forms are removed and the will promptly report occurrence of any defects to the Engineer. All repair works will be carried out as per the instructions and in the presence of the Engineer or his representative. Generally, repair work will consist of any or all of the following operations:-

a) Sack rubbing with mortar and stoning with carborundum stone
b) Cutting away the defective concrete to the required depth and shape.
c) Cleaning or reinforcement and embodiments.
d) Roughening by sand blasting or chipping
e) Installing additional reinforcement/welded mesh fabric
f) Dry packing with stiff mortar
g) Plastering, guniting, shotcreting etc
h) Placing and compacting concrete in the void left by cutting out defective concrete.

Grouting with cement sand slurry of 1:1 mix.

3.14.1.1 Finishing Unformed Surfaces

The requirements of finishes of formed surfaces are given separately under clause 3.20.7 of this specification. The Contractor is to include in his quoted rate for concrete, the provision of normal finishes in unformed surfaces which can be achieved by screening, floating, trowel ling etc., as and where required by the Engineer without any extra cost of the Owner. A few typical and common cases of treatment of concrete surface are cited below:-

a) Floor

Wherever a non-integral floor finish is indicated, the surface of reinforcement concrete slab shall be struck off at the specified levels and slopes and shall be finished with a wooden float fairly smooth removing all laitance No over trowel ling, to obtain a very smooth surface, shall be done at it will prevent adequate bond with the subsequent finish.

If desired by the Engineer, the surface shall be scored and marked without any extra cost to the Owner to provide better bond.

Where monolithic finish is specified or required, concrete shall be compacted and struck off at the specified levels and slopes with a screed, preferably a vibrating type and then floated with a wooden float. Steel trowelling is then started after the moisture film and shine have disappeared from the surface and after the concrete has hardened enough to prevent excess of fines and water to rise to the surface but not hard enough to prevent proper finishing of aberration Steel trowel ling properly done will flatten and smoothen sandy surface left by wooden floats and procedure a dense surface free from blemishes, ripples and trowel mark. A fine textured surface that is not slick and can be obtained by trowel ling the surface lightly with a circular motion after initial towelling keeping the steel trowel flat on the surface.

To provide a better grip the Engineer may instruct marking the floor in a regular geometric pattern after initial trowel ling.

**b) Beams, Columns & Walls**

If on such or any other concretes structure it is intended to apply plaster or such concrete surfaces against which brick work or other allied works are to be built. The Concrete shall hack the surface adequately as soon as the from it stripped off so that proper bond can develop pattern adequacy and details of such hacking shall meet with the approval of the Engineering who shall be informed to inspect such surfaces before they are covered up.

3.15 **Protection and curing of concrete**

i) Newly placed concrete shall be protected approved means from rain sun and wind. Concrete placed below the ground level shall be protected aghast contamination from falling earth during and after placing. Concrete placed in ground containing deleterious substances. Shall be protected from contact with such ground. Or with water draining from such ground, during placing of concrete and for a period of at least three days or as otherwise instructed by the Engineer. The ground water around newly poured concrete shall be kept to an approved level by pumping out or other adequate means of drainage to prevent floatation of flooding. Steps, as approved by the Engineer, shall be taken to protect immature concrete from damage b debris, excessive loadings, vibration, abrasion, mixing with earth or, other deleterious materials, etc, that may impair the strength and durability of the concrete.

As soon as the concrete has hardened sufficiently, it shall be covered either with sand, hession, canvas or similar materials and kept continuously wet for at least 14 (fourteen) days after final setting. Curing by continuous sprinkling of water will be allowed if the Engineer is satisfied with the adequacy of the arrangements made by the Contractor.

The Contractor shall remain extremely vigilant and employ proper equipment and workmen under able supervision for curing. The Engineer's decision regarding the adequacy of curing is final. In case any lapse on the part of the Contractor is noticed by the Engineer, he will inform the Contractor or his supervisor verbally or in writing to correct the deficiency in curing. If no satisfactory action is taken by the Contractor within 3 (three) hours of issuance of such instruction, the Engineer will be at liberty either to employ sufficient means through any agency to make good the deficiency and recover the cost there of from the contractor, or pay for the part where adequate curing was noticed at a reduced rate, entirely at the discretion of the Engineer.

**3.16 Reinforcement**

Mild steel round bars, cold twisted and deformed bars as medium tensile or high yield strength steel, plain hard drawn steel wire fabric etc., will be used as reinforcement as per drawings and directions.

3.16.1 **Bar Bending Schedules**

The Contractor shall submit the Engineer for approval Bar Bending Schedules with working drawing in triplicate, showing clearly the arrangements proposed by the Contractor to match available stock of reinforcing steel, within one month of receipt of the Letter of Intent or of the receipt of the relevant design drawings whichever is later. Upon receipt of the Engineer's final approval of the Bar Bending Schedule and drawings, the Contractor shall submit 6 (six) prints of the final drawings with one reproducible print after incorporating necessary modifications or corrections, for final record and distribution. Approval of such detailed drawings by the Engineer shall not relieve the Contractor of his responsibility for correctness nor of any of his obligations to meet the other requirements of the Contract.

**3.16.2 Cleaning**

All steel for reinforcement shall be free from loose scales, oil, grease, paint or other harmful matters immediately before placing the concrete.

**3.16.3 Bending**

Unless otherwise specified, reinforcing steel shall be bent in accordance with the procedure specified in IS:2502 or as approved by the Engineer. Bends and shapes shall comply strictly with the dimensions corresponding to the approved Bar Bending Schedules. Bar Bending Schedules shall be rechecked by the Contractor before any bending is done.

No reinforcement shall be bent when already in position in the work, without approval of the Engineer, whether or not it is partially embedded in concrete. Bars shall not be straightened in a manner that will injure the material. Bars shall not be

straightened in a manner that will injure the material. Rebinding can be done only if approved by the Engineer. Reinforcing bars shall be bent by machine or other approved means producing a gradual and even motion. All the bars shall be cold bent unless otherwise approved. Bending hot at a cherry-red heat (not exceeding 845 Deg. C) may be allowed under very exceptional circumstances except for bars whose strength depends on clod working. Bars bent hot shall not be cooled by quenching.

**3.16.4 Placing in Position**

All reinforcements shall be accurately fixed and maintained in position as shown on the drawings by such approved and adequate means like mild steel chairs and/or concrete spacer blocks irrespective of whether such supports are payable or not. Bars intended to be in contact at crossing points, shall be securely tied together at all such points by No. 20 G annealed soft iron wire or by tack welding in case of Bar larger than 25 mm die., as may be directed by the Engineer. Binders shall be securely held. The vertical distance between successive layers of bars shall be maintained by provision of mild steel spacer bars. They should be spaced such that the main bars do not sag perceptibly between adjacent spacers. Before actual placing, the contractor shall study the drawings thoroughly and inform the Engineer in case he feels that placement of certain bars is not possible due to congestion. In such cases he should no start placing any bar before obtaining clearance from the Engineer.

**3.16.5 Welding**

Normal bond laps in reinforcement may be placed by lap or but welding reinforcement bars, if asked by the Engineer, under certain conditions. The work should be done with suitable safeguards in accordance with relevant India Standards for welding of mild steel bars used in reinforced concrete construction as per IS:2751 and IS:456. Welded mesh fabrics conforming to IS: 1566 may also be used if specified in the Schedule of Items and Drawings.

**3.16.6 Control**

The placing of reinforcements shall be completed well in advance of concrete pouring. Immediately before pouring, the reinforcement shall be examined by the Engineer for accuracy of placement and cleanliness. Necessary corrections as directed by him shall be carried out. Laps and anchorage lengths of reinforcing bars in a lap are not of the same diameter, the smaller will guide the lap length. The laps shall be staggered as for as practicable and as that reinforcement in position do not have to bear extra load and get disturbed.

The cover for concrete over the reinforcement shall be as shown on the approved drawings unless otherwise directed by the Engineer. Where concrete blocks are used for ensuring the cover and postioning reinforcement, they shall be made of morar not

leaner than 1 (one) part cement to 2 (two) parts sand by volume and cured in a pond for at least 14 (fourteen) days. The type, shape, size and location of the concrete blocks shall be as approved by the Engineer.

**3.17 Cold Weather Concreting**

When conditions are such that the ambient temperature may be expected to be 4.5 Deg. C or below during the placing and curing period, the work shall conform to the requirement of Clause 13 of IS:456 and IS:7861.

**3.18 Hot Weather Concreting**

When depositing concrete in very hot weather, the Contractor shall take all precautions as per IS:7861 and stagger the work to the cooler parts of the day to ensure that the temperature of wet concrete used in massive structures does not exceed 38 Deg. C while placing. Positive temperature control by precooling, post cooling or any other method, if required, will be specified and paid for separately.

3.19 **Concreting under water**

When it is necessary to deposit concrete under water it shall be done in accordance with the requirements of clause 13 of IS:456.

**3.20 FORM WORK**

**3.20.1 General**

If it is so desired by the Engineer, the contractor shall prepare, before commencement of actual work, designs and working drawings for form work and cantering and get them approved by the Engineer. The formwork shall conform to the shape, grade, lines, levels and dimensions as shown on the drawings:

Materials used for the formwork inclusive of the supports and cantering shall be capable of withstanding the working load and remain undistorted throughout the period it is left in service. All supports and scaffolds should be manufactured from structural or tubular steel except when specifically permitted otherwise by the Engineer.

The cantering shall be true to vertical, rigid and thoroughly braced both horizontally and diagonally. Rekers are to be used where forms are to support inclined members. The forms shall be sufficiently strong to carry without undue deformation, the dead weight of the concrete as a liquid as well as the working load, in case the Contractor wishes to adopt any other design criteria, he has to convince the Engineer about its acceptability before adopting it. Where the concrete is vibrated, the form work shall be strong enough to withstand the effects of vibration without appreciable deflection, bulging, distortion or loosening of its components. The joints in the formwork shall be sufficiently tight to prevent any leakage of slurry or mortar.

To achieve the desired rigidity, tie bolts, spacer blocks, tie wires and clamps as approved by the Engineer shall be used but they must in no way impair the strength of concrete or cause stains or marks on the finished surface. Where there are chances of these fixtures being embedded, only mild steel or concrete of adequate strength shall be used. Bolts passing, completely through liquid retaining walls/slabs for the purpose of securing and aligning the formwork shall not be used.

The formwork shall be such as to ensure a smooth uniform surface free from honeycombs, air bubbles, bulges, fins and other blemishes. Any blemish or defect found on the surface of the concrete must be brought to the notice of the Engineer immediately and rectified free of charge as directed by him.

For exposed interior and exterior concrete surfaces of beams, columns and wall, plywood or other approved form shall be thoroughly cleaned and tied together with approved corrosion-resistant devices. Rigid care shall be exercised in ensuring that all Colum forms are plumb and true thoroughly cross-braced to keep them so. All floor and beam centering shall be crowned not less than 8 mm in all directions for every 5 meters span. Unless specifically described on the drawings or elsewhere to the contrary, bevelled forms 25 mm by 25 mm shall be fixed in the form-work at all corners to provide chamfering of the finished concrete edges without any extra charge. The formwork should lap and be secured sufficiently at the lift joints to prevent bulges and offsets.

Temporary openings for cleaning, inspection and for pouring concrete shall be provided at the base of vertical forms and at other places, where they are necessary and as may be directed by the Engineer. The temporary openings shall be so formed that they can be conveniently closed when required, during pouring operations without leaving any mark on the concrete.

**3.20.2 Cleaning and Treatment of Forms**

All parts of the forms shall be thoroughly cleaned of old concrete, wood shavings, saw dust, dirt and dust sticking o them before they are fixed in position. All rubbish, loose concrete, chippings, shavings, saw dust etc shall be scrupulously removed from the interior of the forms before concrete is poured. Compressed air jet and/or water jet along with wire brushes, brooms etc. shall be used for cleaning. The inside surface of the formwork shall be treated with approved non-staining oil or other compound before it is placed in position. Care shall be taken that oil or other compound does not come in contact with reinforcing steel or construction joint surfaces. They shall not be allowed to accumulate at the bottom of the formwork. The oiling of the formwork will be inspected just prior to placement of concrete and redone wherever necessary.

**3.20.3 Design**

The formwork shall be so designed and erected that the forms for slabs and the sides of beams, columns and walls are independent of the soffits of beams and can be removed without any strain to the concrete already placed or affecting the remaining

formwork. Removing any props or repropping shall not be done except with the specific approval of the Engineer. If formwork for column is created for the full height of the column, one side shall be left open and built up in sections, as placing of concrete progress. Wedger, spacer, bolts, clamps or other suitable means shall be provided to allow accurate adjustment and alignment of the form work and to allow it to be removed gradually without jarring the concrete.

**30.20.4.1 Inspection of forms**

Casting of Concrete shall start only after the formwork has been inspected and approved by the Engineer. The concreting shall start as early as possible within 3 (three) days after the approval of the formwork and during this period the formwork shall be kept under constant vigilance against any interference. In case of delay beyond three days, a fresh approval from the Engineer shall be obtained.

**3.20.4 Removal of Forms**

Before removing any formwork, the Contractor must notify the Engineer well in advance to enable him to inspect the concrete if he so desires.

The Contractor shall record on the drawing or in any other approved manner, the date on which concrete is placed in each part of the work and the date on which the formwork is removed there from and have this record checked and countersigned by the Engineer regularly. The Contractor shall be responsible for the safe removal of the formwork and any work showing signs of damage through premature removal of formwork or loading shall be rejected and entirely reconstructed by him without any extra cost of the Owner. The Engineer may, however, instruct to postpone the removal of formwork if he considers it necessary.

Form for various types of structural components shall not be removed before the minimum periods specified herein and the removal after the minimum periods shall also be subject to the approval of the Engineer in each case.

**TABLE – VI**
**SCHEDULE OF REMOVAL OF FORM**

| part of Structure | Ordinary Portland Cement Concrete | | | | Rapid Hardening Portland Cement Concrete | | | |
|---|---|---|---|---|---|---|---|---|
| | Temperature $^0$C | | | | Temperature $^0$C | | | |
| | Above $40^0$C | $40^0$ $20^0$ | $20^0$ $5^0$ | Below $5^0$ | Above $40^0$C | $40^0$ $20^0$ | $20^0$ $5^0$ | Below $5^0$ |
| | Days | Days | Days | Days | Days | Days | Days | Days |
| a) Columns & Walls | 2 | 1 | 1 | Do not remove forms until site cured test specimen develop at least 50% of the specified 28 days 12 strength | 1 | 1 | 1 | Do not remove forms until site cured test specimen develop at least 50% of the specified 28 days strength |
| b) Beam sides | 3 | 2 | 3 | | 2 | 1 | 1 | |
| c) Slabs, 125 mm | 10 | 7 | 8 | | 7 | 4 | 5 | |
| d) Slabs over 125 mm thick and soffit of minor beams | 18 | 14 | 16 | | 12 | 8 | 9 | |
| e) Soffit of main beams | 24 | 21 | 22 | | 14 | 10 | 12 | |

Wherever exposed surfaces of concrete can be effectively sealed to prevent loss of water, the periods specified for temperature above 40 Deg. C can be reduced to those of the temperature range of 20 Deg. C to 40 Deg. C subject to approval of the Engineer.

Construction joints in beams, if required to be provided, will be located at the middle of span according to clauses 3.13.1 (b) of this specification. In such cases, however, entire span of beam shall have to be kept supported by form work till its removal for the portion of beam, cast at a later date, is due and so approved by the Engineer.

**3.20.5 Tolerance**

The from work shall be so made as to produce a finished concrete true to shape, lines, levels, plump and dimensions as shown on the drawings subject to the following to lerances otherwise specified in this Specification or drawings or directed by the Engineer:

For a) Sectional dimension - $\pm$ 5mm

b) Plumb - 1 in 1000 of height

c) Levels - ± 3mm before any deflection has Taken place

The tolerance given above are specified for local aberration in the finished concrete surface and should not be taken as tolerances for the entire structure taken as a whole or for the setting and alignment of formwork, which should be as accurate as possible to the entire satisfaction of the Engineer. Any error, within the above tolerance limits or any other as may be specially set up by the Engineer, if noticed in any lift of the structure after stripping of forms, shall be corrected in the subsequent work to bring back the surface of the structure to its true alignment.

**3.20.6 Re-use of Forms**

Before re-use, all forms shall thoroughly scraped, cleaned, joints and planes examined and when necessary required, and inside surface treated as specified here in before. From work shall not be used/re-used if declared unfit or unserviceable by the Engineer.

**3.20.7 Classification**

Generally, the 'ordinary 'class from work shall be used unless otherwise directed by the Engineer:

a) **Ordinary :** These shall be used in places where ordinary surface finish is required and shall be composed of steel and/or approved good quality partially seasoned timber.

b) **Plywood :** These shall be used in exposed surfaces, where a specially good finish is required and shall be made of approved brand of heavy quality plywood to produce a perfectly uniform and smooth surface conforming to the shape described in the drawing with required grain texture on the concrete. .
Re- use may only be permitted after speciation and approval by the Engineer. He may also permit utilisation of used plywood for the ordinary class, if it is still in good condition.

**c) Ornamental:** These shall be used where ornamental and curved surface are required and shall be made of selected best quality well seasoned timbers or of plywood, which can be shaped correctly.

**3.21 Opening, Chases, Grooves, Rebates, blackouts etc.**

The Contractor shall leave all openings, grooves, chase, etc. In concrete work as shown on the drawings or as specified by the Engineer.

**3.22 Anchor Bolts, Anchors, Sleeves, Inserts, Hangers/Conduits/Pipe and Other Miscellaneous Embedded Fixtures**

The Contractor shall build into concrete work all the items noted below and shall embed them partly or fully as directed and secure the same as may be required. The materials, if required to be supplied by the Contractor, shall be as specified and be of best quality available according to relevant Indian Standards of approved manufacture and to the satisfaction of the Engineer. Exposed surfaces of embedded materials are to be painted with one coat of approved anti-corrosive paint and / or bituminous paint without any extra cost to the Owner. If welding is to be done subsequently on the exposed surface of embedded material the paint shall be cleaned off the member to a minimum length of 50 mm beyond each side of the weld line.

Necessary templates, fixtures, supports etc. shall be used as may be required or directed by the Engineer, free of cost to the Owner.

**Items to be embedded**

a) Inserts, hangers, anchors, frames around openings, manhole covers frames, floor clips, sleeves, conduits and pipes.

b) Anchor bolts and plates for machinery, equipment and for structural steel work.

c) Steel structural to be left embedded for future extension. Special connection etc.

d) Dowel bars, etc. for concrete work falling under the scope of the contractors.

e) Lugs or plugs for door and window frames occurring in concrete work.

f) Flashing and jointing in concrete work.

g) Any misc. embodiments and fixture as may be required.

Correct location and alignment as per drawings/instruction of all these embedded items shall be entirely the responsibility of the Contractor.

## 3.23 Expansion and Isolation Joints

### 3.23.1 General

Expansion and isolation joints in concrete structures shall be provided at specific places as per details indicated on the drawings. The materials and types of joints shall be as specified herein after. In case, of liquid retaining structures, additional precautions shall be taken to prevent leakage of liquids as may be specified on the drawings or as directed by the engineer. All materials are to be procured from reliable manufacturers and must have the approval of the engineer. Where it is the responsibility of the Contractor to supply the material, the Engineer may demand test certificates for the materials and/or instruct the

Contractor to get them tested in an approved laboratory free of cost to the Owner. Joints shall be formed true to line, level, shape, dimension and quality as per drawings and specifications. Prior approval of the method of forming the joints should be obtained from the engineer before starting the work.

**3.23.1 Bitumen Board/Expanded Polystyrene Board**

**3.23.2.1 Bitumen Board**

Bitumen impregnated fibre board of approved manufacturer as per IS: 1838 may be used as fillers for expansion joints. It must be durable and waterproof. It shall be compressible and posess a high degree or rebound. The dimensions of the board should be equal to that of the joint being formed. It should preferably be manufactured in one piece, matching the dimension of the joint and not prepared by cutting to size smaller piece, from larger boards at site. At the exposed end, the joint shall be sealed with approved sealing compound to a depth of at least 25 mm after application of an approved primer. The sealing compound and the primer shall be applied as specified by the manufacturer.

**3.23.2.2 Expanded Polystyrene Boards**

If required, commercial quality of expanded polystyrene products commonly used for thermal insulations may also be sued as filler material in expansion joints. The thickness may vary from 12 mm to 50 mm. The material will have to be procured from reliable manufacturers as approved by the Engineer. The method of installations will be similar to that recommended by the manufacturers for fixing on cold storage walls. A coat of Bitumen paint may have to be applied on the board against which concrete will be placed.

**3.23.2 Joint Sealing Strips**

Joint sealing strips may be provided at the construction, expansion and isolation joints as a continuous diaphragm to contain the filler material and/ or to exclude passage of water or any other material into or out of the structure. The sealing strips will be either metallic like G.I. Aluminium or Copper, or non-metallic like rubber or P.V.C.

Sealing strips will not have any longitudinal joint and will be procured and installed in largest practicable lengths having a minimum number of transverse joint. The material is to be procured from reputed manufacturers having proven records of satisfactory supply of joint strips of similar make and shape for other jobs. The jointing procedure shall be as per the manufacturer's recommendations, revised if necessary , by the Engineer. The Contractor is to supply all labour and material for installation including the material and tools required for jointing testing, protection, etc. If desired by the Engineer joints in rubber seals may have to be vulcanized.

**3.23.3.1 Metal Sealing Strips**

Metal sealing strips shall be either G.I. Aluminium or Copper and formed straight, U shaped, Z shaped or any other shape and of thickness as indicated in the drawing and schedule of items and/or as instructed by the Engineer.

The transverse joints will be gas welded using brass rods and approved flux and will be tested by an approved method to establish that it is leak proof, longer lap lengths and different method of brazing which will tender it leak proof, will be adopted by the Contractor without any additional cost to the Owner. The edges shall be neatly crimped and bent to ensure proper bond with the concrete.

a) **G.I. Strips**

G.I. Strips shall be minimum 1.5 mm thick and 150 mm in width unless specified otherwise. The Standard of Galvanising shall be as per relevant Indian Standards for heavy duty work. At the joints, the overlapping should be for a minimum length of 50 mm.

b) **Aluminium Strips**

Aluminium strips shall be minimum 10 SWG thick and 300 mm wide unless specified otherwise and shall conform to IS:737 of 19000 grade or 31000 grade (Designation as per IS: 6051. A minimum lap of 50 mm length is required at the joints.

c) **Copper Strips**

The Copper strips shall be minimum 18 SWG in thickness and 300 mm wide unless specified other wise and shall conform to the relevant Indian Standards.

It should be cleaned thoroughly before use to expose fresh surface, without any reduction in gauge. A minimum lap of 50 mm in length is required at the joints.

**3.23.3.2 Non-metallic Sealing Strips**

The will be normally in Rubber or P.V.C. joint be of shape having any combination of the following features:-

a) Plain

b) Central bulb

c) Dumb-bell or flattened ends.

d) Ribbed and Corrugated Wings

e) V shaped

As these types of seals be easily handled in very lengths unlike metal strips, transverse joints will be only under unavoidable circumstances and with the specific approval of the Engineer.

The method of forming these joint, laps etc. shall be specified by the manufacturer and /or as approved by the Engineer taking particular care to match the central bulbs and the edges accurately

a) **Rubber Sealing Strips**

The minimum thickness of Rubber sealing strips shall be 3mm and the minimum width 100 mm. The actual size and shape will be as shown in drawings/schedule of items and/or as directed by the Engineer. The material will be natural rubber and be resistant to corrosion, abrasion and tear and also service. The physical properties will be generally as follows. The actual requirements may be slightly different as decided by the Engineer.

| | | |
|---|---|---|
| Specific Gravity | : | 1.1 to 1.15 |
| Shore Hardness | : | 65 A to 75 A |
| Tensile Strength | : | 25-30 N/Sq.mm |
| Maximum Safe Continuous Temperature | : | 75 Deg.C |
| Ultimate Elongation | : | Not less then 350 % |

b) **P.V.C. Sealing Strips**

The minimum thickness of P.V.C. sealing strips will be 3 mm and the minimum width 100 mm. The actual size and shape will be as shown in drawings / Schedule of items and / or as directed by the Engineer. The material should be of good quality polyvinyl Chloride highly resistant to tearing, abrasion and corrosion as well as to chemicals likely to come in contact with during use. The physical properties will generally be as follows, which will be directed by the Engineer, may very slightly:-

| | | |
|---|---|---|
| Specific Gravity | : | 1.3 to .1. 35 |
| Shore Hardness | : | 60 A to 80 A |
| Tensile Strength | : | 10 – 15 N/Sq.mm |
| Maximum Safe Continuous Temperature | : | 70 Deg.C |
| Ultimate Elongation | : | Not less then 275 % |

**3.23.4 Bitumen Compound**

When directed, the gap in expansion joints shall be thoroughly cleaned and bitumen compound laid as per manufacturer's specifications. The compound to be used shall be of approved manufacture and shall conform to the requirements of IS: 1834.

**3.23.5 Isolation Joints**

Strong and tough alkathene sheet or equivalent, about 1 mm in thickness and as approved by the Engineer shall be used in isolation joints. It shall be fixed by an approved adhesive compound on the cleaned surface of the already set concrete, to cover it fully. Fresh concrete shall be laid against the sheet, care being taken not to damage the sheet in any way.

### 3.23.6 Rubber Pad

Hard Foundation quality rubber pads of required thickness and shapes shall be put below machine or other foundations as shown on the drawings or as directed by the Engineer. The rubber shall have a unit weight of 1,500Kg/Cu.m., a shore hardness – 65A to 70A and be of best quality of approved manufacture, durable, capable of absorbing vibration and must be chemically inert in contact with moist or dry earth or any earth or any earth or any other deleterious material expected under normal conditions.

### 3.24 Grouting under Machinery or Structural Steel Bases

If required, grouting under base plates of machines or structural steel etc., shall be carried out by Contractor. In general, the mix shall be 1 (one) part cement and 1 (one) part sand and just enough water to make it flow as required. The areas to be grouted shall be cleaned thoroughly with compressed air jet and/or with water in locations where accumulated surplus water can be removed. Where directed by the Engineer, 6mm down stone chips may have to be used in the mix. Surface to be grouted shall be kept moist for at least 24 hours in advance. The grout shall be placed under expert supervision, so that there is no locked up air. Edges shall be finished properly. If desired by the Engineer, admixtures like Aluminium powder, 'Ironite' etc. may have to be added with the grout in proportions to be decided by the Engineer Admixture, if directly to be added, will be measured and paid sep[separately.

### 3.25 Precast Concrete

The specification for precast concrete will be similar as for the cast-in-place concrete described herein and as supplemented in this section. All precast work shall be carried out in a yard made for the purpose.

This yard shall be dry, properly levelled and have a hard and even surface. If the ground is to be used as a soffit former of the units, it shall be paved with concrete or masonry and provided with a layer of plaster (1:2 proportions) with smooth neat cement finish or a layer of M.S. sheeting. Where directed by the Engineer, casting will have to be done on suitable vibrating table. The yard , lifting equipment , curing tank, finished material storage space etc. shall be designed such that the units are not lifted from the mould before 7 (seven )days of curing and can be removed for erection after 28 days of curing. The moulds shall preferably be of steel or of timber lined with G.I. sheet metal. The yard shall preferably be fenced.

Lifting hooks, where necessary or as directed by the Engineer, shall be embedded in correct position of the units to facilitate erection, even though they may not be shown on the drawings, and shall be burnt off and finished after erection.

Precast concrete units, when ready, shall be transported to site by suitable means approved by the Engineer. Care shall be taken to ensure that no damage occurs during transportation. All adjustments, levelling and plumbing shall be done as per instructions of the Engineer. The Contractor shall render all help with instruments, materials and men to the Engineer for cheeking the proper erection of the precast units.

After erection and alignment, the joints shall be filled with grout or concrete as directed by the Engineer. If centrings have to be used for supporting the precast units, they shall not be removed until the joints have attained sufficient strength and in no case before 14 (fourteen) days. The joint between precast roof planks shall be pointed with 1:2 cement: sand mortar where called for in the drawings.

## 3.26 Water Proofing of Concrete Structure

### 3.26.1 General

Waterproofing of concrete structures shall be by either suitable extraneous treatments like applying paints, fixing bitumen felts etc. or internally by suitable design of the concrete mix, addition of suitable admixtures in the concrete or mortar at the time of mixing and/or installing water bars at the joints.

The design, material and workmanship shall conform to the relevant I.S.Codes where applicable. The Engineer's approval of the materials shall be obtained by the Contractor before procurement. If desired by the Engineer, test certificates for the materials and samples shall be submitted by the Contractor free of charge. The materials shall be of best quality available indigenously. Fresh clean and suitable for the duties called upon.

### 3.26.2 Water Bar/Seal

Water bearing structures and under ground structures may have water bar/seals installed at the joints. They may be either metallic rubber or P.V.C. The materials and installation will be as described under Clause 3.23.3.

### 3.26.3 Waterproofing Admixtures

a) In Concrete:
The admixtures shall be procured from reliable and reputed manufacturers and approved by the Engineer. The method of application and other details shall conform to the manufacturer's specification and /or as instructed by the Engineer. The contractor shall have the services of the manufacturer's supervisor at no extra cost to the Owner to supervise the work, if des8ired by the Engineer.

b) In Plaster:
The concrete surface, to be plastered, shall be hacked to Engineer's satisfaction, cleaned thoroughly and kept wetted for 24 hours. The plaster shall be in cement sand mortar mixed in proportion varying from 1:1to 1:4 by volume along with the approved water

proofing 15 mm/layer or as per manufacturer's specification. The additive shall be of quality and type approved by the Engineer. If desired by the manufacturer's supervisor at no extra cost to the Owner. On completion, the plastered surface shall be cured continuously for a minimum period of 14 days like concrete.

### 3.26.4 Bituminous of Tar Coating

The surface to be waterproofed shall be render ed absolutely dry , clean and dust free. The surface shall be sand papered, cleaned and completely coated with hot coal tar pitch of approved manufacture and quality as per IS: 216 (not heated above 375 Deg.F) using not less then 2 kg per Sq. M or with hot asphalt i.e., bitumen according to IS: 73 (not heated above 400 Deg.F) using not less then 1.5 kg. Per Sq. m when the first coat has completely dried up and approved by the Engineer, the second coat shall be applied in the same manner using hot less then 1.25 kg .per sq. M in case of coal tar and 1 kg per Sq. M. in case of asphalt Immediately after application of the second coat and be for it is dried up, sand shall be spread on the surface to cover it completely sufficient time shall be allowed after spreading of before back filing is done in order to allow the final coat to dry up completely.

### 3.26.5 Bitumen Felt: Application for Tanking

This specification shall cover laying the waterproof coarse on the outside and inside of the walls and bases of structures

The materials shall conform to IS: 1322, and the workmanship to IS: 1609. The bitumen felt shall be Hessian base and/or fibre base as specified in Drawing/Schedule of Items. If required by the Contractor without charging any extra to the Owner.

Cleaning the surface, keeping it dry, proving necessary corner fillets and cement rendering and cutting chases, etc., shall be included in the rate for this item. If any protective brickwork on/against concrete sub-bases or walls are required, this will be paid extra under suitable items in the contract. A 20 years guarantee for satisfactory performances shall be given by the Contractor as well as his specialist sub- contractor jointly and severally, for this item of work. Free rectification of any defects noted in the work within this guarantee period will be carried out by the contractor even if is beyond the specified maintenance period of the contract as a whole.

### 3.26.6 Polyethylene films: Application in Walls or base of Structures

Waterproof treatment shall be applied as outlined and as per sequence given here under.

i) The concrete surface shall be made smooth with 12 mm cement plaster 1:6

ii) apply hot bitumen 80/100 grade (IS 73-1961 )at the rate of 1.0 Kg/Sq m Minimum

iii) Lay back poly ethylene film 250 micro (IS 2508- 1977) with cut back bitumen adhesive in overlaps over hot bitumen surface, gently pressed,

taking care not puncture the film.

Alternatively, the overlaps shall be sealed by an electric iron having three parallel sealing bars. A long piece of plywood is to be placed below the Polyethylene film to be heat spread a cushion for better welding of the LDPE film, with 100 mm overlap, is to be stretched. On the overlapped film another Cellophane tape is to be placed to prevent the heat heat sealer from sticking to the LDPE film After this, the electric iron is to be pressed on the overlap join for sufficient time so as to allow perfect welding. The operation is to be repeated for subsequent lengths of joints. After heat sealing, the Cellophane tape is to be removed and the joints are to be tested for leaks.

iv) Lay 100 gm brown craft paper laminated with a layer of straight run bitumen
v) Lay hot bitumen 80/200 grade (IS: 73-1961 )at 1.0 Kg/Sq.m minimum.
vi) Lay 250-micron polyethylene film as second layer similar to (iii) above.
vii) Lay second layer of 100 gm brown craft paper laminated similar to (iv) above.
viii) Apply hot bitumen (straight run grade) to IS: 73-1961 at 1.0 Kg/Sq.m. dusted with fine sand.
ix) Protecting with a layer of 75 mm plain cement concrete M-100, or a layer of brick laid in cement mortar 1:6. In case of wall apply a 12 mm thick plaster as shown on the drawing or a protective brick wall in 1:6 cement mortar as shown on the drawing.

## 4.0 SAMPLING AND TESTING

### 4.1 General

The Contractor shall carry out all sampling and testing in accordance with the relevant India Standards and as supplemented here in for the following items at his own cost unless otherwise specified in this specification. The Contractor shall get, the specimens tested in a laboratory approved by the Engineer and submit to the Engineer the test results in triplicate with in 3 (three) days after completion of the test.

### 4.2 Cement

Representative samples will be taken from each consignment of cement received from the manufacturer/supplier for carrying out the tests for fineness (by hand sieving), setting time and compressive strengths as per IS:269. soundness Tests may also be required to be carried out if required by the Engineer. The test shall be carried out free of charge by the Owner, if Cement is supplied by him or by the Contractor is directed arrange for the supply as per the terms and conditions of the Contract. In case due to any circumstances, the agency of supply is changed in the middle of the Contract, the party who bore the original contractual obligation will carry on with the test, free of charge to the other, till the end of the works unless satisfactory 3(three ) days and 7 days test results for compressive strength are know. The Owner, Engineer and Contractor will jointly associate themselves with the tests irrespective of whether they are carried out by the Owner or the Contractor. These tsets are of great importance as

their results will have a bearing on the acceptance of concrete or otherwise as per the terms and conditions of the Contract.

**4.3.1 Aggregates**

The Contractor shall carry out any or all the tests aggregates as may be required by the Engineer in accordance with IS2300 (PARTS-I to VIII). The acceptance criteria of the samples tested shall be in accordance with the requirements of the relevant Indian Standards.

**4.4 Water**

Sampling and Testing of water being used for concrete works per IS:3550 will be carried out by the Contractor at regular intervals and whenever directed by the Engineer. The final acceptance criteria in case of doubt will be as per IS: 3025 & IS: 456.

4.5 **Admixture**

**4.5.1 Air Entraining Agents**

Initially, before starting to use A.E.A., relationship between the percentage of air entrained and the cylinder cube crushing strength via-a via quantity of A.E.A. used for all types of concrete will be established by the Contractor free of change by carrying out sufficiently large number of tests. Contractor will check up free of charge, the actual presented by the Engineer, the Contractor with earlier test results.

**4.5.2 Other Admixtures**

Tests for establishing the various of any other admixtures which may be Required to be added shall be carried out by the Contractor free of charge to Owner.

4.6 **Concrete**

The sampling of concrete, making the test specimens, curing and testing procedure etc. shall be in accordance with IS:516 and IS:1199 the size of specimen being 15 cm cubes. Normally, only compression tests shall be perfumed but under special circumstances the Engineer may require other tests to be performed in accordance with IS:516

Sampling procedure, frequency of sampling and test specimen shall conform to Clause 14 of IS: 456.

To control the consistency of concrete from every mixing plant, slump tests and/or compacting factor tests in accordance with IS:1199 and as mentioned in Clause 3:6 of this Specification shall be carried out by the Contractor every two hours or as directed

by the Engineer. Slump corresponding to the test specimens shall be recorded for reference.

The acceptance criteria of concrete shall be in accordance with Clause 15 of IS:456. However, in exceptional circumstances, the Engineer may, at his discretion, accept a concrete of lower strength then specified and which is otherwise unacceptable according to IS:456.

Payment for concrete which is normally unacceptable as per the criteria laid down in IS: 456, but which has been accepted by the Engineer shall be made at a reduced rate prorate to the strength obtained.

Concrete work found unsuitable for acceptance shall have to be dismantled and replacement is to be done as per specification by the Contractor. No payment for the dismantled concrete, the relevant formwork and reinforcement, embedded fixtures etc. wasted in the dismantled portion shall be made. In the course of dismantling, if any damage is done to free of charge by the Contractor, to the satisfaction of the Engineer.

## 5.0 ACCEPTANCE CRITERIA

### 5.1 Standard Deviation

Standard deviation shall be based on test results and determination of Standard deviation shall conform to clause 14.5 of IS: 456.

### 5.2 Acceptance Criteria

The strength requirements and acceptance criteria shall conform to Clause 15 of IS:456.

### 5.3 Inspection and Core Tests

Inspection of concrete work immediately after stripping the formwork and core test of structures shall conform to Clause 16 of IS: 456.

### 5.4 Load Test

Load tests of structural members may be required by the Engineer, when the strength of test specimen results fall below the required strength as per “Load Test on parts of structures”, .Clause 16.5 of IS:456. If load testing is decided by the Engineer, the member under consideration shall be subjected to a test load equal to 1:25 (one and a quarter )times the specified live load user for design and this load shall be maintained for a period of 24 (twenty-four)hours before removal. The detailed procedure of the test is to be decided by the Engineer. Load tests shall not be made until the structure is at least 56 days old.

If the member shows evident failure, such changes as are necessary to make the structure adequately strong shall be made by the Contractor free of cost to the Owner.

Alternatively, if permitted under Statutory Regulations and at the discretion of the Engineer .the structure under test or a portion thereof may be retained as such without any modification by dearating its load bearing capacity, provided the design criteria allows such dearating.

A reinforced concrete beam, floor or roof shall be deemed to have passed the test if the maximum deflection at the end of 24 hours dose not exceed the deflection given in Clause 16.5 of IS: 456.

The entire cost of load testing shall be borne by the Contractor. If a portion of the structure is found to be unacceptable, it shall be dismantled and replaced by a new structure as per specification. The entire cost of dismantling and replacement and restoration of the site being borne by the Contractor.

If in the course of dismantling, any damages done to the embedded items and or other adjacent to the satisfaction of the Engineer.

## 6.0 RATES

The rate for any item in the schedule, unless specifically excluded in the contract, shall be deemed to include the cost of all materials consumed or used in the work or incidental to it a labour, tools, plants, equipment, templates, supports, scaffolds approaches, security, and safety measures, power, fuel, lubricants, storage, handing transport, testing, insurances, taxes overheads, profits etc., the various items of work which are to be provided are mentioned under Clause 2.1 and elsewhere in this specification. If no separate item is provided for any such wok in the schedule of items. It is implied that the contractor shall not claim for any of the connected items of the schedule viz., detailed drawings and drawings of formwork in the item of from work of concrete etc., rate for R.C.C. items shall include for carrying out specimen tests as per specifications.

## 7.0 METHOD OF MEASUREMENT

### 7.1 Concrete

a) Actual volume of work as executed or as per drawings issued, whichever is less shall be measured in Cu.M. Deductions for openings, conduits, pipes, ducts pockets, chases etc. shall be made, provided they are larger then 0.1 sq. M. in area each.

No deduction shall be made for embedded fixtures including reinforcements, sleeves, anchor bolts and similar items.

b) Precast concrete work shall be measured in the same way as specified in foregoing paragraph. No separate payment shall be made for formwork. Lifting hook where required in the design, shall be treated as reinforcement steel and paid accordingly. Payment shall be due only after erection, grouting and curing of the precast units in proper position unless otherwise provide for

in the contract. All breakages and damages of the precast units will be to the Contractor's account and shall be replaced free of charge to the Owner.

**7.2 Admixture**

Admixture will be measured on the basis of theoretical requirement or actual consumption, whichever is less.

**7.3 Reinforcement**

a) Bar or any other type of reinforcement used like Hard drawn steel Wire fabric etc. for reinforced shall be measured by weight in tonnes. The weight will be arrived at by multiplying the actual or theoretical length; whichever is less, by the sectional weights. In case the Owner issues the reinforcing steel, the section weights will be the same as were applied at the time of issue. In case the steel is to be supplied by the contractor, the sectional weight to be adopted will be the I.S. Sectional Weight or as per actual which will be arrived at by accurately measuring representative samples as directed by the Engineer, whichever is less.

b) Standard hooks; cranks, bonds, authorised laps etc. shall be measured.

c) Lap welding or butt welding if permitted will be, measured diameter wise per Joint. The actual length of steel in lap will be measured separately in case of lap welding. The rate quoted for the smaller size bar will be applied in case of joint between two bars of different diameters.

d) Separator pieces between two or more layers of steel shall be measured.

e) No payment shall be made for binding wires,spacer block, supports, chairs, hangers, etc. of height 300 mm and less, required of keeping the steel in position unless otherwise specified in the contract. For supporting horizontal reinforcement at heights larger then 300 mm support drawings will be prepared by the Engineer, or as actually placed, whichever is less, at the same rate as for Reinforcement.

f) No extra will be paid for modification of already embedded reinforcement, if required due to faulty fabrication or placement.

g) Dowels neither shown on the drawings not instructed by the Engineer, but required for construction facilities and/or sequence, shall not be measured.

**7.4 Form work**

a) Formwork shall be measured as the actual surface in contact with the concrete and paid in Sq.M unless included in the rate for concrete.

b) Formwork shall not be measured separately for precast concrete work which shall be included in the cncrete rates.

**c)** No payment for from work or any other requirement in construction joints shall be made.

**d)** Openings upto 0.1 Sq.M shall be neglected as if non-existent for the purpose of from work measurement.

**e)** No extra measurement or payment shall be made for making the from work waterproof or for supports, scaffolding, cantering approaches, etc.

**f)** No measurement shall be taken for he from work in pockets, openings, chases etc. in concrete if the cross-sectional area is less then or equal to 0.1 Sq.M. in each case if the cross-sectional area of any opening exceeds 0.1 Sq.M the from work shall be measured under appropriate classification.

**g)** Fixing and removing pockets and openings of sectional area less then 0.1 Sq.M. shall be measured on number basis and paid separately.

### 7.5 Anchor Bolts, Anchor Sleeves, Inserts, Hangers, Conduit Pipes and Other Miscellaneous Embedded Fixtures

a) These will be measured on theoretical weight basis of the complete insert handled by the Contractor irrespective of the amount of insertion. Where theoretical weight cannot be assessed satisfactorily, the actual weight shall be allowed under certification of the Engineer.

b) No extra shall be to be paid for templates and other arrangements required to secure these in position. The protection of these materials with proper anticorrosive paints/grease and covering with gunny bags against any damages till the structure is handed over, shall be the responsibility of the Contractor at no extra cost.

c) Any ‘boxing ‘ left for inserts, etc. during construction , for facility of the Contractor’s work , and later on filled in by the same Contractor after placing the inserts shall be considered for measurement purpose, as if the inserts, etc. were placed before concreting.

d) No extra payment shall be made for cleaning of the inserts, etc. required for bond with the concrete.

### 7.6 Expansion and Isolation Joints

a) Expansion and isolation joints will be measured and paid on area basis. The drawings and or schedule of items will describe the thickness. Painting, filling material, sealing, strips, metal fixtures, inserts, etc. to be used in the joint.

b) Formwork for the 'leading side' of the joint will be measured and paid under the relevant item. No payment for the formwork for the 'following side' will be made even if the Contractor is required to use from work for constructional facilities.

c) Joints sealing strips made out of Copper, Aluminium or G.I.or P.V.C.or rubber, will be measured and paid on area basis under relevant items. Rubber pads below foundation will be measured on area basis under the relevant item.

d) Any other fixtures and inserts like dowels, installed as per drawing, riding plates etc., will be measured and paid if under the respective items of the schedule of Items.

e) All other work like installing Bitumen coating, Bitumen boards, Expanded polystyrene Boards, Alkathene sheets, Bitumen filler etc. and trimming the top , repair, finishes and other connected items will be deemed to be included in the unit rate for expansion/Isolation joints.

**7.7 Joints Seals: G.I. Copper, Aluminium, Rubber or P.V.C.**

All seals, whether used as water bars or in expansion or Isolation Joints shall be measured as joint seals and on area basis. In case of Metallic seals like G.I. copper or Aluminium the developed area will be measured. In case of Rubber and P.V.C. seals also, developed area will be measured but the central bulb, corrugation ribs etc. will be neglected. In all cases laps will not be measured.

**7.8 Rubber pad**

Rubber pads will be measured on area basis. The theoretical or actual area, whichever is less, will be recorded.

**7.9 Grouting under Base Plates etc.**

Grouting shall be measured on theoretical volume basis neglecting the volume of embedded items. The cost shall include the cost of backing the old concrete
Plus necessary from work if any Edges of the groutting shall be measured equal even if chamfered. Necessary curing shall also be included Admixtures. If added, Will be measured and paid separately under the relevant items.

**7.10 Water proof Plaster**

The measurement will be no finished square area basis. The thickness, method of applications, waterproofing additive to be used etc. will be specified in the specification/drawings/schedule of items.

The waterproofing additive will be measured and paid separately under admixtures (Clause 7.2 ) .No deduction will be made for opening less then 0.1 Sq .m in area each.

**7.11 Bitumen Coating/Tar Coating**

These shall be measured on next useful area, neglecting openings up to 0.1 Sq.M in area each.

**7.12 Bitumen Felt**

Bitumen felt waterproofing shall be measured nett on area of structure cover, neglecting openings up to 0.1 Sq.M . in area each, measuring only once for the completed work and once for each layer.

**7.13 Polyethylene Film**

Polyethylene Film waterproofing shall be measured nett on area of structure covered, neglecting openings up to 0.1 Sq.M. in area each, measuring only once for the completed work and not once for each layer.

**7.14 Tests**

a) Tests on concrete specimens shall not be paid for separately. The specimen shall be either in the from of 15 cubes or 15 cm dia. 30 cm along cylinders. No separate measurement shall be made for column of concrete used in the specimen or for the mould.

b) No payment shall be made for tests carried out for approval of samples or different materials in accordance with the specification.

c) Load Test, if required to be made as per terms and conditions of the contract, shall not be paid.

**8.0 LIST OF IS: CODES AND STANDARDS FOR REFERANCE**

All work under this specification shall, unless specified other wise, conform to the latest revisions and/or replacements of the following or any other Indian Standard Specifications and Codes of practice. In case any particular aspect of work is not specifically covered by Indian standard Specifications, any other standard practice, as may be specified by the Engineer, shall be followed: -

IS : 73 - Indian Standard Specification for paying Bitumen.

IS : 216 - Indian Standard Specification for Coal Tar Pitch.

IS : 226 - Indian Standard Specification for Structural Steel (Standard quality).

IS : 269 - Indian Standard Specification for Ordinary, and Low Heat Portland Cement.

| | | |
|---|---|---|
| IS:8112 | - | 43 garde ordinary portlant cement. |
| IS : 383 | - | Indian Standard Specification for Coarse and Fine Aggregates from Natural Sources for Concrete.. |
| IS : 432 | - | Indian Standard Specification for Mild Steel land Medium Tensile Steel Bars and Hard Drawn Steel Wire for concrete Reinforcement. |
| IS : 455 | - | Indian Standard Specification for Slag Cement. |
| IS :456 | - | Indian Standard Code of Practice for Plain and Reinforced Concrete. |
| IS : 457 | - | Indian Standard Code of Practice for General Construction of plain and Reinforced Concrete for Dams and other Massive Structures. |
| IS : 516 | - | Indian Standard Specification for Methods of Test for Strength of Concrete. |
| IS :1139 | - | Indian Standard Specification for Mild Steel and Medium Tensile Steel Bars and High yield Strength Steel; Deformed Bars for concrete Reinforcement. |
| IS : 1199 | - | Indian Standard Specification for Methods of Sampling and Analysis of Concrete. |
| IS : 1200 (part-II ) | - | Indian Standard Specification for Method of measurement Cement Concrete work. |
| IS : 1200 (part-V ) | - | Indian Standard Specification for Method of measurement Form work. |
| IS : 1322 | - | Indian Standard Specification for Bitumen Felts for waterproofing and Damp-proofing. |
| IS : 1489 | - | Indian Standard Specification for Portland – Pozzolana Cement. |
| IS : 1566 | - | Indian Standard Specification for Methods for sampling and Analysis of Concrete. |
| IS : 1609 | - | Code of practice for laying Damp-Proof Treatment using Bitumen Felts. |
| IS : 1786 | - | Indian Standard Specification for Cold-twisted Steel Bars for Concrete Reinforcement. |
| IS : 1791 | - | Indian Standard Specification for Batch Type Concrete Mixers. |

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| IS : 2185 | - | Indian Standard Specification for Hollow Cement Concrete Blocks. |
| IS : 2210 | - | Indian Standard Specification for Design of Reinforced Concrete shall Structures and Folded plates. |
| IS : 2386 | - | Indian Standard Specification for methods of Test for Aggregates for Concrete – part-I to VIII. |
| IS : 2502 | - | Indian Standard Code of practice for Bending and Fixing of Bars for Concrete Reinforcement. |
| IS :2505 | - | Indian Standard Specification for Concrete Vibrators. Immersion Type. |
| IS ; 2506 | - | Indian Standard Specification for Screed Board Concrete Vibrators. |
| IS : 2514 | - | Indian Standard Specification for Concrete vibrating Tables. |
| IS : 2722 | - | Indian Standard Specification for portable Swing Weigh Batches for Concrete ( Single and Double Bucket type ). |
| IS : 2751 | - | Code of practice for Welding of Mild Steel Bars used for Reinforced Concrete Construction. |
| IS : 2770 | - | Indian Standard Specification for Method of Testing Bond in Reinforced Concrete Construction. |
| IS : 3025 | - | Indian Standard Specification for methods of sampling and Test (physical and Chemical ) for Water used in Industry. |
| IS : 3201 | - | Indian Standard Specification for Design and construction of precast Concrete Trusses. |
| IS : 3370 | - | Indian Standard Specification for Code of practise for Concrete structures for Storage of Liquids. |
| IS ; 3550 | - | Indian Standard Specification for Method of Test for Routine Control for water used in Industry. |
| IS : 3558 | - | Code practice for use of Imersion Vibrator for Consolidating Concrete. |
| IS : 3590 | - | Indian Standard Specification for Load Baring Light Weight Concrete Blocks. |
| IS : 3696 | - | Safety code for Scaffolding and Ladders. |

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| IS : 3812 | - | Indian Standard Specification for fly Ash for use as Admixture for Concrete. |
| IS : 4031 | - | Indian Standard Specification for Method of Tests for Hydraulic Cement. |
| IS : 4031 | - | Indian Standard Specification for Method of Test for Hydraulic Cement. |
| IS :4082 | - | Indian Standard Specification for Recommendation on Stacking and Storage of Construction Materials at site. |
| IS : 4090 | - | Indian Standard Specification for Design of Reinforced Concrete Archs. |
| IS : 4634 | - | Indian Standard Specification Method of Testing performance of batch- type Concrete Mixes. |
| IS : 4656 | - | Indian Standard Specification for From Vibrators for Concrete. |
| IS : 4925 | - | Indian Standard Specification for Concrete Batching and mixing Plant. |
| IS : 4926 | - | Indian Standard Specification for read mixed Concrete. |
| IS : 4990 | - | Indian Standard Specification for Plywood for Concrete Shuttering work. |
| IS : 4991 | - | Indian Standard Specification for Blast Resistant Design of Structure for Explosion above ground. |
| IS : 4995 Part I & II | - | Indian Standard Specification for Design of reinforced Concrete Bins for the Storage of granular and powdery Materials. |
| IS : 4998 | - | Indian Standard Specification for Design of reinforced Concrete Chimneys. |
| IS : 5512 | - | Indian Standard Specification for Flow table for use in Testes of Hydraulic Cement and Pozzolanic Materials. |
| IS : 5513 | - | Indian Standard Specification for Vie at Apparatus |
| IS : 5515 | - | Indian Standard Specification for Compaction factor Apparatus. |
| IS : 5751 | - | Indian Standard Specification for precast concrete Copying Blocks. |

IS : 5816 - Indian Standard Specification for method of Test for Splitting Tensile Strength of concrete Cylinders.

IS : 5891 - Indian Standard Specification for Hand Operated Concrete Mixers.

IS : 6452 - Indian Standard Specification for High Aluminium Cement for Structural Use.

IS : 6909 - Indian Standard Specification for super-sulphated Cement.

IS : 6923 - Indian Standard Specification for method of Test for Performance of Screed Board Concrete Vibrators.

IS : 5891 - Indian Standard Specification for Hand Operated Concrete Mixers.

IS : 6452 - Indian Standard Specification for High Aluminium Cement for Structural Use.

IS : 6909 - Indian Standard Specification for super-sulphated Cement.

# FABRICATION OF STRUCTURAL STEEL WORK

| REV. NO. | PRAPARED | APPROVED | DATE |
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| 00 | marina | P Mishra | |
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**1.0.0 SCOPE**

This specification covers supply fabrication, testing, painting and delivery to site of structural steelwork including supply of all consumable stores and rivets. Bolts, nuts, washers, electrodes and other materials required for fabrication and field connections of all structural steelwork covered under the scope of the contract.

2.00.0 **GENERAL**

2.1.0 **WORK TO PROVIDED FOR BY THE CONTRACTOR**

The work to provided for by the contractor, unless specified otherwise. Shall include but not be the following.

a) Furnish all labour, supervision, services including facilities as required under statutory labour regulations, materials, equipment, tools and plants, transportation, etc, required by the Engineer
b) Prepare and submit working drawing showing the approaches, slope, beam, shoring, sumps for dewatering, including drains and outfall for drainage, space for temporary stacking of spoil, disposal area, fencing, etc and all other details as may be required by the Engineer.
c) To carry out sampling and testing and submit to the Engineer, results of soil compaction tests if required by the Engineer to assess the degree of compaction.
d) Construction, maintenance and removal after comp lection of Magazine of proper capacity as well as design for storing of explosives required for blasting work to be carried out scope of this tender.

2.2.0 **WORK TO PROVIDED FOR BY OTHERS.**

No work under this specification will be provided by any agency other than the Contractor unless specifically mentioned elsewhere in the Contract

2.3.0 **CODES AND STANARDS**.

All works under this specification, unless specified otherwise shall conform to the Latest revision and /or replacement of the following or any other Indian Standard Specifications and codes of practice. In case any particular aspect of work is no Covered specially by Indian Standard Specification any other standard practice as

May be specified by the Engineer shall be followed: -

IS: 226: Structural steel (Standard Quality)

IS: 800: Code of practice for use of steel in general building construction

IS:806: Code of practice for use of steel tubes in general building construction

IS:808: Rolled steel beams channels and angle sections

IS:813: Scheme of symbols for welding

IS:814: Covered electrodes for metal are welding of structural steel

IS:815: Classification and coding of covered electrodes for metal are welding mild steel and low ally high tensile steel.

IS:816: Code of practice for use of metal are welding for general construction in mild steel

IS:817 : Code of practice for training and testing metal are welders.

IS:818: Code of practice for safety, and health requirements in electric and gas welding and cutting operations.

IS:822: Code of practice for inspection of welds.

IS:9595: Recommendations for metal are welding of carbon and carbon manganese steel:

IS:919: Recommendations for limits and fits for Engineer.

IS:961: Structural Steel (High tensile)

IS:1148: Rivets bars for structural purposes.

IS:1149: High tensile rivets bars for structural purposes

IS:1161: Steel Tubes for structural purposes

IS:1200: Method of measurement of steelwork and ironwork (Part-B)

IS:1239: Mild Steel Tubes

IS:1363: Black hexagon bolts, nuts and lock nuts (dia. 6 to 30mm) and black hexagon screws (dia 6 to 24mm)

IS:1363: Black hexagon bolts, nuts and lock nuts (dia. 6 to 30mm) and black hexagon screws (dia 6 to 24mm)

IS 1346: Precision and semi-precision hexagon bolts, screws, nuts and locknuts.(dia 6 to 24 mm

IS:1367: Technical supply conditions for threaded fasteners

IS:1442: Covered electrodes for the metal are welding of high tensile structural steel.

IS:1600: Method for tensile testing of steel products other than sheet strip, wire and tube

IS1730: Dimensions for steel plates, sheet and strip for structural and general engineer purposes.

IS: 1731: Dimensions for steel flats for structural and general engineering Purposes.

IS: 1852: Rolling and cutting tolerance for hot-rolled steel products

IS:1977: Structural steel (Ordinary quality) St-42-0

IS:2062: Structural steel (fusion welding quality )

IS:2074: Ready mixed paint red oxide Zinc chromate painting

IS:2629: Recommended practice for Hot – Dip Galvanising of Iron and Steel

IS:2633: Method for testing uniformly of coating on Zinc Coated Articles

IS:3757: High Tensile Fraction Grip bolts

IS:4759: Specifications for Hot – Dip Zinc coatings on structural Steel and other Allied products

IS 7215: Tolerance for fabrication of steel structures

## 2.4.0 CONFORMITY WITH DESIGNS.

Except where the standard connection details are furnished, the contractor shall design all connection, supply and fabricate all steelwork and furnish all connection materials in accordance with the approved drawings and/or as instructed by the Engineer keeping in view the maximum utilization of the available sizes and sections of steel materials. The methods of painting, marking, packing and delivery of all fabricated materials shall be in accordance with the provisions of the contract and/or as approved by the Engineer. Provision of all relevant Indian standard Specifications and codes of Practice shall be followed unless otherwise specified in the contract

## 2.5.0 MATERIALS TO BE USED

### 2.5.1 GENERAL

All steel material required for the work will be supplied by the contractor unless otherwise specified elsewhere in the contract. The materials shall be free from all imperfections, mill scales slag intrusions, laminations, pitting, rusts etc. that may

impair their strength, durability and appearance all materials shall be of tested quality only unless otherwise permitted by the Engineer and/ of Consultant. If desired by the Engineer. Test Certificates in respect of each consignment shall be submitted in triplicate. Whenever the materials are required to be used from unidentified stocks. If permitted by the Engineer. A random sample shall be tested at an approved laboratory from each lot of 50 tonnes or less of any particular section.

The arc welding electrodes shall conform to the relevant Indian Standard Codes of Practice and Specifications and shall be of heavily coated type and the thickness of the coating shall be uniform and concentric with each container of electrodes, the manufacturer shall be uniform and concentric with each container of electrodes, the manufacturer shall furnish instructions giving recommended voltages and amperage (polarity in case of D.C supply) for which the electrodes are suitable.

2.5.2 **STEEL**

All steel materials to be used in construction within the purview of this specification shall comply with any of the following Indian Standard Specifications as may be applicable.

1) IS 226 - Structural steel (Standard quality)

2) IS 961 - Structural steel (high Tensile)

3) IS 1977 - Structural steel (Ordinary quality) St-42-0

4) IS 2062 - Structural steel ( Fusion Welding Quality)

In case of imported steel materials being used, these shall conform to specifications equivalent to any of the above as may be applicable.

2.5.3 **Rivet Steel**

All rivets steel used in construction within the purview of this Specification shall comply with one of the following Indian Standard Specifications as may be applicable

1) IS 1148 – Rivet Bars for Structural purpose

IS 1149- High tensile rivet bars for structural for purposes where high tensile steel is specified for rivets, steps shall be taken on ensure that the rivets are so anufactured that they can be driven and heads formed satisfactorily without the physical properties of steel being impaired.

2.5.4 **ELECRODES**

All electrodes to be used the Contract shall comply with any of the following Indian Standard Specifications as may be applicable:-

IS:814: Covered electrodes for metal are welding of structural steel

IS:815: Classification and coding of covered electrodes for metal are welding mild steel and low ally high tensile steel.

IS:1442: Covered electrodes for the metal are welding of high tensile structural steel.

2.5.5 **BOLTS AND NUTS**

All bolts and nuts shall conform to the requirements of Indian Standard Specification IS:1367: Technical supply conditions for threaded fasteners.

Materials for Bolts and nuts under the purview of this contract shall comply with any of the following Indian Standard Specifications as may be applicable.

a) Mild steel all mild steel for bolts and nuts when tested in accordance with the following Indian Standard, Specification shall have a tensile strength of not lees than 44kg/mm$^2$ and a minimum elongation of 23 per cent on a gauge length of 5.6 A, Where A is the cross sectional area of the test specimen:-

   1) IS:1367: Technical supply conditions for threaded fasteners.
   2) IS:1600: Method for tensile testing of steel products other than sheet strip, wire and tube.

b) High Tensile Steel (Structural Quality) The material used for the manufacture of high tensile steel bolts and nuts shall have a minimum tensile strength 58kg/mm$^2$ . Other mechanical properties shall conform to grade HT of IS 961.

c) High Tensile Steel (Special Quality). The material used for the manufacture of special quality high tensile steel bolts and nuts shall have the mechanical properties appropriate to the particular class of steel as set out in IS:1367 or as approved by the Engineer.

2.5.6 **WASHERS**

Washers shall be made of steel conforming to any of the following Indian Standard Specifications as may be applicable under the provisions of the Contract:-

1) IS: 226: Structural steel (Standard Quality)
2) IS:961: Structural Steel (High tensile)
3) IS:1977: Structural steel (Ordinary quality) St-42-0

2.5.7 **PAINTS**

Paints to be used for shop coat of fabricated steel under the purview of this contract shall conform to the Indian to Standard Specifications IS:2074: Ready mixed paint red oxide Zinc chromate painting.

## 2.6.0 STORAGE OF MATERIAL

### 2.6.1 GENERAL

All materials shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged shall be removed from the contractor's yard immediately, failing which, the Engineer shall be at liberty to get the material removed and the cost incurred thereof shall be realised from the Contractor. The Contractor shall maintain up to date accounts in respect of receipt, use and balance of al sizes and sections of steel and other materials. In case the fabrication is carried out in contractor's fabrication shop outside the plant site where other fabrication works are also carried out, all materials meant for use in this contract shall be stacked separately with easily identifiable marks.

### 2.6.2 STEEL

The steel to be used in fabrication and the resulting cut-pieces shall be stored in Separate stacks off the ground section wise and lengthwise so that they can be easily inspected. Measured and accounted for at any time. If required by the Engineer, the materials may have to be stored under cover and suitably painted for protection against weather.

### 2.6.3 ELCTRODES

The electrodes for electric are welding shall be stored in properly designed racks, separating different types of electrodes in distinctly marked compartments. The electrode shall be kept in dry and warm condition if necessary by resorting to heating.

### 2.64 BOLTS, NUTS AND WASHERS

Bolts, nuts and washers and other fastening materials shall be stored on racks of the ground with a coating of suitable protective oil. These, shall be stored in separate gunny bags or compartments according to diameter, length and quality.

### 2.6.4 PAINTS

Paints shall be stored under cover in air tight containers paints supplied in sealed containers shall be used up as possible once the container is opened.

## 2.7.0 QUALITY CONTROL

The Contractor shall establish and minimum quality control procedures for different items of work and materials to the extent the deems necessary to ensure that all work is performed

in accordance with this specification. In addition to the Contractor's quality control procedures, materials and workmanship at all times shall be subjected to inspection by the Engineer or Engineer's representative. As far as possible, all inspection by the engineer or Engineer's representative shall be made at the Contractor shall co-operative with the Engineer or Engineer's representative in permitting access for inspection to all places where work is being done and in providing free of cost all necessary help in respect of tools and plants, instrument, labour and materials required to carry out the inspection. The inspection shall be so scheduled as to provide the minimum interruption to the Contractor.

Materials or workmanship not in reasonable conformance with the provisions of this Specification may be rejected at any time during the progress of the work.

The quality control procedure shall cover but not limited to the following items of works:-

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| 1) Steel | - Quality. manufacturer's test certificates, test reports of representative samples of materials from unidentified stocks if permitted to be used. |
| 2) Rivets, Bolts, Nuts & Washers | - Manufacturer's certificate, dimen sion checks, material testing. |
| 3) Electrodes | - Manufacturer's certificate, thickness and quality of plus coating. |
| 4) Welders | - Quality Tests. |
| 5) Welding sets | - Performance Tests. |
| 6) welds | - Inspection, x-ray. Ultrasonic tests. |
| 7)Paints | - Manufacturer's certificate, physical inspection reports. |
| 8) Galvanizing | - Tests in accordance with IS: 263 Method for testing uniformity of coating of Zinc Coated Articles and IS 4759: Specifications for Hot – Dip Zinc coatings on structural Steel and other Allied products |

2.8.0 **STANDARD DIMENSIONS, FORMS AND WEIGHTS**

The dimensions, forms, weights and tolerances of all rolled shapes rivets, bolts, nuts, studs, washers etc. and other members used in the fabrication of any structure shall, wherever applicable, conform to the requirements of the latest relevant Indian Standards, wherever they exist, or, in the absence of Indian Standards, to other equivalent standards.

2.9.0 **SHOP DRAWINGS**

The contractor shall within 15 days after the award of the Contract submit to the Engineer the Schedule of Fabrication and erection of structural steel work for approval. He shall, within 15 days after the award of the contract start to for approval. The shop drawings based on the Design Drawings furnished to him and, before proceeding with in fabrication work, shall get the said shop drawings approved in accordance with the contract.

The sequence of submission of shop drawings for approval shall match with the approved fabrication and erection schedule. The approval for the shop drawings will be accordance only towards general conformity with the design requirements as well as specifications and will ensure the correctness of general arrangement for centreline dimensions and level, Section sizes, and adequacy of connections including splice joints as to the no. of bolts, welds length, size of gusset/ end plated. The correctness of all other details like cutting lengths, matching of holes, notch dimensions, match markings, bill of materials, bolt list etc. will be entirely the contractor's responsibility. The approval of the drawing however shall not relieve the contractor of his sole responsibility in carrying out the work correctly and fulfilling the complete requirements of contract documents.

The shop drawings shall include but not be limited to the following:-

a) Assembly drawings giving exact sizes of the sections to be used and identification marks of the various sections.
b) Dimensional drawings of base plates, foundation bolt location etc.
c) Comparison sheet to show that the proposed alternative section, if any, are as strong as the original sections shown on the Design Drawings.
d) Complete Bill of Materials and detailed drawings of all sections as also their billing weights.
e) Any other drawings or calculations that may be required for the clarification of the works or substituted parts thereof

The preparation of shop drawings shall not be submitted without prior approval of Engineer. These drawings shall give all the necessary information for the fabrication. Erection and painting of the steelwork in accordance with the provisions of this Specification shop drawings shall be made in accordance with the best modern practice and with due regard to sequence, speed and economy in fabrication and erection. Shop drawings shall give complete information necessary for fabrication of two various components of the steelwork, including the location. Type, sizes and extent of welds. These shall also clearly distinguish between shop and field rivets, bolts and welds and specify the class of bolts and nuts The drawings shall be drawn to a scale large enough to covey all the necessary information adequately. Notes on the shop drawings shall indicate those joints or groups of joints in which it is particularly important that the welding sequence and technique of welding symbols used shall be in accordance with the requirements of the Indian Standard Specification.

IS:813: Scheme of symbols for welding shall be consistent throughout Weld lengths called for on the drawings shall mean the net effective length.

The Contractor shall be responsible for and shall pay for any alterations of the work due to any discrepancies, errors or omissions on the drawings or other particulars supplied by him. Whether such drawings or other particulars have been

duly approved or not in accordance with the Contact, provided that such particulars on the Design furnished to the Contractor. In the Contractor. In the latter case, the Contractor will be paid for any alteration that has to be made after materials have been fabricated by the Contactor.

3.0.0 **WORKMANSHIP**

3.1.0 **FABRICATION**

3.1.1 **GENERAL**

All workmanship shall be equal to the best practice in modern structural shops, and shall conform to the provisions of the Indian Standard IS:800: Code of practice for user of steel tubes in general building construction and other relevant Indian Standards or Equivalent.

3.1.2 **STRAIGHTENING MTERIAL**

Rolled materials before being laid off or worked, must be clean, free from sharp kinks, bends or twists and straight within the tolerances allowed by the Indian Standard Specification IS: 1852: Specification Rolling and cutting tolerance for hot-rolled steel products. If straightening it necessary, it may be done by mechanical means or by the application of limited amount of localized heat. The temperature of heated areas, as measured by approved methods, shall not exceed 600sq.c

3.1.3 **CUTTING**

Cutting shall be effected by shearing. Cropping or sawing use of mechanically controlled gas cutting torch be permitted for mild steel only. Gas cutting of high tensile steel may also be permitted provided special care is taken to leave sufficient metal to be removed by machining, so that all meal that has been hardened by flame is removed. Gas cutting without a mechanically controlled torch may be permitted if special care is taken and done under expert hand, subject to the approval of the Engineer.

To determine the effective size of members cut by gas, 3mm shall be deducted from each cut edge. Gas cut edges, which will be subjected to substantial stress or which are to have weld metal deposited on ‘them, shall be reasonably free from gouges, occasional notches or gauges not more than 4mm deep will be permitted Gouges greater than 4mm, that remain from cutting, shall be removed by girding. All re-entrant corners shall be shaped notch-free to a radius of at least 12mm. Shearing, cropping and gas cutting shall be clean, reasonably squire and free from any distortion.

3.1.4 **PLANNING OF EDGES**

Planning of finishing of sheared or cropped edges of plates or shapes or of edges Gas-cut with a mechanically controlled torch shall not be required, unless specifically required by design and called for on the drawings, included in a stipulation for edge preparation for welding or as may be required after the inspection of the cut surface. Surface

cut with hand-flame shall generally be ground, unless specifically instructed otherwise by the Engineer.

3.1.5 **CLEARNCES**

The erection clearance for cheated ends of members connecting steel to steel shall preferably be not greater than 2mm at each end. The erection clearance at ends of beams without web cleats shall be not more than 3mm at each end, but where, for particular reasons, greater clearance is necessary, suitably designed clearings shall be provided.

3.2.0 **RIVETED AND BOLTED CONSTRUCYION**

3.2.1 **HOLES**

Holes through more than one thickness of material for members, such as compound stanchions and girder flanges. Shall be drilled after the members are assembled and tightly clamped or bolted together punching may be permitted before assembly, if the thickness of the materials is not greater than the nominal diameter of river or bolts plus 3mm subject to a maximum thickness of 16mm provided that the holes are punched 3mm less in diameter than the required size and rammed after assembly to the full diameter.

Holes for rivets or black bolts shall be not more than 1.5mm or 2.0mm (depending on whether the diameter of the rivet or bolt is less or more than or equal to 25mm) Larger in diameter than the nominal diameter of the rivet or black bolt passing through them.

Holes for turned bolts shall be drilled to a diameter equal to the nominal diameter of the shank or barrel subject top a tolerance grade of HB as specified in IS:919. Parts to be connected shall be firmly held together by tacking welds or clamps and the holes drilled through all the thickness in one operation and subsequently reamed to size. Holes not drilled through all thickness in one operation shall be drilled to a smaller size and reamed out after assembly.

Holes for rivets or bolts shall not be formed by gas cutting process.

3.2.2 **ASSEMBLY**

All parts of riveted member shall be well pinned or bolted and rigidly held together while riveting drafting to enlarge unmatching holes shall not generally be permitted. In case drafting is permitted to a slight extent during assembly it shall not distort the metal on enlarge the holes. Holes that must be enlarged to admit the rivets or bolts shall be to assembled that they are neither twisted not otherwise damaged, and shall be so prepared that the specified cambers, if any, are maintained.

Rivets shall ordinarily be hot driven, in which case their finished heads shall be approximately hemispherical in shape and shall be or uniform size throughout the work for rivets of the same size full, neatly finished and concentric with the holes. Rivets shall be heated uniformly to a temperature not exceeding the holes. Rivets shall be heated uniformly

to a temperature not exceeding $1065^0$C. They shall not be driven after their temperature has fallen below $540^0$C.

Rivets shall be driven by power riveters, of either compression or manually operated type, employing pneumatic, hydraulic or electric power Hand driven rivets shall not be allowed unless in exceptional cases specially approved by the Engineer. After driving, rivets shall be tight, shall, completely fill the holes and their heads shall be in full contact with the surface. In case of countersunk rivets, the countersinking shall be fully filled by the rivets any proud ness of the countersunk head being dressed off flush, if required.

Rivets member shall have all parts firmly drawn and held together before and during riveting and special care shall be taken in this respect for all single riveted connections. For multiple riveted connections, a service bolts shall be provided in every third or fourth hole.

All loose, burnt or otherwise defective rivets shall be cut out and replaced and special care shall be taken to inspect all single riveted connections. Special care shall also be taken in heating and driving long rivets the Contractor shall prove the quality of riveting by cutting some rivets chosen at random by the Engineer. No extra payment will be made to the Contractor for such cutting and replacing to the extent of ten sound rivet per five hundred done Riveting work, for any particular section or group, will be considered satisfactory when at least 90% of the corresponding cut rivets are found to be sound. If the ratio is below 75%, all the rivets in the particulars section or group shall be cut, removed and replaced and tested again at the Contractor's expense. For cases between 75% and 905 the Engineer shall have the option to instruct cutting and replacing any number of further rivets at the Contractor's cosy as he deems necessary.

Bolted construction shall be permitted only in case of field connections if called for on the Drawings and is subjected to the limitation of particular connections as may be specified. In special cases, however, shop bolt connections may be allowed if directed by the Engineer.

Washers shall be tapered or otherwise suitably shaped, where necessary, to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project out through the nut at least one thread. In all cases the bolt shall be provided with a washer of sufficient thickness under the nut to avoid any threaded portion of the bolts being within the thickness of the parts bolted together. In addition to the normal washer one spring washer or lock-nut shall be provided for each bolt for connections subjected to vibrating forces or otherwise forces or otherwise as many by specified on the Drawings.

## 3.3.0 WELDED CONSTRUCTION

### 3.3.1 GENERAL

Welding shall be in accordance with relevant Indian Standards and as supplemented in the Specification. Welding shall be done by experienced and good welders who have been qualified by tests in accordance with IS:817.

3.3.2 **PREPARATION OF MATERIAL**

Surface to be welded shall be free from loose scale, slag, rust, grease, paint and any other foreign material except that mill scale which withstands vigorous wire brushing may remain. Joint surface shall be free from fine and tears. Preparation of edges by gas-cutting shall, wherever practicable, be done by a mechanically guided torch.

3.3.3 **ASSEMBLING**

Parts to be fillet welded shall be brought in close contact as practicable and in no event shall be separated by more than 4mm. If the separation is 1.5mm or greater, the size of the filet welds shall be increased by the amount of the fillet welds shall be increased by the amount of the separation. The fit at joints at contact surfaces which are not completely sealed by welds, shall be close enough to exclude water after painting.

Abutting parts to be butt-welded shall be carefully aligned Misalignments greater than 3mm shall be corrected and in making the correction the parts shall not be drawn into a sharper slope than two degrees ($2^0$)

The work shall be positioned for that welding whenever practicable.

3.3.4 **WELDING SEQUENCE**

In assembling and jointing parts of a structure of built-up members, the procedure and sequence of welding shall be as will avoid needless distortion and minimize shrinkage stresses. Where it is impossible to avoid high residual stresses in the closing welds of welds of a rigid assembly, such closing welds shall be made in compression elements.

In the fabrication of cover-plated be beams and built-up members, all shop splices in each component part shall be made before such component part is welded to other parts of the member. Long girders or girder sections may be made by shop splicing not more than three sub-sections, each made in accordance with this paragraph.

When required by the Engineer, welded assembles shall be stress relieved by heat treating in accordance with the provisions of the relevant Indian Standard or any other Standard approved by the Engineer.

3.5.5 **WELDING TECHNIQUE**

All complete penetration groove welds made by manual welding, except when produced with the aid of backing materials not more than 8mm thick with root opening not less than shall have the root of the initial layer gouged out on the back side before welding is started from that side, and shall be so welded as to secure sound metal and, complete fusion throughout the entire cross-section. Groove welds made with the use of the backing of the same material as the base metal shall have the weld metal thoroughly fused with the backing

material. Backing strips need not removed. If required, they maybe removed by gouging or gas cutting after welding is completed, provided no injury is done to the base metal and weld metal and the weld metal surface is left flush or slightly convex with full throat thickness

Groove welds shall be terminated at the ends of a joint in a manner that will ensure their soundness. Where possible, that should be done by use of extension bars or run-off plates. Extension bars of run-off plates need not be removed upon completion of the weld unless otherwise specified elsewhere in the Contract.

To get the best and consistent quality of welding, automatic submerged are process shall be preferred. The technique of welding employed, the appearance and quality of welds made, and the methods of correcting defective work shall all conform to relevant Indian Standards.

**3.3.6 TEMPERATURE**

No welding shall normally be done on parent material at temperature below (-) $5^0$ C. However, if welding is to be undertaken at low temperature, adequate precautions as recommended in relevant Indian Standard shall be taken. When the parent material is less than 40mm thick and the temperature is between (-) $5^0$ C. and $0^0$ C, the surface around the joint to a distance of 100mm or 4 times the thickness of the material, whichever is greater, shall be preheated till it is hand warm. When the parent material is more than 40mm thick, the temperature of the area mentioned above shall be in no case be less than $20^0$ C. all requirements regarding preheating of the parent material shall be in accordance with the relevant Indian Standard.

**3.3.7 PEENING**

Where required, intermediate layers of multiple-layer welds may be peened with light blows from a power hammer, using a round-nose tool. Peening shall be done after the welds has cooled to a temperature warm to the hand Care shall be exercised to prevent sealing or flaking of weld and base metal from over peening.

3.3.8 **EQUIPMENT**

There shall be capable of producing proper current so that the operator produce satisfactory welds. The welding machine shall be of a type and capacity as recommended by the manufactures of electrodes or as may be approved by the Engineer.

3.4.0 **FINISH**

Column splices and butt joint compression members deepening on contact for stress transmission shall be accurately machined and close-butted over the whole section with a clearance not exceeding 0.1 mm locally at any place. In column caps and bases, the ends of shafts together with the attached gussets angles, channels etc, after welding/riveting together, should be accurately machined so that the parts connects butt over the entire surface of contact, Care should be taken that those connecting angles on channels are fixed with such accuracy that they are reduced in thickness by machining by more than 1.0mm.

3.5.0 **SLAB BASES AND CAPS**

Bases and caps fabricated out of steel slabs, except when cut from material with true surface, shall be accurately machined over the bearing surface and shall be in effective contact with the end of the stanchion. A bearing face which is to be grouted direct to a foundation need be machined if such face is true and parallel to the upper face.

3.6.0 **LACING BARS**

The ends of lacing bars shall be neat and free from burns.

3.7.0 **SEPARATORS**

Rolled section or built-up steel separated or diaphragms shall be required for all double beams except where encased in concrete, in which case, pipe separators shall be used.

3.8.0 **BEARING PLATES**

Provision shall be made for all necessary, steel bearing plates to taken up reaction of beams and columns and the required stiffeners and gussets whether or not specified in Drawings.

3.9.0 **ARCHITECTURAL CLEARANCES**

Bearing plates and stiffener connections shall not be permitted to encroach the designed architectural clearances.

3.10.0 **SHOP COMMUNICATIONS**

a) All shop connections shall be either riveted or welded at specified on the Drawings

b) Heads of rivets on surfaces carrying brick walls shall be flattened 10mm thick projection.

c) Certain connections, specified to be shop connections, may be changed to field connections if desired by the Engineer for convenience of erection and Contractor will have to make the desired changes at no extra cost to the Owner.

3.11.0 **CASTINGS**

Steel castings shall be annealed

3.12.0 **SHOP ERECTION**

The steelwork shall be temporarily shop-erected complete or as directed by the Engineer so that accuracy of fit may be checked before despatch. The parts shall be shop-erected with a sufficient member of parallel drifts to bring and keep the parts in place in case of parts

drilled or punched using steel jigs to make all interchangeable, the steelwork shall be shop erected in will facilitate the check of interchange ability

3.13.0 **SHOP PAINTING**

3.13.1 **GENERAL**

Unless otherwise specified, steelwork which will be concealed by interior building finish need not be painted, steelwork to be uncared in concrete shall not be painted. Unless specifically exempted, all other steelwork shall be given one coat of shop paint, applied thoroughly and evenly to dry substances which have been cleaned, in accordance with the following paragraph, by brush, spotty, roller coating, flow-coating or dripping as may be approved by the Engineer.

After inspection and approved and before leaving the shop, all steel work specified to be painted shall be cleaned by hand-wire brushing or by other method of loose mill scale loose rust, weld slag or flux deposit, dirt and other foreign matter. Oil and grease deposits shall be removed by solvent. Steelwork specified to have no shop paint shall, after fabrication, be cleaned of oil of grease by solvent cleaners and be cleaned of dirt and other foreign material by through sweeping with a fibre brush.

3.13.2 **INACCESSIBLE PARTS**

Surface not in contact, but inaccessible after assembly, shall receive two coats of shop paint, positively of different colours to prove application of two coats before assembly. This does not apply to the interior of sealed hollow sections.

3.13.3 **CONTACT SURFACES**

Contact surface shall be cleaned in accordance with Sub-clause 3.13.1 before assembly.

3.13.4 **FINISHED SURFACES**

Machine finished surface shall be protected against corrosion by a rust inhibiting coating that can be easily removed prior to erection or which has characteristics that make removal unnecessary prior to erection.

3.13.5 **SURFACES ADJACENT TO FIELD WELDS**:

Unless otherwise provided for surfaces within 50 mm of any field weld location shall be Free of materials that would prevent proper welding or produce objectionable fumes while welding is being done.

3.14.0 **GALVANIZING**

3.14.1 **GENERAL**

Structural steelwork for switchyard or other structures as may be specified in the Contract shall be not dip galvanized in accordance with the American Society for Testing and Materials Specification ASTH-A 123 or IS:2629: Recommended practice for Hot – Dip Galvanising of Iron and Steel. Where the steel structures are required to be galvanized the field connection materials like bolts, nuts and washers hall also be galvanized.

3.14.2 **SURFACE PREPARATION**

All members to be galvanized shall be cleaned, by the process of picking of rust, loose scale, dirt, oil, grease, slag and spatter of welded areas and other foreign substances prior to galvanizing pickling shall be carried out by immersing the steel in an acid bath containing either sulphuric or hydrochloric acid at a suitable concentration and temperature. The concentration of the acid and the temperature of the bath can be varied, provided that the pickling time is adjusted accordingly.

The pickling process shall be completed by thoroughly rising with water, which should preferably be warm, sop as to remove the residual acid.

3.14.3 **PROCEDURE**

Galvanizing shall be carried out by hot dip process in a proper and uniformly heated bath. It shall meet all the requirements when tested in accordance with
IS:2633: Method for testing uniformly of coating on Zinc Coated Articles and
IS:4759: Specifications for Hot – Dip Zinc coatings on structural Steel and other Allied products.

After finishing the threads of bolts, galvanizing shall be applied over the entire surface uniformly. The threads of bolts shall not be machined after galvanizing and shall not be clogged with zinc. The threads of nuts may be tapped after galvanizing but care shall be taken to use oil in the threads of nuts during erection.

The surface preparation for galvanizing and process of galvanizing itself, shall not adversely affect the mechanical properties of the materials to be galvanized where members are of such lengths as to prevent complete dipping in one operation, great care shall be taken to prevent warping.

Materials on which galvanizing has been damaged shall be acid stripped and re-galvanized unless otherwise directed, but if any member becomes damaged after having been dipped twice, it shall be rejected. Special care shall be taken not to injure the skin on galvanized surface during transport, handling and erection. Damages, if occur, shall be made good in accordance with the provision or as directed by the Engineer.

4.0.0 **INSPECTION TESTING, ACCEPTANCE CRITERIA**

**4.1.0 Inspection**

Unless specified otherwise, inspection to all work shall be made by the Engineer or Engineer's representative at the place of manufacture prior to delivery . The Engineer or his representative shall have free access at all responsible times to those parts of the manufacturer's works which are concerned with the fabrication of the steel work under this contract and he shall be afford al responsible facilities for satisfying himself that the fabrication if being done in according with the provisions, of this specification.

The contractor shall provide free of charge, such labour, materials, electricity, fuel, water, stores, tools and paint, apparatus and instruments as may be required by the engineer to carry out inspection and/or tests in accordance with the contract.

The contractor shall guarantee compliance with the provisions of this specification.

**4.2.0 TESTING AND ACCEPTANCE CRITERIA**

**4.2.1 General**

The contractor shall carry out sampling and testing in accordance with the relevant Indian standards and as supplemented here in for the following items at his own cost, unless otherwise specified in the contract. The contractor shall get the specimens tested in a laboratory approved by the engineer and submit to the engineer the test results in triplicate within 3 (three) days after completion of the test.

**4.2.2 Steel**

All steel supplied by the contractor shall conform to the relevant Indian standards except otherwise mentioned in the contract, only tested quality steel having mill test reports shall be used. In case unidentified steel materials are permitted to be used by the engineer, random samples of materials will be taken from each unidentified lot of 50 MT or less of any particular section for tests to confirm to relevant Indian standards. Cost of all tests shall be borne by the contractor.

All materials shall be free from all imperfections, mill scales, slag intrusions, laminations, pittings, rusts etc. That may impair their strength, durability and appearance.

**4.2.3 Welding**

All electrodes shall be procure from reliable manufacturers with test certificates.
The correct grade and size of electrode which has not deteriorated in storage shall be used. The inspection and testing of welding shall be performed in accordance with the provisions of the relevant Indian standards or other equivalents. For every 50 tonnes of welded fabrication , the engineer may ask for 1 (one) test-destructive or non- destructive including X-ray, ultrasonic test or similar., the cost of which shall be borne by the contractor in the event of further tests as may be desired by the engineer, the cost of such tests shall be borne by the contractor if the results are found to be unsatisfactory; and if the test shows no defect, the cost shall be borne by the owner. In cases of the test results showing deficiency,

the engineer shall have option to reject or instruct any remedial measures to be taken free of charge to the owner.

**4.2.4 RIVETS, BOLTS, NUTS AND WASHERS**

All rivets, bolts, nuts and washers shall be produced from M/s Guest Keen Williams ltd, or equivalent and shall conform to the the relevant Indian Standards. If desired by the Engineer, representative samples of these materials may have to be tested in an approved laboratory and in accordance with the procedures described in relevant Indian Standards. Cost of all such testing shall have to be borne by the Contractor. In addition to testing the rivets by hammer, 2% (two percent) of the rivets done shall be cut off by chisels to ascertain the fit. Quality of material and workmanship. The removal of the cut rivets and reinstallation new rivets shall be done by the Contractor at his own cost.

**4.2.5 SHOP PAINTING**

All paints and primers shall be of standard quality and produced from approved manufactures and shall conform to the provisions of the relevant Indian Standards.

4.2.6 **GALVANIZING**

All galvanizing shall be uniform and of standard quality when tested in accordance with IS:2633: Method for testing uniformly of coating on Zinc Coated Articles and IS:4759: Specifications for Hot – Dip Zinc coatings on structural Steel and other Allied products.

4.3.0 **TOLERANCE**

The tolerance on the dimensions of individual rolled steel components shall be as specified in IS: 1852: Rolling and cutting tolerance for hot-rolled steel products. The tolerance on straightness, length etc. of various fabricated components (such as beams and girders, columns, crane gantry girder etc.) of the steel structures shall be as specified in IS 7215: Tolerance for fabrication of steel structures.

4.4.0 **ACCEPTANCE**

Should any structure or part of a structure be found not to comply with any of the provisions of this Specification, the same shall be liable to rejection. No structure or part of the structure, once rejected, shall be offered again for test, except in cases where the Engineer considers the defects rectifiable. The Engineer may, at his discretion, check the test results obtained at the Contractor's works by independent tests at an approved laboratory and should the items, so tested, be found to be unsatisfactory, the costs shall be borne by the Contractor, and if satisfactory, the costs shall be borne by the Owner.

When all tests to be performed in the Contractor's shop under the terms of this contract have been successfully carried out, the steelwork will accepted forthwith and the Engineer will issue an acceptance certificate, upon receipt of which, the

items will be shop painted, picked and despatched. No item to be delivered unless an acceptance certificate for the same has been issued. The satisfactory completion of these tests or the issue of the certificates shall not bind the Owner to accept the work., should it, on further tests before or after erection, be found not in compliance with the Contract.

## 4.5.0 DELIVERY OF MATERIALS

### 4.5.1 GENERAL

The Contractor will deliver the fabricated structural steel materials to site with all necessary field connection materials in such sequence as will permit the most efficient and economical performance of the erection work. The Owner may prescribe or control the sequence of delivery of materials, at his own discretion.

### 4.5.2 MARKING

Each separate piece of fabricated steel work shall be distinctly marked on all surface before delivery in accordance with the markings shown on approved erection drawings and shall bear such other marks as will further facilitate identification and erection.

### 4.5.3 SHIPPING

Shipping shall be strictly in accordance with the sequence stipulated in the agreed programme. Payment may held up for items sent in advance of the sequence till they could be erected. The contractor shall include and provide for in his rates, the Freight and other charges for despatching the materials to avoid loss or damage during transport by rail, road or water. All packing shall allow for easy removal and checking at site. Special precautions shall be taken against rusting, corrosion, breakage or damage otherwise of the materials. All parts shall be adequately braced to prevent damage in transit.

Each bundle, bale or package delivered under this contract shall be marked on as many sides as possible and distinct marking (all previous irrelevant markings being carefully obliterated)shall show the following:-

a) Name and address of the consignee

b) Name and address of the consignor

c) Gross weight of the package in tonnes and its dimensions

d) Identification marks and / or number of the package

e) Custom registration number, if required

All markings shall be carried out with such materials as would ensure quick drying and indelibility.

Each component or part or piece of material when shipped, shall be indelibly marked and/or tagged with reference to assembly drawings and corresponding piece numbers.

Each packing case shall contain in duplicate in English a packing list pasted on to inside of the cover in water-proof envelope, quoting especially:-

a) Name of the Contractor

b) Number and date of the Contract

c) Name of the office placing the contact

d) Nomenclature of stores

e) A schedule of parts or pieces, giving the parts or piece number with reference to assembly drawing and the quantity of each

The shipping dimensions of each package shall not exceed the maximum dimensions permissible for transport over the Indian Railways/ Roads.

After delivery of the materials at site, all packing materials shall automatically become the property of the Owner without any extra payment.

Not withstanding anything stated hereinbefore, any loss or damage resulting from inadequate packing shall be made good by the Contractor at no additional cost to the Owner. When facilities exist, all shipments shall be covered by approved Insurance Policy for transits at the cost of the Contractor.

The contractor shall ship the complete materials or part on board a vessel belonging to an agency approved by the Owner or on rail and / or road transport
As directed. The Contractor shall take all reasonable steps to ensure correct appraisal of freight rates, weights and volumes and in no volumes and in no case will the Owner be liable to pay any warehouse, wharf age, demurrage and other charges.

If, however, the Owner has to make payment of any of above mentioned charges, the amount paid will be deducted from the progressive bills of the Contractor.

Necessary advise regarding the shipment with relevant details shall reach the Engineer at least a week in advance.

5.0.0 **WITH TENDER**

The following information are required to be submitted with the Tender.

a) Progress Schedule.

The Contractor shall quote in his tender a detailed schedule of progress of work and total time of completion, itemising the time required for each of the following aspects of work.

1) Preparation and approval of shop drawings

2) Procurement of materials

3) Fabrication and shipping of all anchor bolts

4) Fabrication and shipping of main steel work

5) Fabrication and shipping of main steel work for bunkers Tanks and / or silos as applicable.

6) Fabrication and shipping of all other remaining steelwork including miscellaneous steelwork.

7) Final date of completion of all shipments

Time required for completion being one of the main criteria for selecting the successful bidder, it is desired that the bidder quotes the minimum time required by him for completing the work

b) Shop

Location of the Tender's fabrication workshop giving details of equipment, manpower, the total capacity that will be available exclusively for this contract shall be submitted.

c) **MATCHING STEEL**

A rough indication fop the quantities and details of matching steel section required to start the work shall be furnished.

d) **TRANSPORT OF STEEL**

In case the tendered is to draw steel materials from the Owner's stores at site as per terms and conditions of the Contract, the mode of transport proposed by the Tender shall be stated.

5.1.0 **AFTER AWARD**

After award of the Contract the successful Tender is to submit the following:-

a) Complete fabrication drawings, material lists, cutting lists, rivet and bolt lists, field welding schedules based on the design drawings furnished to him in accordance with the approved schedule.

b) List of phase wise requirement of matching steel section in six (6) copies in accordance with the approved schedule shall be submitted within 2(two) weeks after the award of the contract, and/or receipt of the design drawings

c) Monthly progress Report with necessary, photographs in six (5) coppice to reach the Engineer on or before the 7th day of each month, giving the up to date status of preparation of detailed shop drawings bill of materials. Procurement of materials, actual fabrication done, shipping and all other relevant information.

d) Detailed monthly material reconciliation statements relevant to the work done and reported in the progress report, giving the stock at the hand of raw steel, work in progress, finished materials and scrap.

e) Results of any test and when conducted and as required by the Engineer.

f) Manufacturer's mill test report in respect of steel materials, rivets, bolts, nuts and electrodes as may be applicable.

## 6.0.0 ADDOTIONAL CODES AND STANDARD

| | |
|---|---|
| IS:823 | Code of Procedure for manual Metal ARC welding of Mild Steel |
| IS:1024 | Code of practice for the use of welding in Bridges and Structures subjected to Dynamic loading |
| IS:1365 | Slotted counter sunk Head and slotted Raised counter sunk Head Screw (dia 1.6 to 20mm) |
| IS:1447 | Code of practice for Finishing of Ferrous Metals in Buildings Painting and Allied finisher |
| IS:2016 | Plain Washers |
| IS:3664 | Code of practice for Ultrasonic Testing by Pulse Echo Method |
| IS:5334 | Code of practice for Magnetic particle Flow detection of Welds. |
| IS:7318 | Approval Test for Welds when welding procedure Approval is not Required |
| IS:7318 | Fusion welding of Steel (part I) |

## METHOD AND BASIS FOR PAYMENT FOR FABRICATION & ERECTION OF STRUCURAL STEEL.

1) Payment for structural steel works shall be made on the basis of admissible weight in tons (determined as described in clause between of structure accepted by the Engineer-in-charge. The rate shall include supplying, fabrication, erecting in position ( at al level & location), testing/examining (excluding radiography only) of bolted and/or welded structural steel works of all types(including all built up/compound sections made out of rolled sections and/or plates) including all handling, transporting, storing, straightening if required, cutting, edge preparation, preheating, bolting and welding),of joints (including sealing the joints of ox sections with continuous welding), finishing edges by grinding, fixing in line & level with temporary staging & bracing and removal of the same erection, grouting with ordinary/non-shrink grout as specified, including preparation of fabrication & erection drawings, erection schedule and getting them reviewed, preparing the surfaces for painting, surface cleaning, wire brushing, removal or mill scale, dust, rust, oil or grease and applying one coat of red oxide zinc chromate primer after fabrication etc. all complete as specified.

2) The weight for payment shall be determined from the fabrication drawings and respective Bill of materials prepared by the contractor wherever applicable. In case sections used are different from IS sections, then Manufactures Hand Book shall be adopted No allowance in weight shall be made for rolling tolerances.

3) Welds, bolts, nuts, washers, shims, pack plates, wedges and grout shall not be measured. The quoted rate shall be deemed to include the same.

IS:816: Code of practice for use of metal are welding for general construction in mild steel

IS:817 : Code of practice for training and testing metal are welders.

IS:818: Code of practice for safety, and health requirements in electric and gas welding and cutting operations.

IS:822: Code of practice for inspection of welds.

IS:9595: Recommendations for metal are welding of carbon and carbon manganese steel:

IS:919: Recommendations for limits and fits for Engineer.

IS:961: Structural Steel (High tensile)

IS:1148: Rivets bars for structural purposes.

IS:1149: High tensile rivets bars for structural purposes

IS:1161: Steel Tubes for structural purposes

IS:1200: Method of measurement of steelwork and ironwork (Part-B)

IS:1239: Mild Steel Tubes

IS:1363: Black hexagon bolts, nuts and lock nuts (dia. 6 to 30mm) and black hexagon screws (dia 6 to 24mm)

IS:1367: Technical supply conditions for threaded fasteners

IS:1442: Covered electrodes for the metal are welding of high tensile structural steel.

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# ERECTION OF STRUCTURAL STEEL WORK

| REV. NO. | PRAPARED | APPROVED | DATE |
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1.0.0 **SCOPE**

This specification covers the erection of structural steelwork including receiving and taking delivery of fabricated structural steel materials arriving at Site, and/or from Owner's Site stores and store Yard. Installing the same in position, painting and grouting the stanchion bases all-complete as per drawings, this Specification and provision of the Contract.

2.0.0 **GENERAL**

2.1.0 Work to be provided for by the Contractor

The work to be provided for by the Contractor, unless otherwise specified in the Contact, shall include but not be limited to the following:-

a) The Contractor shall provide all construction and transport equipment, tools, tackle, consumables, materials, labour and supervision required for the erection of the structural steelwork.

b) Receiving, unloading, checking and moving to storage yard at site including prompt attendance to all insurance matter as necessary, for all fabricated steel materials arriving at site. The Contractor shall pay all demurrage and/ at Wharf age charges etc. on account of default on his part.

c) Transportation of all fabricated structural steel materials Site storage yard, handling, rigging, assembling, riveting, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location according to approved erection drawings and/or as directed by the Engineer. If necessary suitable temporary approach roads transportation of fabricated steel structures.

d) Checking centre lines, levels of all foundation blocks including checking line, level, position and plumb of all bolts and pockets. Any defect observed in the foundation shall be brought to the notice of the Engineer. The Contractor shall fully satisfy himself regarding the correctness of the foundations before installing the fabricated steel structures on the foundation blocks.

e) Aligning, plumbing, levelling, riveting, bolting, welding and securely fixing the fabricated steel structures in accordance with the Drawings or as directed by the Engineer.

f) Painting of erected steel structures if required by the Contract.

g) All minor modifications of the fabrications of the fabricated steel structures as directed by the Engineer including but not limited to the following:-

1) Removal of bends, kinks, twists etc. for parts damaged during transport and Handling.

2) Cutting, chipping, filling, grinding etc. if required for preparation and Finishing of site connections.

3) Reaming of holes for use of higher size rivet or built if required.

4) Welding of connections in place of riveting or bolting for which holes are

Either not drilled at all or wrongly drilled during fabrication. Welding in place of riveting or bolting will be permitted only the discretion of the Engineer.

5) Refabrication of parts damaged beyond repair during transport and Handling of Refabrication of parts, which are incorrectly fabricated.

6) Fabrication of parts omitted during fabrication by error, or subsequently Found necessary.

7) Drilling of holes which are either not drilled at all or are drilled in incorrect location during fabrication.

8) Carry out tests in accordance with this Specification if directed.

2.2.0 **WORK BY OTHERS**

No work under this specification will be provided for by any agency other than the contractor unless specifically mentioned elsewhere in the contract

2.3.0. CODES **AND STANDARDS**:

All work this specification unless specified otherwise, conform to the latest revisions and/or replacements of the following or any other Indian Standard Specification and codes of practice of equivalent:-

IS – 800: Code of practice for use of structural steel in general building construction.

IS - 456: Code of practice for plain or reinforced concrete.

2.4.0 **CONFORMITY WITH DESIGNS**

The Contractor will erect the entire fabricated steel fabricated steel structure, align the all members, complete all field connections and group the foundations all as per the provisions of this specification and sequence and the design criteria laid down by the Engineer. All work shall conform to the provisions of the relevant Indian Standard Specifications and/ or the instructions the engineer. The testing and acceptance of the erected structures shall be in accordance. The testing and acceptance of the erected structures shall be in accordance with the provisions of this Specification and / or the Instruction of the Engineer.

2.5.0 **MATERIAL**

2.5.1 **GENERAL**

All fabricated steel structures and connection materials shall be supplied by the Contractor for fabrication work through the Owner. The Contractor for erection work will take delivery of all the materials from the Owner’s Stores or storage yard at sire. The Contractor may also have to take delivery directly from railway wagons or trucks at Site, in which case he shall

have to unload the materials and perform all formalities like checking of materials and attend to insurance matters in accordance with Sub-Clause 2.1.0 and as specified hereinbefore.

While taking delivery, the Contractor will check the quantity, quality and the sizes of the materials and verify the adequacy of the same in accordance with the Drawings and Specifications. In case the Contractor finds any materials inadequate, he shall inform the Engineer immediately prior to taking delivery of the same. No claim whatsoever, in respect of bad quality, shortage or difference in size will be entertained once the delivery is taken and the Contractor shall make good any such deficiency, if detected later, either by repair or with fresh material as be directed, by the Engineer at the Contractor's Own cost.

Excepting all field connection materials like rivets, bolts, nuts, washers and electrodes, which will be supplied by the fabrication Contractor to the extent of 10% in excess of the estimated requirements as per Drawings, all other consumables like Oxygen and acetylene gas, paints, fuels, lubricants, oil, grease, cement, sand, aggregates and any other materials that may be required for the execution of the works in accordance with the contract will be supplied by the contractor for erection work and will be deemed to have been including in this rates.

2.5.2 **MATERIALS TO CONFORM TO INDIAN STANDARDS**

All materials required to the supplied by the Contractor under this Contract shall conform to the relevant Indian Standard Specifications.

2.6.0 **STORAGE OF MATERIALS**

2.6.1 **GENERAL**

All material shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for use in the works. Any material which has been deteriorated or damaged beyond repairs and has become unfit for use be removed immediately from the site, failing which, the Engineer shall be at liberty to get the materials removed by agency and the cost incurred thereof shall be realised from the Contractor's dues.

2.6.2 **YARD**

The Contractor will have to be establishing a suitable yard in the approved location at site for storing the fabricated steel structures and other materials will be delivered to him by the Owner recording to the Contract. The yard shall have proper facilities like, drainage, lighting, suitable access for large cranes, trailers and other heavy equipment and shall be of sufficiently large area to permit systematic storage of the fabricated steel structures without overcrowding and with suitable access for cranes, trailers and other equipment for use in erection work in proper sequence in accordance with the approved programme of work.

The Tender should visit the site prior to submission of his Tender to acquaint himself with the availability of land and the development necessary by way of filling, drainage, access roads, fences, sheds etc. all of which shall be carried out by the Contractor at his own cost as directed by the Engineer.

2.6.3 **COVERED STORE**

All field connection materials, paints, cement etc. shall be stored on well designed racks and platforms off the ground in the ground in a property covered store building to be built at the cost of the Contractor.

**2.2.0 QUALITY CONTROL**

The Contractor shall establish and maintain quality control procedures for different items of work and materials as may be directed by the Engineer to assure compliance with the provisions of the Contract and shall submit the record of the same to the Engineer. The quality control operation shall include but not be limited to the following items of work:-

1) Erection: Lines, levels, grades, plumbs, joint characteristics including Tightness of bolts.
2) Grouting: Cleaning and roughness of foundation, quality of materials used for grouting, administers, consistency and strength of grout.
3) Painting: Preparation of surface for painting, quality of primers and paints, thinners, application and uniformity of coats.

2.2.0 **TAKING DELIVERY**

The erection Contractor shall take delivery of fabricated structural steel and necessary connection materials supplied by the Fabrication Contractor from railhead, trucks and/or the Owner's stores at site as may be necessary and as directed by the Engineer. He shall check, unload; transport the materials to his stores for proper storing at his own cost. The erection Contractor shall submit claims to insurance or other authorities and pursue the same in case of loss or damaged during transit and handling and all loss there of shall be borne by him.

The erection contractor shall also take all precautions against damage of the materials in his custody after taking delivery and till the same are erected in place and accepted. The Contractor shall salvage, collect and deliver all the packing materials to the Owner free of charge.

3.0.0 **WORKMANSHIP**

3.1.0 **ERECTION**

3.1.1 **PLANT AND EQUIPMENT**

The suitability and adequacy of all erection tool s and equipment proposed to used shall be efficient, dependable, in good working condition and shall have the approval of Engineer.

3.1.2 **METHOD AND SEQUENCE OF ERECTION**

The method and sequence of erection shall have the prior approval of the Engineer. The Erection shall arrange for most economical method and sequence available to him consistent with the Drawings and Specifications and such information as may be furnished to him prior to the execution of the contract.

3.1.3 **TEMPORARY BRACING**

Unless adequate bracing is included as a part of the permanent framing, the erector during erection shall install, free of cost to the owner, temporary guys and bracings
Where needed to secure the framing against loads such as wind or seismic forces comparable in intensity to that for which the structure has been designed, acting upon exposed framing as well loads due to erection equipment and erection operations.

If additional temporary guys are required to resist or seismic forces acting upon components of the finished structure installed by others during the course of the erection of the steel framing, arrangement for their installation by the erecter shall be made free of cost to the owner.

The responsibility of the contractor in respect of temporary bracings and guys shall cease when the structural steel is once located, plumbed, levelled, aligned and grouted within the tolerances permitted under the specification and guyed and braced to the satisfaction of the Engineer.

The temporary guys, braces, false work and cribbing shall not be the property of the Owner and they maybe removed immediately upon completion of the steel erection unless other agreed arrangements are made. The Owner shall remove and return the same in good condition to the Contractor without any charge if they have been left in place under such other agreed arrangements.

3.1.4 **TEMPORARY FLOORS FOR BUILDINGS**

It shall be the responsibility of the Contractor to provide free of cost planking and to cover such floors during the work in progress as may be required by any Act of parliament and/or by laws of state, Municipal or other local authorities.

3.1.5 **SETTING OUT**

Positioning and levelling of all steelwork, plumbing of stanchions and placing of every part of the structure with accuracy shall be in accordance with the approved Drawings and to the satisfaction of the Engineer. Concrete foundations, where required, shall be made by other agencies. The Contractor shall check the positions and levels of the anchor bolts, etc. before concreting and get them properly secured against disturbance during pouring operations. He shall remain responsible for correct positioning. For heavy columns, etc. the Contractor shall set proper screed bars if desired by the Engineer, to maintain proper level. No extra payment shall be made for this. Each tire of column shall be plumbed and maintained in a true vertical position subject to the limits of tolerance allowable under this Specification.

No permanent field connections by riveting bolting or welding shall be carried out until proper alignment and plumbing has been attained.

**3.1.6 Filed riveting**

All riveting shall be heated and driven with pneumatic tools. Hand passing or ‘throwing’ of rivets are desirable. Any other method of conveying hot rivets from the furnace to the driving

point must be approved by the engineer. No cold rivets shall be driven. All other requirements of reverting including quality and acceptance criteria shall be in accordance with the relevant portions of the Specification for Fabrication of Structural Steel work of the project.

### 3.1.7 Field bolting

All relevant portions in respect of bolted construction of the Specification for Fabrication of structural Steelwork applicable the Project shall also be applicable for filed bolting in addition to the following: -

Bolts shall be inserted in such a way so that they may remain in position under gravity even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled, all joint surfaces, including those adjacent to the washers shall be free of scale except tight mill scale. They shall be free of dirt, loose scales, burns, and other defects that would prevent solid seating of the parts. Contact surfaces within friction-type joints shall be free of oil, paint, lacquer, or galvanizing.

All high tensile bolts shall be tightened to provide, when all fasteners in the joint are tight, the required minimum bolt tension by any of the following methods.

a) Turn-of-nut-method

When the turn-of-nut method is used to provide the bolt tension, there shall first be enough bolts brought to a 'snug tight' condition to ensure that the parts of the joint are brought into good contract with each other. 'Snug tight' is defined as the tightness attained by a few impacts of an impact wrench or the full effort of man using an ordinary spud wrench. Following this initial operation, bolts shall be placed in any remaining holes in the applicable amount of nut rotation specified in table-1 with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation there shall be no rotation of part not turned by the wrench.

**TABLE-1**

| Bolts length not | Bolts length | Remarks |
|---|---|---|
| Exceeding 8 dia. Or 200mm | Exceeding 8 dia. or 200mm | |
| ½ turn | 2/3 turn | Nut rotation is relative To bolt regardless of The Element (nut or bolt) being turned. Tolerance on rotation - $30^0$ over or under. |

Bolts may be installed without hardened washers when tightening is done by the Turn- of – nut method. How ere, normal washers shall be used.

Bolts tightened by the turn- of – nut method may have the outer face of the nut Match-marked with the protruding bolt point before final tightening, thus affording the inspector visual means of noting the actual not rotation such marks can be made by the wrench operator by suitable means after the bolts have been brought up snug tight.

b) Torque wrench tightening

When torque wrenches are used to produce the bolt tensions, the bolts shall be tightened to the torques specified in TABLE-II. Nuts shall be in tightening motion when torque wrenches to install several bolts in a single joints, the wrench shall be returned to touch up bolts previously tightened, which may have been loosened by the tightening of subsequent bolts, until all are tightened to the required tension.

**TABLE-II**

| Nominal Bolt Diameter (mm) | Torque to be applied (keg's) for bolts Class 8.8 of IS: 1367 |
|---|---|
| 20 | 59.94 |
| 22 | 81. 63 |
| 24 | 103. 73 |

In either of the above two methods, if required, if required, for bolt entering and wrench operation clearances, tightening may be done by turning the bolt while the nut is prevented from rotating.

Impact wrenches if used shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately ten seconds.

Holes for turned bolts to be inserted in the field shall be reamed in the field. All drilling and reaming for turned bolts shall be done only after the parts to be connected are assembled. Tolerances applicable in the fit of the bolts shall be in accordance with relevant Indian Standard Specifications. All other requirements regarding assembly and bolt tightening shall be in accordance with this clause.

3.1.8 **FIELD WELDING**

All field assembly and welding shall be carried out in accordance with the requirements of the specification for fabrication work applicable to the project, excepting such provisions herein which manifestly apply to shop conditions only. Where the fabrication structural steel members have been delivered paints, the paint shall be removed before field welding for a distance of at least 50 mm on either side of joints.

3.1.9 **HOLES, CUTTING AND FITTING**

No cutting of sections, flanges, webs, cleats, rivets, bolts, welds etc. shall be done unless specifically approved and/or instructed by the Engineer.

The erector shall not cut, drill or otherwise alter the work of other trades, or his own work to accommodate other trades, unless such work is clearly specified in the Contractor or directed by the Engineer. Wherever such work is specified the Contractor shall obtain complete information as to size, location and number of alterations prior to carrying out any work. The Contractor shall not be entitled for any payment on account of any such work.

3.2.0 **DRIFTING**

Correction of minor misfits and reasonable amount of reaming and cutting of excess stock from rivets will be considered as permissible. For this, light drifting may be used to draw holes together and drills shall be used to enlarge holes as necessary to make connection. Reaming, that weakens the member or makes it impossible to fill the holes property or to adjust accurately after reaming, shall not be allowed

Any error in shop which prevents the prevents the proper assembling and fitting of parts by moderate use of drift pins and reamers shall immediately be called to the attention of the Engineer and approval of the method of correction obtained. The use of gas cutting torches at erection site is prohibited.

3.2.0 **GROUTING OF STANCHION BASES AND BEARINGS OF BEAMS AND GRIDERS ON STONE, BRICKS OR CONCRETE (PLAIN OR REINFORCE)**

Grouting shall be carried out with Ordinary Cement grout as described bellow:-
The mix shall be one (1) part cement and one (1) part sand just enough water to Make it workable. The positions to be grouted shall be cleaned thoroughly with Compressed air jet and placed under expect supervision, taking care to avoid air-Looks. Edges shall be finished properly. If the thickness of grout is 25 mm or More, two (2) parts of 6 mm down graded stone chips may be added to the above Noted cement-sand grout mix, if required, by the Engineer or shown on the Drawings.

No grouting shall be carried out until a sufficient number of bottom lengths of Stanchions have been properly lined, levelled and plumbed and sufficient floor Beams are tied in position.

Whatever method of grouting is employed, the operation shall not be carried out until the steelwork has been finally levelled and plumbed, the stanchion bases being supported meanwhile by steel wedges, and immediately before grouting, the space under steel shall thoroughly cleaned.

If required by the Engineer, certain admixtures like aluminium powder, “ironies” or equipment, may be required to the grout. The Contractor will, when so directed by the Engineer, take delivery of the material from the Owner’s site stores and use it in the grout in proportions to be decided by the Engineer and carry out the allowance of 5% (five percent) for wastage shall be allowed over the above theoretical requirement of the admixtures. Cost of any wastage beyond the above limits shall be paid for by the Contractor or will be realised from his dues at the rates prescribed by the owner.

3.3.0 **PAINTING AFTER ERECTION**

Field painting, if required to be done by the Contract, shall only be done after the structure is erected, levelled, plumbed, aligned and grouted in its final position, tested and accepted by the Engineer. However, touch up painting, making good any damaged shop painting and completing any unfinished portion of the shop coat shall be carried out by the erection Contractor free of cost to the Owner. The materials and specification for such painting in the field shall be in accordance with the requirements of the specification for fabrication of structural Steel work applicable for the project.

Painting shall not be done in frosty or foggy, weather or humidity is such as to cause condensation on the surfaces to be painted. Before painting of steel, which is delivered unpainted, is commenced, all surfaces to be painted shall be dried and thoroughly cleaned from all loose scale and rust.

All field rivets, bolts, welds and abrasions to the shop coat shall be spot painted with the same paint used for the shop coat. Where specified, surfaces which will be in contact after site assembling shall receive a coat of paint (in addition to the shop coat, if any) and shall be brought together while the paint is still wet.

Surface which will be inaccessible after field assembly shall receive the full specified protective treatment before assembly. Bolts and fabrication steel members which are galvanized or otherwise treated and steel members to be encased in concrete shall not be painted.

The specification for paint and workmanship shall be in accordance with the requirements of the specification for fabrication for fabrication of structural of structural steelwork applicable to the project. The number of coats and the shades to be used shall be as specified or as directed by the Engineer.

3.4.0 **FINAL CLEANING UP**

Upon completion of erection and before final acceptance of the work by the Engineer, the Contractor shall remove free of cost all false work. Rubbish and all Temporary works resulting in connection with the performance of his work.

4.0.0 **TESTING AND ACCEPTANCE CRITERIA**

4.1.0 **GENERAL**

Loading tests shall be carried out on erected structures, if required by the Engineer, to check adequacy of fabrication and/or erection. Any structure on a part thereof found to be unsuitable for acceptance as a result of the test shall have to be dismantled and replaced with suitable member as per the Contract of either fabrication or erection of steelwork whoever is responsible for it and no payment towards the cost of the dismantled portion and any connected work shall be made to the Contractor, unless it is proved that the deficiency is due to reasons beyond the Contractor's scope. On the basis of the tests, the Engineer will decide

whether the fabricator or the erector is responsible for the unacceptable member or structure and his decision will be final. In case it is established that the unacceptability of the member or structure is due to design deficiency, the cost of replacement and/or modifications will borne by the Owner. In course of dismantling, if any damage is done to any other parts of the Contractor responsible, to the satisfaction of the Engineer, The cost of the tests specified hereinafter shall be borne by the Owner. Any extra claim due to loss of time, idle labour, etc. arising out of these testing operations shall not be entertained, however, only reasonable and appropriate time extensions will be allowed.

The structure or structural member under consideration shall be loaded with its actual dead as long a time as possible before testing and the tests shall be conducted as indicated in the following. Sub-clauses 4.1.1,4.1.2 and 4.1.3. The method of testing and application of loading shall be as approved by the Engineer.

### 4.1.1 STIFFNESS TEST

In this test, the structure or member shall be subjected, in addition to its actual dead load, to a test load equal to 1.5 times the specified superimposed load, and this loading shall be maintained for 24 hours. The maximum deflection attained during the test shall be within the permissible limits. If after removal of the tests load, the member or structure dose not show are recovery of at least 80 % of the maximum strain or deflection shown during 24 hours under to have load, the test shall be repeated. The structure or member shall be considered to have sufficient stiffness, provided that the recovery, after this second test not less than 90% of the maximum increase in stain or deflection recorded during the second test.

### 4.1.2 STRENGTH TEST

The structure or structural member under consideration shall be subjected, in addition to its actual dead load, to a test load equal to the sum of the dead load and twice the specified Superimposed load, and shall be maintained for 24 hours.

In the case of wind load, a load corresponding to twice the specified wind load Shall be applied and maintained for 24 hours, either with or without the vertical Test load for more severe condition in the member under consideration or the structure as a whole. Complete tests under both conditions may be necessary to verify the strength of the structure. The structure shall be deemed to have adequate strength if, during the test, no part falls and if on removal of the test load, the structure shows a recovery of at least 20% of the maximum deflection or strain recorded during the 24 hours under load.

### 4.1.3 STRUCTURE OF SAME DESIGN

Where several structures are built to the same design and it is considered unnecessary to test all of them, one structure, as a prototype, shall be fully tested, as described in previous Sub-clauses, but in addition, during the first application of the test load, particular note shall be taken of the strain or deflection when the test load 1,5 times the specified superimposed load has been maintained for 24 hours. This information is required as basis of comparison in any check test carried out on sample of structure.

When a structure of the same type is selected type is selected for a check test, it Shall be subjected, in addition to its actual dead load, to a superimposed test load, Equal to 1.5 time the specified live load, to a superimposed test load, equal to 1.5 Time the specified live load. In a manner and to an extent prescribed by the Engineer. This load shall be maintained for 24 hours, during which time, the Maximum deflection shall be recorded. The check test shall be considered Satisfactory, provided that the maximum strain or deflection should be recorded. The check test shall be considered satisfactory, provided that the maximum strain or deflection recorded at similar load in test on the prototype.

4.1.4 **REPAIR FOR SUBSEQUENT TEST AND USE AFTER STRENGTH TESTS**

An actual structure, which has passed the "Strength Test" as specified in Sub-Clause 4.1.2 herein before and is subsequently to be erected for use, shall be Considered satisfactory for use after it has been strengthened by replacing any Distorted members and has subsequently satisfied the 'Stiffness Test' as specified In Sub-clause 4.1.1 hereinbefore.

**4.2.0 TOLERANCES**

Some variation is to be expected in the finished dimensions of structural steel Frames. Unless otherwise specified, such variations are deemed to be within the Limits of good practice when they are not in excess of the cumulative effect of Detailed erection clearances, fabricating tolerances for the finished parts and the Rolling tolerance for the profile dimensions permitted under the Specifications for fabrications of structural steel work applicable to this project and as specified Below:

1 For Building Containing Cranes

| **Component** | **Description** | **Variation Allowed** |
|---|---|---|
| **1.** | **2.** | **3.** |
| Main column | a) Shifting of column axis at foundation Level with respect to building line | |
| | i) In longitudinal direction | i) $\pm$ 3.0 mm |
| | ii) In lateral direction | ii) $\pm$ 3.0 mm |
| | b) Deviation of both major or column axis From vertical between foundation and Other member connection levels: | |
| | i) For a column up to and including IOM height | i) $\pm$ 3.5 mm from true vertical |
| | ii) For a column greater than IOM but less | ii) $\pm$ 3.5 mm from vertical |

| | | |
|---|---|---|
| | than 40M height | for any 10M length measured between connection levels, but not more than ± 7.0 mm per 3.0mm length |
| | c) For adjacent pairs of columns across the width of the building prior to placing shown on drawings | ± 9.0 mm on true span |
| | d) For any individual column deviation of Any bearing from levels shown on drawings | ± 3.0 mm |
| | e) For adjacent pairs of column either across The width of building or longitudinally level difference allowed between bearing or seating Level supposed to be at the same level | 3 mm. |
| Trusses | a) Deviation at centre of span of upper chord Member from vertical plane running through Canter of bottom chord. | 1/1500 of the span or not greater than 10mm Whichever is the least. |
| Trusses | b) Lateral displacement of top chord At centre of span from vertical plane running through centre of support. | 1/250 of depth of truss or 20mm which Ever is the least |
| Crane Girders& Tracks | a) Difference in levels of crane rail measured between adjacent columns | 2.0 mm |
| | b) Deviation to crane rail gauge | ± 3.0 mm |
| | c)Relative shifting of ends of adjacent Crane rail in plan and elevation after thermit welding | 1.0mm |
| | d) Deviation to crane rail axis from centre line of web | ± 3.5 mm |
| Setting of Expansion Gaps | At the time of setting of the expansion gaps, due regard shall be taken of the ambient temperature above or Below $30^0$ C. The coefficient of expansion or contraction shall be taken as 0.000012 per$^0$ C per unit length. | |

iv) For Building without Cranes

The maximum tolerances for line and level of the steel works shall be ± 3.0mm on Any part of the structure. The structure shall not be out plumb more than 3.5mm On each 10M section of height and not more than 7.0 mm 30 M section.

These tolerances shall apply to all parts of the structure unless the drawings issued for erection purposes state otherwise.

**4.3.0 ACCEPTANCE**

Structures and members which have passed the tests and conform to all requirements specified in the foregoing sub-clause 4.1, 4.1.1, 4.1.2, 4.3.1 and 4.1.4 and other applicable provisions of this Specification and are within the limits of tolerances specified in Sub-clause 4.2.0 and / or otherwise approved by the Engineer shall be treated as approved and accepted for the purpose of fulfilment of the provisions of this Contract.

## 5.0.0 INFORMATION TO BE SUBMITTED

### 5.1.0 Before t ender

Along with the tenders the Tenderers will be required to submit the following Information:

### 5.1.1 TENTATIVE PROGRAMME

The Tender shall submit a tentative programme based on the information available in the Tender Document and visit to Site indicating the structure wise erection schedule proposed to be maintained by the Contractor to complete the job in time accordance with the Contract.

### 5.1.2 CONSTRUCTIONAL PLANT AND EQUIPMENT, TOOLS, TEMPORARY WORKS & MANPOWER.

A detailed list of all Constructional Plant & Equipment like cranes, derricks, winches, welding sets, erection tools etc. along with their make, model, present condition and location available with the Tender which he will be able to employ on the job to maintain the progress of work in accordance with the contract hall be submitted along with the Tender. The total number of each category of experienced personnel like fitters, welders, riggers etc. that he will be able to employ on the job shall also be indicated.

### 5.1.3 ERRECTION YARD

A site showing the layout and location of the erection yard proposed to be established by the Tender shall be attached with the Tender indicating the storage space for fabricated steel materials, site-fabrication and repair shop, covered stores, offices, locations of erection equipments and other facilities. The Engineer shall have the right to modify the arrangement and location of the proposed yard to suit site conditions and the Contractor shall comply with the same without any claim whatsoever.

## 5.2 AFTER AWARD OF THE CONTRACT

After award of the contract, the Contractor shall submit the following:-

### 5.2.1 DETAILED PROGRAMME

The Contractor shall submit a detailed erection programme within a month of the award of the Contract for completion of the work in time in a accordance with in

Contract. This will show the target programme, with details of erection proposed to be carried out in each fortnight, details of major equipment required and an assessment of required strength of various categories of workers in a perform a approved by the Engineer.

5.2.2 **FORTNIGHTLY PROGRESS REPORT**

The Contractor shall submit fortnightly progress reports in triplicate to the Engineer showing along with necessary photographs, 125 mm x 90 mm size, and
All details of actual achievements against the target programme specified in Sub-clause 5.2.1 above. Any shortfall in the achievement in a particular fortnight must be made up within the next fortnight. Along with this report, the Contractor shall
Also furnished details of fabricated materials in hand at site and the strength of his workers.

# MISCELLANEOUS STEEL WORK

| REV. NO. | PRAPARED | APPROVED | DATE |
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## 1. ANCHOR BOLTS

All materials supplied by the Contractor shall be of tested quality as per specification below and test certifications of raw materials shall be provided by the Contractor.

a) Bolts shall be turned from M.S. conforming to IS: 226 and IS: 422 Grade I.

b) Nuts shall be hexagonal type conforming to IS: 1363 and IS: 3138.

c) Plain washers shall be of mild conforming to IS: 226.

d) Sleeves shall be M.S Tubes (Medium) conforming to IS: 1239.

### 1.1 FABRICATION

Fabrication of anchor bolts shall be in compliance with the specification complete anchor bolts assembly shall be as per drawings, and will include the Cost of sleeve pipes, fine gussets, bottom plate, and other fixtures including all welding work if involved.

a) Threads shall be of coarse type conforming to IS: 1367 and IS: 4218

a) Plain washers shall be of mild steel conforming IS: 2016.

c) Bolt shall conform to IS: 1367.

1.2 The anchor bolt assembly to be anchored or embedded in concretes shall be placed and securely held in position strictly as per drawings before and during pouring of concrete, with necessary wooden or steel templates and other devices.

1.3 Tolerances allowed for anchor bolts positioning shall be:

- For sleeved bolts, and one tenth of bolt nominal diameter.
- For bolts without sleeves one twentieth of the bolt nominal dia.

1.4 The surface not to cover with concrete shall be greased and protected from damage by wrapping and typing just cloth/polythene.

### 1.5 Payment

1.5.1 Payment for supply and fabrication of anchor bolts including sleeves and nuts shall be on weight basis of the finished product and shall include greasing etc. A sample bolt shall be got approved from Engineer –in-Charge.

1.5.2 Payment for fixing where separately specified shall be on weight basis and rate shall including carting, fixing, providing and tying Hessian cloth, welding, if required etc. complete.

**2 M.S Metal Inserts**

2.1 All metal inserts its fabrication, bolting, riveting welding, etc. shall conform to the requirement specified under Specification of structural " Steel ". The metal inserts shall be fabricated as per – drawing and direction of the Engineer- in-Charge.

2.2 The placement of the metal inserts shall be securely placed in brick masonry, plain or reinforced concrete members. It shall be so securely placed in member that its position is not disturbed while concreting. Suitable templates, spacer blocks, dummy structures and staging shall be provided. Necessary cutting in the shuttering and adjustment for the placement of metal inserts if situation so desires. Where indicated, it shall be welded to the reinforcement.

2.3 The exposed surfaces shall be given one coat of red oxide primer and where directed, protected by jute cloth wrapping and tying.

**2.4 PAYMENT**

Payment shall be made on the basis of actual weight of metal inserts shall include supply, fabrication tying, turning, tack wielding, welding on other embedded items such as pipe (for puddle flanges) cutting and adjusting the shuttering and reinforcement and dry packing, if required with cement motor 1:3 painting, protecting with jute cloth etc. complete.

**3 M.S. Chequered Plates**

3.1 Chequered plates shall be 6mm thick (7mm, over chequers and shall conform To IS: 3502). Steel for Chequered plate shall conform to IS: 226. It shall be rolled, and free from harmful surface defects such as cracks, surface flaws etc. The plates shall be cut to shape and fixed to bearing members as shown in the relevant drawing and as directed by Engineer-in-Charge. The edges shall be made smooth and no burs or jagged end shall be left. The plates may be spliced with prior consent of Engineer –in-Charge but in that case care should be taken so that there is continuity in the pattern of the plates between the two portions.

**3.2 Payment**

Payments shall be made on the basis of weight of Chequered plate actually laid. The rate shall include cost of cutting to size, making holes to required shape, smoothing ends, transporting and welding, bolting, fixing, in positions etc. complete. No deductions will be made for openings up to size of 300mm square.

**4. M.S. Grating**

4.1 Material: Both the types of Gratings shall be fabricated, out of M.S. Flats. The steel shall conform to IS: 236 and shall be of weld able quality. It shall be clearly rolled and shall be free from harmful surfaces defects.

4.2 Fabrication Drawings: Based on the arrangement of supporting beams of design Drawings, the Contractor shall prepare shop fabrication drawings and get the same approved as per the procedure outlined for shop fabrication drawings for structural steel work.

4.3 Type I Gratings

4.3.1 These shall be of ready made bought out type and designed to carry specified loads with limits.

4.3.2 Unless otherwise mentioned in schedule of rates these shall be capable of carrying a uniformly distributed load of 500 kg. per square metre or a concentrated loads of 1000 kg. at mid span, whichever is governing. The maximum span for the above loading condition shall be 1200 millimetres. The deflection shall not exceed span /200 or 6mm whichever is less. The design shall be done as per IS: 800. Before fabrication or procurement the contractor shall submit the design calculations, drawings and manufacturer's Literature and gets the same approved from Engineer –in-Charge.

4.4 The gratings for stair treads shall be provided with nosing of Chequered plate of approved size and thickness.

4.5 Payment

4.5.1 Gratings shall be paid on the basis of weight of the area of M.S. Grating and frame actually laid.

4.5.2 The rate shall include cost of preparation of fabrication drawings, calculations, cost of cutting to size fabricating, welding, bolting, smoothing ends if necessary shop coat of red oxide zinc chromate primer, transporting and fixing in positions by welding or clips as per the design drawings. Loading, unloading, strong, safe custody, watch and ward, returning back of surplus materials to go down of issue where applicable.

## 5 M.S. Tube Hand Rails.

5.1 All mild steel tubes and fittings shall conform IS: 1239 and shall be of medium grade. All screwed pipes shall have threads as per IS: 554. All fittings shall be malleable iron fittings as approved by Engineer-in-Charge.

5.2 All pipes shall either be directly welded or jointed with screwed couplings. Care shall be taken to remove burrs from the ends of the pipe and if required the vertical members should be grouted with cement mortar as specified. The pipe shall be fixed to pipe or angle uprights by means of suitable clamps or by means of welding. After fixing, the pipe shall be painted with two coats of white paint over a coat of primer as directed by Engineer-in-Charge.

## 5.3 Payment

The payment shall be made on running metre basis of the actual of handrails fixed and shall include the cost of pipes. Clamps and fittings, if any, transportation, cutting of pipes as required, threading or welding, fixing painting etc .all complete as per direction of the Engineer-in-Charge.

## 6 M.S. Rungs

M.S.bars used for rungs shall conform IS: 432 and shall be fixed in positions as per detailed drawings and directions of Engineer-in-Charge.

## 6.1 Payment

Payment shall be made of the basis of actual weight in kilogram (kg) of M.S. rungs.

## 7 EXPANSION FASTENERS

### 7.1 SCOPE

The specification deals with the use of expansion fasteners for providing fixture to concrete surfaces.

## 7.5 Installation Procedure

The Contractor shall install the expansion at the specified places according to the approved manufactures specification with the help of necessary tools specified by the manufactures with the prior approval of Engineer –in-Charge for the approval of Engineer-in-Charge for every installation of expansion fasteners in regard to its correct location and strength.

## 7.6 Payment

Payment shall be made on number basis. The rate shall include cost of fasteners, nuts, washers and bolts of required sizes necessary scaffolding, drilling with electric drill, labour, materials, complete.

# MISCELLANEOUS METAL

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0.0 SCOPE

This shall include supply, fabricators and erection of miscellaneous metal items of light nature in gates, grills balcony and steps handrails particulars structural mullions and transoms, ladders hangers masonry anchors, shell angles, anchor bolts fasters etc. as shown or drawing or as instructed by the Engineer. The above items shall be of fabricated or cast M.S./Aluminium Brass. Cast iron .M.S. and galvanised M.S sheets aluminium sheets expanded metal with mesh etc. as shown on drawings and/or described in the Schedule of items.

**1.0 INSTALLATION**

**2.1 Fabrication/Casting**

**2.1.1 General**

All work shall be done according to approved shop drawings. All workmanship shall be equal to the best practice in modern structural foundry shop.

**2.1.2 Shop Connections**

a) All shop connections shall be riveted or welded except when noted otherwise on drawings.

b) Welding of steel shall be done on accordance with the IS: 816. Use of metal are welding for general construction in Mild Steel.

c) Welding of Aluminium shall be done in accordance with IS : 2912. Are welding of aluminium and alloys. Special care shall be taken to grind smooth all welded surface that shall remain exposed to view Welds shall be electrically continuous if so required by ; the Engineer.

**2.1.3 Shop Coat**

Before leaving the shop, all metal work shall be thoroughly cleaned by effective means of all loose mill/scale, rust and foreign matter. Except where encased in concrete all steel work shall be given one coat of approved metal protective paint, applied by ; brush thoroughly evenly, well worked in to joints and other open spaces. All paint shall be applied to dry surfaces. When specified on Schedule, steel work shall be galvanised or galvanised and painted with a coat of zinc chromate primer Aluminium surfaces which shall come in contact with masonry shall be given one coat of bituminous paint

**2.2 Erection**

**2.2.1 Bracing**

The Contractor shall provide all necessary temporary guys and braces to ensure alignment and stability of the members and to take ; care of all loads to which the structure may be subjected including erection of equipment and operation of the same.

**2.2.2 Temporary Bolting- Up**

As erection proceeds the Contractor shall plumb up and level all members and shall securely bolt up to take care of all dead load. Wind load and erection stresses. Wherever piles of materials erection equipment or other loads are carried during erection . proper provision shall be made to take care of the stresses resulting from the same.

**2.2.3 Turned Bolt**

For field connections where bolting is specified, holes for the turned bolts may be reamed in the field, if required. All drilling or reaming for turned bolts shall be done after the parts to be connected are assembled.

**2.2.4 Welding**

Where specified on drawings, welding shall be done in accordance with IS:816 for steel and IS:2812 for Aluminium and Alloys.

**2.2.5 Cutting and Fitting**

No cutting of sectors, flanges, webs of angles should be done without the approval of the Engineer. Where indicated on the drawings, holes cuttings etc. shall be provided as regulated for installation, to the work by the other Contractors. No additional holes or cuttings their those shown on drawings, shall be made without the approval of the Engineer.

**2.2.6 Drifting**

Correction of minor misfits and a reasonable amount of reaming and cutting of excess stock from rivets may be permitted. For this, light drifting may be allowed to draw holes together. Twist drills shall be used to enlarge as necessary to make connections Reaming that weakens the members or make it impossible to first the holes properly or to adjust accurately after ream one shall not be allowed.

Any error in shop work which prevents the proper assembling and fitting of parts by moderate use of draft pans of a moderate amount of reaming and slight chipping and cutting shall immediately be called to the attention of the Engineer and approval of the method of confection obtained. The sue of cutting torches to enlarge or alter rivet holes shall not be permitted.

**2.2.7 Grouting**

All beaming plates, loose, lintels and beams etc. shall be set to proper grade and level by the Contractor and the Engineer's approval obtained before proceeding with the Grouting. Grouting shall be done in 1:11/2:3 concrete with 5mm down stone chips.

**2.2.8 Anchor Bolting**

When shown on drawings, the miscellaneous metal items shall be fixed to crete by case hardened and drawn carburizing steel expander nut and bolt. The contractor shall submit the manufacturer's literature shown the average pull out and average shear values for bolts of various sizes. The bolts shall be fixed strictly as per the manufacturer's instructions.

**2.2.9 Pipe Joints**

M.S. Pipes shall be joined by threaded sockets or by welding Cast iron pipes shall be socket and spigot jointed and caulked with hemp and molten head.

**2.2.10 Spot Painting**

All field rivets and bolts and also any serious abrasion to shop paint shall be spot painted with the same materials and used for the shop paint or equivalent.

**2.2.11 Making Good**

All cutting to concrete or masonry shall be made good to the satisfaction of the Engineer.

**3.0 ACCEPTANCE CRITERIA**

a) All items shall be of correct shape, size, weight etc., shown on drawings and schedule of items.

b) For installed items, the tolerances shall be follows:

   i) Permissible deviation from straightness –1 in 1000.

   ii) Seats, stiffener connections etc, shall be as per approved drawings and shall not interfere with architectural clearances.

c) All castings shall be free from blow holes, cracks and other blemishes.

**4.0 RATES**

The Contractor shall quote unit rate for supply of materials fabrication, shop paint and erection. This shall also include transporting the fabricated materials to the site, unloading storing and erection, including furnishing necessary temporary bracings guys, staging and planking. This shall also include cutting and drilling to steel, concrete or masonry and welding, bolting, grouting and making good damages after erection and removing all rubbish and clearing the site upon completion of erection.

Where only erection of materials supplied by the Owner at site to actual erection site, erection including free of cost is involved, the rate shall include handling, transportation from the Owner's stores at site to actual erection site, erection including furnishing necessary temporary bracing, guys, staging and planking etc., complete with all cutting drilling welding grouting bolting etc., making good damages removing all debris on completion of the job.

## 5.0 METHOD OF MEASUREMENT

a) For supply and/installation generally, cast items except pipes shall be measured for actual numbers used or for weight as mentioned in the Schedule.
b) Cast Iron rain water down corners or drain pipes shall be measured for length along the center line of piping including all bends, joints shoes and specials.
c) Fabricated items shall be measured for weight.
d) Ornamental metal grills, gates etc., shall be measured either for weight or area or such grills, gates etc.

## 6.0 I.S CODES

| | | |
|---|---|---|
| IS:226 | - | Structural Steel (Standard Quality) |
| IS:800 | - | Code of Practice for use of structural steel in general building construction. |
| IS:816 | - | Use of metal arc welding for general construction |
| IS:2812 | - | Arc Welding of Aluminium and Alloys |
| IS:3150 | - | Hexagonal Wire Netting |
| IS:4948 | - | Welded steel wire fabric for general use. |

# PAINTING ON STRUCTURAL STEEL

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**1.0 SCOPE**

1.1 This specification covers the general requirements for painting structural steel work. It covers the supply and delivery of all necessary materials, labour, scaffolding, tools, equipment and everything that for the job completion on schedule.

1.2 The scope of painting work could be one or more of the following.
a) Shop painting after fabrication.
b) Painting after erection.
c) Painting after fabrication and painting after erection.
d) Routing maintenance painting or repainting of erected structural steel.

1.3 Shop painting shall be understood to mean painting prior to erection whether such Materials are fabricated in shop or at site. In case the contract covers shop painting only, the contractor shall ensure that the painted surfaces are not abrased/scratched etc, as they leave his works/shops. In case of ex-works delivery contract and in case of FOR site contracts, the materials as received at site should be good condition. Otherwise all damaged, abraded and scratched surfaces shall be touched up on receipt of materials at site as specified. If the contract covers both shop painting and painting after erection, the responsibility would be total. In
Case of routine maintenance painting of erected steel work, the surface preparation, primer application and painting shall be as per the instructions of the Engineer.

2.0 **APPLICABLE CODES**

The following Specifications, Standards and Codes are made a part of this Specification. All standards, tentative specifications, Specifications and Codes of Practice referred to here in shall be the latest editions including all applicable official amendments and revisions.

In case of discrepancy between this Specification and those referred to herein, this Specification shall govern, In case as discrepancy between tender drawings and this Specification of the tender drawings shall govern.

In case of discrepancy between this Specification and those referred to herein, this Specification shall govern, In case as discrepancy between tender drawings and This Specification of the tender drawings shall govern.

a) IS : 800 Code of practice for Use of Structural Steel in General Building Construction.

b) IS: 012 Ready Mixed paints, Brushing, Red Lead, Non setting, Priming.

c) IS : 129 Ready Mixed Paint, Brushing, Finishing, Interior, Oil glass, for General purposes, to Indian Standard colours.

d) IS : 157 Ready Mixed Pints, Brushing, Acid and Alkali Resisting, Lead Free, for General Purposes, to Indian Standard Colours No.446 Red Oxide, NO.632 Dark Admiralty Grey and other colours as required.

e) IS : 159 Ready Mixed paint, Spraying, Acid Resisting, for protection against Acid Fumes, Colour as required.

f) IS : 160 Ready Mixed paint, Spraying, Acid Resisting, for protecting against Acid Fumes, Colour as required.

g) IS : 341 Black Japan, Types A,B,c

h) IS : 1236 Ready Mixed Paint, Brushing, Oil Gloss, Heat Resisting, to Indian Standard Colour No630 Deep Buff.

i) IS : 1477 code of practice for painting of Ferrous Metals in Buildings.
(part-I) - pre-treatment
(part-I) – painting.

j) IS : 2074 Ready Mixed paints, Red Oxide – Zinc chrome, priming.

k) IS : 2330 Aluminium paint for General purposes, in Dual Container.

l) IS : 5905 Sprayed Aluminium and Zinc Coatings on Iron and Steel.

2.0 **PAINT**

3.1 All paints delivered to the fabrication shop/site shall be ready mixed, in original Sealed containers, as packed by the paint manufactures and no thinners shall be Permitted.

3.2 Paint shall be stirred frequently to keep the pigment in suspension.

3.0 **WORKMANSHIP**

4.1 The surface of steel works to be painted in the shop shall be thoroughly cleaned for All loose mill scale, rust, grease, dirt and foreign matter by hand tool cleaning, Power tool cleaning, flame cleaning or sand / shot blasting as specified in Data Sheet A. In power tool brushing, sufficient care shall be exercised no to burnish mill scale to a slick finish to which paint may not adhere property.

4.2 All fabricated steel martial, except those to be galvanised shall receive protective Paint coating of red Oxide Zinc chromate or as specified in schedule of items.

4.3 The paint treatment shall be applied either by brushing or spraying on the

thoroughly cleaned and dry surface, Airless spraying shall be done if so specified. The number or coats of paint shall be one or as specified in schedule of items.

4.4 Surface inaccessible after assembly shall receive an additional coat for the specified paint prior to assembly.

4.5 Steel delivered at the erection site be touched up with the specified paint on surface which are scratched.

4.6 After steel has been erected, all bare and abraded spots, rivet heads, field welds, Bolt heads and nuts shall be painted with primer specified in Data Sheet A. Before paint is applied, the surface shall be dry and free from dust, dirt, scale, oil and grease.

4.7 Surface inaccessible after erection, including top surface of floor beams shall Receive treatment with one additional coat of red oxide zinc chromate primer.

4.8 No painting shall be done in frosty/foggy weather or when the humidity is high Enough to cause condensation on the surface to be painted. Paint shall not be applied when the temperature of surface to be painted in $5^0$C or lower.

4.9 In addition, colour code marking as specified shall be clearly painted in the Fabrication shop on the member in the manner specified.

4.10 Separate colours code of identification mark shall be adopted in the fabrication Shop for member fabricated from steel supplied by the OWNER and the VENDOR/CONTRACTOR

4.11 Surfaces coming in contact with concrete, and such other areas should not be painted, if so specified or directed by Engineer.

4.12 All machine finished surface shall be provided with a coat of white lead tallow Before despatch to site to prevent rust formation.

## 4.0 METHOD OF PAYMENT

5.1 Payment for painting of structural steel works shall be made on the basis of weight in metric tons of the painted structures accepted by the Engineer-in- charge. The rate shall include supplying and applying two coats of synthetic enamel paint of approved quality and shade over a coat of ed oxide zinc chromate primer besides one coat of shop primer already applied to structure steel works of all types/ shapes at all locations & positions including storage, surface preparation, degreasing, cleaning, drying, touching up of shop primer coat, providing temporary staging, testing etc, all complete as specified.

# INSERTS/EMBEDMENTS IN CONCRETE WORK

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1.0 **SCOPE**

This specification source the general the requirement for providing insert and cut oust concrete work as indicated in the drawings supplied to the contractor.

2.0 **GENERAL**

Numerous insert are requirement to be fixed/embedded in concrete as indicated In construction drawing/as directed by the Engineer. These insert comprise plates, angle, pipe sleeves, anchor bolts assemblies, owner, etc to be supplied by owner free of coat at his stores, for incorporation in the works, other inserts are required to be supplied and fabricated, by the Contractor These would be indicated clearly on the construction drawings.

3.0 **MATERIALS AND INSTALLATION**

3.1 Steel templates shall be used by the CONTRACTOR to locate and very accurately position bolts, group of inserts, inserts, embedded parts, etc, at his cost. Such templates shall be got previously approved by the Engineer. Templates shall invariably be supported such that the same is not disturbed due to vibration, movement of labours, materials, shuttering work, reinforcement, etc, while concreting. The CONTRACTOR will have to suitably bend, cut or otherwise adjust the reinforcement in concrete at the location of inserts, as directed by the Engineer. If the Engineer so directs, the insert will have to be welded to reinforcement to keep these in place. The contractor shall be responsible for the accuracy of dimensions, levels, alignments and canter lines of the insert in accordance with the drawings and for maintenance of the same until the erection of equipment structure or final acceptance by the Owner.

3.2 The Contractor shall ensure proper protection of all bolts, inserts, etc, from weather by greasing or other approved means such as applying white lead putty and wrapping them in gunny bags or canvas or other means as directed by the Engineer to avoid damage due to movement of his labourers, materials, equipment etc. No extra claim from the Contractor on this account shall be entertained. The contractor shall be solely responsible for all the damage caused to bolts inserts, etc, due to his negligence and in case damage does occur, they shall be rectified to the satisfaction of the Engineer at the Contractor's cost.

4.0 **RATE**

4.1 The rate quoted by the Bidder for embedment works shall hold good for accurately fixing the inserts at the correct-levels/alignment and shall include the cost of templates and any temporary supports/anchors etc, including cutting, bending , welding, etc as requirement.

**5.0 MEASUREMENT:**

All embedment will be measured by weight including lugs.

Templates and temporary supports, if any will not be measured.

Permanent supports such as road, structural sections etc, used exclusively for supporting the embodiments shall be paid for under ordinary embodiments (not under Foundation hardware).

# GROUTING

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1.00.0 **GROUTING OF BASE PLATES**

1.01.0 **GENERAL**

Grouting under base plates constitute a special kind of work requiring judicious selection of materials and careful execution of work. Grouting should ensure complete filling of the space and perfect bond. The grouting shall be done under Expert supervision. Care must be taken to ensure that there is no locked air in the grouting.

1.02.0 **MATERIALS**

1.02.01 CEMENT : Only fresh Portland conforming to IS:8112

1.02.02 SAND : Fine aggregate shall comply in general with requirement of concrete aggregate (IS:383) and shall have a fineness modules of 2.5 to 3.0

1.02.03 ANTI-SHRINKAGE MATERIAL : Aluminium powder or anti-shrinkage admixture like Groutex CRS-NS grout (by Cement Research Institute of India) or conbextra GP2 its equivalent shall be of standard brand from reputed manufactures And shall be approved by the Engineer prior to use in work.

1.02.03 **MORTAR**

Water cement ratio should not exceed 0.5 Mortar shall be made up of cement and sand in the proportion 1:1 by weight and blended with Aluminium powder (about 0.005 by weight of cement or with anti –shrinkage admixture) in a suitable proportion to cement mortar in accordance with the recommendation of the manufacturer and subject to the approval of the Engineer.

1.04.0 **SCOPE**

The work covers all operation connected with grouting including all labour and materials. Any damage to the concrete foundation works caused during such operations due to the carelessness, or negligence shall be made good by the Contractor in a manner to be decided by the Engineer, whose decision shall be final and binding.

1.05.00 **SURFACE PREPARATION: CONCRETE**

Concrete surface receiving the grout shall be properly roughened removing latency and exposing good concrete. The preparation of the surface may be accomplished through the use of a chipping hammer or hand bush hammer and wire brush. The surface shall be thoroughly cleaned removing all the free water from the surface but keeping it wet before the grouting begins.

1.06.0 **SURFACE PREPARATION:STEEL**

The steel surface coming in contact with the grout should be cleaned or rust, mill scales, paints, oil or grease and be wet before setting into place for grouting.

1.07.0 **WORKMANSHIP**

Grouting arrangements should ensure mortar to fill all the voids completely. Provisions of grout holes and rod ding arrangements should be checked before commencement of grouting. If necessary, pressure grouting with grout pump shall be restored to. Edges shall be finished properly.

1.08.0 **METHODS OF GROUTING**

1.08.01 **USE OF DRY PACK CONCRETE**

The widely used method of obtaining satisfactory grout is based on the principle of using lowest water cement ratio reducing the shrinkage to a minimum. Pozzolana cement having less shrinkage than ordinary Portland cement is preferred for this grouting. Only enough water shall be added to produce a grout. The proper amount of mixing water and proper consistency are those which will produce a grout which is at the point of becoming rubbery when the material is solidly packed. Any mortar which has been mixed for period longer than an hour shall not be used.

1.08.0 **USE OF DRY PACK CONCRETE**

To reduce the shrinkage anti-shrinkage materials as specified earlier to be added.

1.08.02 **LEVELLING & PLUMBING**

No grouting shall be carried out until the steel-works shall been finally levelled and plumbed and sufficient number of floor beams are tied in position. The stanchions, meanwhile, are to be supported by steel wedges, and immediately
Before grouting, the space under steel base plate shall be thoroughly cleaned. The steel wedges must not be welded to the underside of base places.

2.00.0 **DISMATLING, ALTERATION AND RE-ERECTION OF STEEL WORK**

In case it is found that alteration are to be done for certain portions of steel work already erected for any reasons what so ever, this shall be done only on the written orders of the Engineer. Complete scheme of alterations shall be detailed and got approved by Engineer before work is taken up at site.

The sections requiring modifications which cannot be done in the erected position shall be dismantled carefully without damaging other structure, lowered dismantling, cutting, re-welding or supporting, re-aligning of other adjacent connected member as well.

3.00.0 **MEASUREMENT**

3.00.01 Grouting under base plates of structures erected by the Contractor will not be

measured. The rate for erection is expected to include cost of grouting However, Volume of grout will be considered for the purpose of theoretical consumption of cement.

3.00.02 Grouting under base plates and machine bases erected by other will be measured for actual volume of grout. The volume of embedded base plate/machine basis will be deducted from the overall volume of grout.

3.00.03 Grouting in pocket for erection done by other will be measured for the volume of Of pockets. No deduction will be done for volume of bolts etc.

# MASONRY AND ALLIED WORKS

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**1.0.0 SCOPE**

This specification covers furnishing, installation, repairing, finishing, cutting, protection, maintenance and handing over of masonry and allied works of use in structures and locations covered under the scope of the Contract.

**2.0.0 INSTALATION**

**2.1.0 SOLING**

**2.1.1 BRICK SOLING**

The ground shall be dressed, consolidated by ramming or by light rolling and a 12mm thick cushion of sand laid. On the sand cushion the bricks shall be laid with fine joints and placed firmly in position by hammering with wooded mallet. The surface shall be free from undulations. The "frog" side shall be on the underside. The joints shall be broken the in all direction and bricks cut as required. The pattern of laying and number of layers shall be as per Schedule of item. Orientation shall be as designed by the Engineer. After laying of each layer of brick sand shall be spread over and worked into the joints to pack the bricks tight.

**2.1.2 STONE SOILING**

The stones for soling shall be selected on the basis of thickness of soling specified in the Schedule of Items. The larger stones shall be laid and the gaps filled by smaller stones. The interstices shall then be firmly packed with sand by flooding with water.

**2.2.0 BRICKS EDGING**

Excavation shall be done closed to the brick dimensions in perfect alignment. Bricks shall be firmly placed by hammering with wooden mallets and sides and joints packed firmly with earth so that the edging is not disturbed easily. Alignment and level shall be acceptable to the Engineer.

**2.3.0 MASONRY**

**2.3.1 GENERAL**

All masonry work shall be true to lines and levels and as shown on drawings. All Masonry shall be tightly built against structural members and bonded with dowels, inserts etc, as shown on drawings.

**2.3.2 MORTAR**

Mix for mortar shall be specified in the Schedule of Items.
When lime is used hydrated lime shall be mixed with water to from a putty and stored with care to prevent evaporation for at least 24 hours before use, Quick lime shall be slaked with enough water to make a cream, passed through a No.10

sieve and stored avoiding evaporation for seven days before use.
Lime putty and sand in proper proportion shall be mixed on a water-light platform with necessary addition of water and thoroughly ground in a mortar mill. This mix shall be transferred to a mechanical mix, required quantity of cement added and the content mixed for at least 3 minutes. Mixtures of lime putty and sand may be stored avoiding drying out. For cement sand mortar cement and sand in requisite proportions shall be mixed dry in a mechanical mixer and then water added and mixed further. Minimum quantity of water shall be added to achieve working consistency. Surplus mortar droppings from masonry, if received on surface free from dirt may be mixed with rest mortar if permitted by the Engineer who may direct addition of additional cement without any extra payment. No mortar which has stood for more than half an hour shall be used.

### 2.3.3 BRICK MASONRY

Bricks shall be soaked by submergence in clean water for at two hours in approved vats before use. Bricks shall be laid in English bond unless specified otherwise. Broken bricks shall not be used. Cut bricks shall be used if necessary to complete bond or as closures. Bricks shall be laid with frogs upwards over full mortar beds. Bricks shall be pressed into mortar and tapped into final position so as to embed fully in mortar. Inside faces shall be buttered with mortar before the next bricks is placed and passed against it. Thus, all joints between bricks shall be fully filled with mortar.

Mortar joints shall be kept uniformly 10mm thick. All joints on face shall be racked to minimum 10 mm depth using raking tool while the mortar is still green to provided bond for plaster or pointing. Where plaster or pointing is not provided, the joints shall be struck flush and finished immediately. Brickworks two bricks thick or more shall have both faces in true plane. Brickwork of lesser thickness shall have one selected face in true plane.

### 2.3.4 EXPOSED BRICKWORK

Brickwork in superstructures which is not covered by plaster shall be as shown on drawing and executed by specially skilled mason. Courses shall be truly horizontal and vertical truly vertical. Wooden straight edges with brick course graduations and position of window sills and lintels shall be used to control uniformly of brick courses. Masons must check workmanship frequently with plumb, sprit level, rule and strings. All brickwork shall be cleaned at the end of dry work. If face bricks are specified in the Schedule of item, the brickwork shall be in routine bricks, but maintaining the bond fully. Where face bricks are not specified, bricks for the exposed brickwork on completion of work shall be rubbed down, washed clean and pointed as specified. Where face bricks are are used carborundum stone shall be used for rubbing down.

**2.3.5 REINFOCED BRICKWORKS**

Reinforcements shall be as specified in the Schedule of Items. All reinforcements Shall be thoroughly cleaned and fully embedded in mortar. Where M.S. bars are used as reinforcement, these shall be laced with dowels if left in R.C. columns or welded to steel stanchions.

**2.3.6 REINFORCED BRICKWORKS**

Reinforcements shall be as specified in the Schedule of Items. All reinforcements shall be thoroughly cleaned and fully embedded in mortar. Where M.S bars are used as reinforcement, these shall be laced with dowels if left in R.C. columns or welded to steel stanchions.

**2.3.7 STONE MASONRY**

Stones shall be thoroughly socked before laying. Stones shall laid on their natural quarry beds. Individidual stones shall be executed by specially skilled mason. Stones used for exposed face shall be specially selected. All exposed stone faces shall be kept clean and free from mortar and pointed up neatly as the work proceeds in a manner called for in the drawings or the Schedule of Items or Instructions. A sample wall, 10 sq.m. In area shall be build and approved by the Engineer and all works shall match with this sample.

**2.3.8 COMPOSITE MASONRY**

Where stonework facing with brick masonry backing is specified the bond between them shall be achieved by bond stones of dimensions and frequency as desired by the Engineer.

**2.3.9 EXPANSION & SEPARATION JOINTS**

Location of joints shall strictly be as shown on drawings or as instructed by the Engineer. Expansion joints shall be as shown on drawings and specified in the Schedule of Items. Expansion joint filler boards and sealing strip shall have minimum traverse joints. Transverse joints shall meet the approval of the Engineer.

Separation joints shall be with standard water proof paper or with alkathene sheets about 1mm in thickness. Length and sealing of laps shall be to the satisfaction of the engineer.

**2.3.10 MOULDINGS, CORNICES, DRIP COURSE**

These shall be made as shown in drawings. Bricks or stone shall be cut and dressed as required. If no subsequent finish is envisaged, these shall be rubbed to correct profile with carborundum stone.

**2.3.11 CURING**

Masonry shall be cured by keeping it wet for seven days from the date of laying. In dry whether at the end of days work top surface of masonry shall be kept wet by ponding.

**2.3.12 EMBEDDING OF FIXTURES**

All fixtures shall generally be embedded in mortar and masonry units shall cut as required.

**2.3.13 ENCASING OF STRUCTURE STEEL**

This shall be done by masonry work round flanges, webs etc. and filling the gap between steel and masonry by minimum 12 mm thick mortar. Encased members shall be warped with checked wire mesh shown on drawings of instructed by the Engineer. The minimum lap is checked wire mesh shall be 50mm

**2.4.0 DAMP PROOF COURSE**

Unless otherwise specified Damp-proof course shall be 40 mm Thick 'artificial stone' proportion 1:1-2/3 cement sand stone-chips (10mm down) with admixture of a waterproof compound as approved by the Engineer. The percentage of admixture shall be as manufacture's specifications but not less than 2% weight of cement. The top surface shall be double chequered cured by ponding for seven days.

**2.5.0. DAMP PROOF MEMBRANE**

Damp proof treatment using fibre or hessian base bitumen felt shall be 6,8 or 10 course treatment is specified in IS:1609. The number of courses shall be as mentioned in the schedule of items. Sequence or work shall be as directed by the Engineer. Extreme sequential care shall be taken to prevent damage to felt during and after laying. The contractor shall be obliged at the own expense, if to rectify and leakage appearing within 5 years of installation by removing and renewing the coats at the point of leakage.

Where shown on drawing damp proof measurance with one layer bitumen paper or one land alkathene sheet shall be laid with minimum 150 mm lap under sides on grade.

**3.0.0 RATES**

Rates shall be units rates for the complete work as detailed out in the Specification unless any particular portion is specifically in the Schedule of Item.

**4.0.0 METHOD OF MEASUREMENT**

**4.1.0 SOLING**

Soling of different types as enumerated in the Schedule of Items shall be measured on actual area basis.
Deductions shall not be made for areas less than 0.1 Sq.M.

**4.2.0 BRICK EDGING**

Edging shall be measured on running length unless included in other relevant items.

**4.3.0 MASONRY**

**4.3.1** Thickness of brick walls shall be measured in normal brick sizes.

**4.3.2** For masonry work exceeding 150mm in thickness, actual volume of work shall be measured and deductions for opening, lintels, sills, conduit ducts, pipes etc., shall be made. No opening less than 0.1 Sq.M Min area shall however be deducted.

**4.3.3** No deductions shall be made for embedded fixtures nor any extra by paid for the mortar used for fixing or for necessary cutting of bricks.

**4.3.4** For encasing of steel beams, columns etc. the sizes as shown on drawings shall be measured and deductions made for the volume of encased steel.

**4.3.5** No extra payment shall be for cutting of masonry units.

**4.3.6** Walls 150mm in thickness or les shall be measured for actual area of works and deductions made as in Clause 4.3.2.

**4.3.7** Exposed brickwork using selected ordinary brick or free bricks for the exposed face shall be measured in area as an extra over the ordinary brickwork if no provided in the Schedule of Items. It shall be measured by volume including the composite backing if so provided in the Schedule. Deductions shall be as described in Clause 4.3.2

**4.3.8** Reinforcements shall be measured and paid separately under relevant items in the schedule unless included in the items for masonry work.

Laps in wire mesh reinforcements shall not be measured. Reinforcing mesh shall be measured on actual area basis. Reinforcing bare shall be measured by weight.

The weight shall be arrived at on the basis sectional weights as per I.S. No extra Shall be paid for necessary modifications of existing dowels, if any, to tie up with the Contractor's work.

**4.3.9 EXPOSED STONE WORK**

Exposed stone work using selected stone for exposed face shall be measured in area as an extra over ordinary stone work if as provided in the Schedule of Items. Deductions shall be made as described in Clause 4.3.2.

**4.3.10 COMPOSITE MASONRY**

Composite masonry shall be measured for vale including backing if so provided in the Schedule of taxes. If not, brickwork and stone-work shall be measured separately and paid under relevant items.

**4.3.11 EXPANSION AND SEPARATION JOINTS**

Joints shall be measured for length or area for the complete work as shown on drawings including filler boards, sealant strips, sealing compounds, painting, cover etc. If so provided in the Schedule of items unless any particular work is specifically excluded from the item.

**4.3.12 MOULDING, CORNICE, DRIP COURSE:**

Mouldings, cornice, drip course unless indicated specifically under separate items shall be considered in masonry items. However, cut in bricks or stone shall be neglected in measurements.

**4.3.13 EMBEDDED FIXTURES**

Inserts etc shall be measured by weight or by number and paid separately under relevant item is the Schedule of Items.

**4.4.0 DAMP PROOFING:**

Damp proofing shall be measured and paid in net area. No deductions shall however be made for opening less than 0.1sq.m in area. No separated payment shall be made for preparation of base, formworks and additive for cast-in-situ damp proofing unless specified otherwise.

**5.0.0 I.S.CODES**

Some of the important relevant codes these sections are:-

IS:1127 : Recommendations for dimensions and workman ship of natural building stones for masonry work
IS:1597 : Code of practice for construction of Stone Masonry.
IS:1609 : Code of practice for laying Damp-proof treatment using bitumen felts.
IS:2212 : Code of practice for Brickwork.
IS:2250 : Code of practice for preparation and use of Masonry Mortar.
IS: 5134 : Bitumen Impregnated paper & Board.

# FINISH TO MASONRY AND CONCRETE

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1.0.0 **SCOPE**

The Specification covers furnishing, installation, repairing, finishing, curing, testing, protection, maintenance till handing over or finishing items for masonry and concrete. This shall also include the work to be done to make the surface suitable for receiving the finishing treatment.

Before commencing finishing items the Contractor shall obtain the approval of the Engineer regarding the scheduling of work to minimise damage by other trades. He shall also undertake normal precaution to prevent damage or disfiguration to work of other trades or other installation.

2.0.0 **INSTALATION**

2.1.0 **PREPARATION OF SURFACE**

All joints masonry walls shall be racked out to a depth of 10mm with a hooked tool made for the purpose while the mortar is still green. Walls shall be brushed down with stiff wire brush to remove all loose dust from joints and thoroughly washed with water. All latency shall be removed from concrete to be plastered.

For all types of flooring, skirting and dado work, the base cement concrete slab or masonry surface shall be roughened by chipping and cleaned of all dirt, grease or loose particles by hard brush and water from the base course. Any excess of water shall be mopped up.

At any point, the level of base shall be lower than the theoretical finished floor level by the thickness of floor finish. Any chipping or filling to be done to bring the base in the required level shall be brought to the notice of the Engineer and his approval shall be taken regarding the method and extent of rectification work required.

Prior to commencement of actual finishing work, the approval of the Engineer shall be taken as to the acceptability of the base.

2.2.0 **PLASTERING**

2.2.1 **MORTAR**

Mortar for plastering shall be as specified in the Schedule of Items.

For sand cement plaster, sand and cement in the specified proportion shall be mixed dry on a watertight platform and minimum water added to achieve working consistency.

For lime gauged plaster, lime putty or hydrated lime and sand in the required proportion shall be mixed platform with necessary addition of the water and thoroughly ground in mortar mill. This mix shall then be transferred to a mechanical mixer to which the required quantity of cement is added and mixed for at least 3 minutes.

No plaster which has stood for more than half an hour shall be used; plaster than shows tendency to become dry before this time, shall have become dry before this time, shall have water added to it.

2.2.2 **APPLICATION OF PLASTER**

Plaster, when more than 12mm thick, shall be applied in two costs a base coat followed by the finishing coat. Thickness of the base cost shall be sufficient to fill up all unevenness in the surface, no single cost, however, shall exceed 12mm in thickness. The lower coat shall be thicker than the upper coat, the over all thickness of the coats shall not be less than the minimum thickness shown on the drawings. The undercoat shall be allowed to dry and shrink before applying the second coat at plaster. The undercoat shall be scratched or roughened before Appling the second coat at plaster. The undercoat shall be scratched or roughened before it is fully hardened to from a mechanical key. The method of application shall be thrown on rather than 'applied by trowel'.

To ensure even thickness and true surface, patches of plaster about 10 mm to 150mm square or wooden screen 75mm wide and of the thickness of the plaster, shall be fixed vertically about 2000mm to 3000mm apart, to act as gauges. The finished wall surface shall be true to plumb, and the Contractor shall, without any extra cost to the Owner, make up any irregularity in the brickwork with plaster.

All vertical edges of brick pillars, doorjambs etc., shall be chamfered or rounded off as directed by the Engineer. All drips, grooves, mol dings and cornices as shown on drawing or instructed by the Engineer shall be done with special care to maintain true lines, levels and profiles. After the plastering work is completed, all debris shall be removed and the area left clean. Any plastering that is damaged shall be repaired and left in good condition at the completion of the job.

2.2.3 **FINISH**

Generally, the standard finish shall be used unless otherwise shown on drawing or directed by the Engineer. Where ever, any special treatment to the plastered surface is indicated, the work shall be done exactly as shown on the drawings, to the entire satisfaction of the Engineer regarding the texture, colour and finish.

a) **Standard Finish**
Where punning is indicated, the interior plaster shall be finished rough. Otherwise, the interior plaster shall generally be finished to a smooth surface. The exterior surface shall generally be finished with a wooden float.

b) **Neat cement finish**
Immediately after achieving a true plastered surface with the help of a wooden straight edges, the entire area shall be uniformly treated with a paste of neat cement at the rate of one (1)kg. Per Sq.M. and rubbed smooth with a trowel.

c) **Coloured plaster Finish**
This shall be done in the same way as specified in Clause 2:2:2 but using coloured cement in place of ordinary cement. When coloured plastering is specified in more one coat, the top coat shall be made with coloured cement. Colored cement shall be either ready mixed material or may be obtained by mixing pigments and cement at site, as approved by the Engineer. The pigments to be mixed with cement shall conform to Appendix – A of IS : 2114 latest edition

Samples of colouring material shall be submitted to the Engineer for approval and material produced, shall conform in all respects to the approved samples, Which shall remain with the Engineer. All coloured cement and/ or pigments Shall be stored be stored in an approved manner on order to prevent deteriorations.

d) **Pebble-dash Finish**
Mortar of required thickness consisting of 1 part cement and 4 parts sand by volume shall be applied in the usual manner as described under plastering Clause 2.2.2. While the mortar is still plastic small pebbles or crushed stone of size generally from 10mm to 20 mm as approved by the Engineer shall be thrown on the plastered surface. The aggregate shall be lightly tapped into the mortar with a wood float end of a trowel, in order to ensure satisfactory bond between the dashing and the mortar.

e) **Rough-Cast Finish**
A wet plastic mix of 3 parts coloured cement 6 parts sand and 4 parts aggregate by volume (gravel or crushed stone of size from 6mm to 12mm as approved by the Engineer) shall be thrown on to the wall by means of a plaster's trowel and left in the rough condition.

f) **Scraped Finish**
Ordinary plaster as described under Clause 2.2.2 after being levelled and allowed to stiffen for a few hours, shall be scraped with a steel straight edges to remove the surface skin. The Patten shall be as approved by the Engineer.

g) **Textured Finish**
Mortar consisting of 1 part cement and 3 parts sand by volume shall be applied in a manner as specified under "Plastering" Clause 2.2.2 Ornamental requirements in the from of horizontal or vertical rib texture fan texture etc. shall be applied by means of suitable tools to the freshly applied plastered surface, as approved by the Engineer.

2.2.4 **CURING**

All plastered surface after laying, shall be watered, for all minimum period of seven days, by an approved method, and shall be protected from excessive heat and sunlight by suitable approved means. Moistening shall commence, as soon as the plaster has hardened sufficiently and not susceptible to damage, Each individual coat of plaster shall be kept damp continuously, for at least two days, and then dried thoroughly, before applying the next coat.

2.3.0 **POINTING TO MASONRY**

All joints of brick shall be racked out to a depth of 10mm with a hooked tool made for the purpose while the mortar is still green. The brickwork shall then be brushed down with a stiff wire brush, so as remove all loose from the joints and thoroughly washed with water. Mortar consisting of 1 part cement and 3 parts clean, sharp, well graded sand by volume shall be pressed carefully into the joints and finishes with suitably tools to shape as shown on the drawings. Any surplus mortar shall be scraped off the wall face lagging the surface clean.

The pointed surface shall be kept wet for at least three days for curing.

2.4.0 **PLASTER WITH METAL LATH**

The supports, hangers, brackets, cleats etc., shall be as shown on drawings and/or approved by the Engineer. These shall have a coat of prime paint before and another coat of approved paint after erection.

The metal lath shall be expanded metal, with 12mm x 38mm mesh, 16 BC thick and 3 mm wide strands. Side laps shall be minimum 12mm and end laps 25mm minimum. The plastering shall be minimum 20mm thick measured from the back of latch and applied in two layers. The mortar for plastering shall consist of 1 part cement, ½ part lime and 4 parts sand by volume mixed as specified in plastering, Clause 2.2.1. The application, finish etc., shall be as specified under relevant clause above. Where called for in the Schedule of Items, a 2mm Plaster of Pair punning shall be applied over plaster as a finishing coat to give perfectly smooth and even finish

2.5.0 **LIME PUNNING**

For plastered surfaces, where an even smooth surface is specified, lime punning with 5 parts of shell lime properly slacked, strained and aged, mixed with 1 part clean, washed, sleeved, fine sand by volume shall be done. The thickness of lime punning shall be not less than 2mm and more than 3mm. The plastered surface shall be saturated with water before application of the lime punning. The punning shall be applied by skilled workman and given a smooth and even finish free from undulations, cracks etc. and to the satisfaction of the Engineer.

2.6.0 **PLASTER OF PAIRS PUNNING**

Plastered surfaces, where specified shall be finished with plaster of parts punning. The material shall be from approved manufactures and approved by

The Engineer. The thickness of the punning shall be 2mm and shall be applied by skilled workmen. The finish shall be smooth, even and free from undulation, cracks etc.Before bulk work is taken in hand, a sample of punning shall be done on roughly 10 Esq. area and approval of the span Engineer taken. The work shall then be taken in hand as per approved sample.

2.7.0 **STONE FANCING**

Stone facing where specified shall be done as shown on design drawings and approved shop drawings. The stone shall be as specified on drawings and/or schedule of items. Samples of stone shall be submitted to the Engineer for approval and then bulk purchase made. The Contractor shall submit three copies of shop drawing for the Engineer's approval before commencing the work.

The thickness of facing stone shall be not less than 25mm unless otherwise specified on drawings.

The stone slabs shall be cut and finished to sizes as per pattern shown on drawings. They shall be fastened to wall with suitable non corrodible anchorage as approved by the Engineer. Where mild steel clamps, stays etc., are sued for anchorage, they shall by galvanized (weight of zinc coating shall not be less than 700gms per squire meter of surface) to prevent rust stains developing on the finished surface. There shall be at least 12mm gap between the stone and masonry, which shall be filled up and packed by a mortar of 1 part cement and 3 parts of sand by volume. After the mortar to set and cured for at least four days, the exposed surface shall be rubbed and polished as approved by the Engineer.

The completed surface shall be neat, or uniform texture and acceptable to the Engineer.

Where pointing is specified on drawings it shall be done by mortar as specified on drawings and/or Schedule of items.

3.0.0 **ACCEPTANCE CRITERIA**

Finish to masonry and concrete shall fully comply with the Specifications, approved samples and instructions of the Engineer with respect to lines, levels, thickness, colour, texture, pattern and any other special criteria as mentioned in the body of the specifications or as shown on drawings.

4.0.0 **RATES**

Rates shall be for the complete work as detailed out in the specification unless any particular portion is specifically excluded in the Schedule of Items. Rate shall include for rounding of corners.

5.0.0 **METHOD OF MEASUREMENT**

a) All surface finish shall be measured on actual area laid. No deductions shall be made for openings, pipes, sleeves etc. unto 0.1 Sq.m in area.
b) Unless separate item is provided for special corner or edges finish, drip course, grooves, mouldings, curbs etc., these shall not be measured separately. Where separate item is provided in the Schedule of Items, such work shall be measured for length.
c) No separate payment shall be made for finishing round openings, sleeves, pipes, etc. No separate payment shall be made for from work, templates etc., required for achieving true lines and profiles as shown on drawing.
d) Finishes applied integrally with walls, floors, steps and ceilings shall be measured separately and paid under relevant items.
e) Any reinforcement incorporated in the finish shall be measured and paid separately under relevant items.
f) Unless otherwise mentioned in the Schedule of Items, hangers, supports and lath plastering shall be measured and paid separately under relevant items.

6.0.0 **I.S. CODE**

Important relevant code for this Section:-

a)IS:1661 : Code of practice for cement and Cement-lime plaster finish on walls & ceilings.

b)IS:4101 : Code of practice for external facings and veneers.

# PAINTING, WHITEWASHING, POLISHING ETC.

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1.0.0 **SCOPE**

This specification covers painting, white washing, varnishing polishing etc. of both interior and exterior surface of wood work, masonry, concrete plastering, plaster of pairs., false ceiling, structural and other miscellaneous steel items, rainwater down comer, floor and roof drains, soil, waste and service water pipes, and other ferrous and non-ferrous metal items as shown on drawings, schedule or as directed by the Engineer.

Copper, bronze, chromium plate, nickel, stainless steel, aluminium and monel metal shall generally not be painted of finished except if otherwise specified.

The painting Contractor shall inspect the work of other prior to the application of paint. If surface to be finished can not be put in suitable condition for painting by customary preparatory methods, the painting contractor shall notify the Engineer in writing or assume responsibility for and rectify unsatisfactory finishing that results.

Before commencing painting, the painting Contractor shall obtain the approval of the Engineer in writing regarding the schedule of work to minimize damage, disfiguration or staining by other trades. He shall also undertake normal precautions to prevent damage, disfiguration or staining to work of other or other installations.

2.0.0 **INSTALLATION**

2.0.1 **MATERIALS**

Materials shall be highest grade products or well-known approved manufacture and shall be delivered to the site in original sealed containers, bearing brand name, manufacturer's name and colour shade, with labels intact and seals unbroken. All materials shall be subject to inspection, analysis and approved by the Engineer. It is desired that materials of one manufacturer only shall be used as far as possible and paint or one shade is obtained from the same manufacturing batch. All paint shall be subject to analysis from random samples taken at site from painters bucket, if so desired by the Engineer.

All prime coats shall be compatible to the material of the surface to be finished as well as to the finishing coats to b applied.

All unspecified materials such as shellac, turpentine or linseed oil shall be of the highest quality available and shall conform to the latest IS standards. All such materials shall be made by reputable recognised manufactures and shall be approved by the Engineer.

All colours shall be as per painting schedule and tinting and matching shall be done to the satisfaction of the Engineer. In such cases, where samples are

required, they shall be executed in advance with the specified materials for the approval of the Engineer.

a) **White Washing**
Shall be done from pure shell lime or fat lime, or fat lime, or a mixture of both as instructed by the Engineer, and shall conform to IS : 712 latest edition. Samples of lime shall be submitted to the Engineer for approval, and lime as per approved sample shall be brought to site in unlaced condition. After slaking, it shall be allowed to remain in a tank of water for two days and then stirred up with a pole. Until it attains the consistency of thin cream. 100 grams of gum to 6 litters of white wash water and a little quantity of indite of synthetic ultramarine blue shall be added to the lime.

b) **Dry distemper**
Shall be made from suitable pigments, extenders, lime proof tinters, water soluble binders etc., and shall conform to IS:427.

c) **Oil Bound Washable Distemper**
Shall be of oil emulsion type, containing suitable preservatives and shall conform to IS:428.

d) **Waterproof Cement Paint**
Shall be made from best quality white cement and lime resistant colours with accelerators, waterproofing agent and fungicides. The paint shall conform to IS:5410.

e) **Acrylic Emulsion on Paint**
Shall be water-bases acrylic copolymer emulsion with rutile titanium dioxide and other selected pigments and fungicide. It shall exhibit excellent adhesion to plaster and cement surface and shall resist deterioration by alkali salts. The paint film shall allow the moisture in wall to able to withstand washing with mild and water without any deterioration in colour, or without showing flaking, blistering or pooling.

f) **Synthetic Enamel Paint**
Shall be made from synthetic resins and drying oil with rutile titanium dioxide and other selected pigments to give a smooth, hard, durable and glossy finish to all exterior and interior surfaces. White and pastel shades shall resist yellowing and darkening with aging. The painting shall conform to IS:2932 and IS:2933

g) **Aluminium paint**
Shall be in two pack containers and shall resist weathering. The paint shall conform to IS: 2339.

h) Shall be best quilt alkyd varnish suitable for brushing over the tint of paint or

Light natural wood and shall not darken or yellow with age.

i) **French Polish**
Shall be made from best quality shellac, denatured spirit and other suitable alcohol soluble ingredients and made by a well known approved manufacturer. The material shall conform to IS:348.

French polish shall not be used on bare wood. It shall only be used as finishing coat on wood after the wood is pre-treated with a liquid wood filler conforming to IS : 345 is applied and rubbed out.

2.0.2 **STIRAGE**

The Contractor shall arrange for safe and proper storage of all materials and tools. The storage space if allotted within the building shall be adequately protected damage, disfigurement stains. Paint shall be kept covered at all times and mixing shall be done in suitable containers. All necessary precautions shall be taken by the Contractor to prevent fire.

2.1.1 **PREPARATION OF SURFACE**

Before startng the work the Contractor shall obtain the approval of the Engineer regarding the soundness & readiness of the surface to be painted on.

2.1.1 **WOOD**

All surface shall be free from dirt and loose or peeling paints. The surface shall be rubbed down smooth. All nails & screws shall be sunk below the surface and filled with putty after applying an under coat. Small knots that do not justify cutting and sap streaks shall be covered with minimum 2 coats of pure shellacs applied thinly & extended 25mm beyond the area. All large, loose or resinous knots shall be removed and filled with sound wood. All work shall be done as per IS :2338.

2.1.2 **MASONRY, CONCRETE AND PLASTERED SURFACE**

Surface shall be from all oil, grease, efflorescence, mildew, loose pair or other foreign and loose materials. Masonry cracks shall be cleaned out and patch filled With mortar similar to the original surface and uniformly textured. Where this type of resurfacing may lead to the finishing paint being different in shade from the original surfaces, the resurfaces area area shall be treated from the original surfaces, the resurfaces area shall be treated with minimum one cost of cement primer which should be continued to the surrounding area for a distance of minimum 100mm.
Surface with mildew or efflorescence shall be treated as below.

a) **Mildew**

All mildew surface shall be treated with an approved fungicide such as ammonia cal wash consisting of 7g of copper carbonate dissolved in 80ml liquor ammonia and diluted to 1 litre with water, or 2,5 percent magnesium silica fluoride solution and allowed to dry thoroughly before paint is applied.

2.1.3 **METAL**

All metal surface shall be absolutely clean, dry and free from wax, grease of dried soap films. In addition, all steel and iron surface shall be from free rust, surface shall be cleaned by mechanical power tools to remove mill scales unless otherwise approved by the Engineer for epoxy chemical resistant paints, surface shall be blast cleaned to near white metal. All galvanised iron surfaces shall be pre-treated with a compatible primer according to the manufacturer's direction. Any abrasion in shop coat shall be touched up with the same quality of paint as the original cost.

2.1.0 **APPLICATION**

2.2.1 **GENERAL**

The method of applicable shall be as recommended by the manufacturer. In case of selection of special shade and colour (not available in standard shades)the Contractor shall mix different shades and prepare test panels of minimum size 1 meter square as per instruction of the Engineer and obtain his approval prior of applicable of finishing paints.

Proper tools and implements shall be used. Scaffolding if used shall be independent of the surface to be painted to avoid shade differences of the freshly repaired anchor holes.

Painting shall be done by skilled labours in a workman like manner. All materials shall be evenly applied so as to be free of sags, runs, crawls or other defects. All coats shall be of proper consistency. In case of application by brush, no brush marks shall be visible. The brushes shall be clean and in good condition before applicable of paint.

All printing undercoats for painting shall be applied by brush only, and rollers spray equipments etc., shall not be used.

No work be done under condition that are unsuitable for production of good results. No painting shall be done when plastering is in progress is in progress or is drying. Application of paint which seals the surface to moisture shall only be done after the moisture on the below the surface has dried out.

All coats shall be thoroughly dry before succeeding is applied. Coats of painting as specified are intended to cover surface perfectly. In case the surface is not covered properly by applying the specified number of coats, further cats shall be applied by the Contractor when so desired by the Engineer.

sample and all finish shall be uniform in colour and texture. All parts of mouldings and ornaments shall be left clean and true to finish.

Painting on ferrous metal surface shall be done as per IS:1477 (part 1&2). The total dry thickness of the film should not be less than 120 micron.

2.2.2 **WHITE WASHING**

The surface where white washing is to be applied shall be cleared of all loose materials and dirt. All holes and irregularities of the surface shall be filled up with lime putty and shall be allowed to dry up before application of the lime solution.

One coat of white wash shall consist of one stroke from top downwards, another from bottom upwards over the first stroke and another from left to right before the previous one dries up. Second coat shall be applied in case the Engineer feels that one more coals are required the Contractor shall do so without any extra coat to the owner. No brush marks shall show on the finished surface.

2.2.3 **DRY DISTEMPER**

New plastered surface shall be allowed to dry for at least two months. New lime or lime cement plastered surface shall be washed with a solution of 1 part vinegar to 12 parts water of 1:50 sulphuric acid solution and 24hours after which the wall shall be thoroughly washed with clean water. For cement plastered surface, the surface shall be washed with a solution of 100gms of zinc sulphate to 1 litre of water then allowed to dry.

Dry distempering shall be done as per manufacture's instruction. In applying the distempers the brush should first be applied horizontally and immediately crossed off perpendicularly. Brushing shall not be continued too long, as otherwise brush brush marks may result.

2.2.4 **OIL HOUND WASHBLE DISTEMPER**

The distemper shall be applied after surface is printed with an alkali resistant primer, and followed by minimum two coats of oil bound washable distemper all as per manufacture's instruction.

2.2.5 **WATERPROOF CEMENT'S PAINT**

Surface to be coated with cement paint shall be washed and brushed down. As soon as the moisture has disappeared, the surface shall be given one coat of paint. Care shall be taken so that the paint dose not dry out too rapidly. After 4 to 6 hours, the water shall be sprinkled over the surface to assist curing and prevent cracking. After the first coat has dried (24 to 48 hours) the second coat shall be applied be applied in a similar manner. The finished surface shall be kept moist by occasional sprinkling with water for seven days after painting.

### 2.2.6 ACRYLIC EMMISION PAINT

Lime gauged cement plastered surfaces shall not be painted for at least one month after plastering. A sample patch shall be painted to check alkali reaction if so desired by the engineer. Painting shall be strictly as per manufactures specification.

### 2.2.7 SYNTHETIC ENAMEL PAINT

Shall be applied on properly prime red surface. Sub sequential coat shall not be applied till the previous coat is dry. The previous shall be lightly sand papered for better adhesion of subsequent coat.

### 2.2.8 ALUMINIUM PAINT

The paint, supplied in two pack containers shall be mixed and applied strictly as per manufacture's direction. When more one coat of paint is required or indicated, the next coat shall only be applied after the previous coat become hard dry.

### 2.2.9 CLEAR SYNTHETIC VARNISH

The varnish shall be applied on wood surface after (a) staining &(c) Sealing operations are carried out. The application of a combination of filler and stain shall not be permitted.

For the finishing coats of varnish, the surface shall be allowed to dry and rubbed down lightly, wiped off and allowed to dry, Careful attention cleanliness is required for varnishing. All dust and dirt shall be removed form the surface as well as from the neighbourhood. Damp atmosphere and draughts shall be avoided, and exposure to extreme heat or cold & dampness shall not be allowed.

The varnish shall be applied liberally with a brush and spread evenly over a portion of the surface with light strokes to avoid frothing. It shall be allowed to flow on while the next section is being laid on excess varnish shall then be scrapped off the brush and the first section be crossed, recrossed and then laid off lightly. The varnish once it has began to set, shall not be retouched. In case of any mistake in application, the varnish shall be removed and the work started a fresh.

The varnish shall be minimum of two coats, with the first coat being a flatting varnish. This shall be allowed to dry hard and be flatted down, before applying the next coat. Sufficient time must be allowed between coats to get a hard dry surface before next coat is applied. All work shall be as per relevant IS Code.

2.2.10 **FRESH POLISH**

All unevenness of the surface shall be rubbed down to smoothness with sand paper and the surface shall well dusted. The pores in the wood shall be filled up with a paste of whitening in water or methylated spirit with a suitable pigment like burnt sienna or umber.
After application of the filler paste, the French polish shall be applied with a pad of woollen cloth covered by a fine cloth. The pad shall be moistened with polish and rubbed hard on the surface in a series of overlapping circles so that the polish is sparingly but uniformly applied over the entire area to give an even surface. A trace of linseed oil may be used on the pad for case of application. A trace of linseed oil may be used on pad for case of application. The surface shall be allowed to dry before further coats are applied in the same manner. To finish off, the pad shall be covered with a fresh piece of clean fine cloths, slightly damped with methylated spirit and rubbed lightly and quickly with circular motions to leave the finished surface with a uniform texture and high gloss.

2.2.11 **CHEMICAL RESISTANT PAINT**

For chemical resistant paints, epoxy, chlorinated rubber or vinyl butryl paint system shall be used manufacture's recommendation regarding the paint system Exposed to moderately severe corrosive condition and subject to acid/alkali spillage and fumes, shall be followed.

2.2.0 **PROTECTION**

Furniture and other movable objects, equipments, fittings and accessories shall be moved, protected and replaced upon completion of work. All stationary equipments shall be well covered so that no paint can fall on them. Work finished by other agencies shall be well protected. All protections shall be done as instructions of the Engineer.

2.3.0 **CLEANING UP**

In addition to provisions in general conditions the Contractor shall, upon completion of painting etc., remove all marks and make good surface, where paint has been spilled, splashed or spattered, including all equipments, fixtures, glass, furniture, fittings etc., to the satisfaction of the Engineer.

2.4.0 **ACCEPTANCE CRITERIA**

a) All painted surfaces shall be uniform and pleasing in appearance.

b) All varnished surface surfaces shall be of uniform texture and high glossy finish.

C) The colour, texture etc., shall match exactly with those of approved samples

d) All stains, splashes and splatters of paints and varnishes shall be removed from surround surfaces.

4.0 **RATES**

Rates shall be unit rates for complete items described in the Schedule of Items. No extra payment will be made for preparation of surface before be made for preparation of surface before painting or for cleaning up after the work is complete.

5.0 **METHOD OF MEASUREMENT**

a) Structural steel work shall not be measured separately and the cost shall be included in this rates for the fabrication and erection.

b) Painting or whitewashing to concrete or masonry shall be measured and on the area painted. For measurement of openings whose jambs, sills, soffits etc., are to be painted the following procedure shall be followed.

I) For openings up to 0.5 Sq.M no deductions shall be made and no additions shall be made for lambs, sills, etc.,

ii) For opening exceeding 0.5 Sq.m. but not exceeding 3.0 Sq.m. each deductions shall be made for half the area of openings, and no additions shall be made for jambs sills etc.

iii) For opening exceeding 3.0Sq.m. each deductions shall be made for the jambs, sills, soffits, reveals etc.

c) For opening, pipes, sleeves etc., whose sides are not finished no deductions shall be made openings etc., up to 0.1 Sq.m. in area each, and full deductions shall be made for all openings above 0.1 Sq.m. in area each.

d) No extra shall be paid for painting etc. done around openings, sleeves, pipes ducts, inserts etc.

e) No extra payment shall be made for painting, etc., on wall features such as grooves, ducts, beads, protections, cornices, etc., unless give different finish or otherwise specified in the "Schedule of Items". The actual area of the features shall be gritted and included in the wall measurements.

f) For painting of uneven surface in doors, windows, ventilators, louvers, guard bars, balustrades, gratis, railings, gates, etc., equivalent plain areas shall be measured as given in Clause 17.2 (Table 11) of IS:1200 unless mentioned otherwise.

g) Corrugated surface shall be measured flat as fixed as not gritted. The quantities as measured shall be multiplied by the following factors to get equivalent plain area:

i) Corrugated steel sheets-shall be multiplied by 1.14

ii) Corrugated asbestos sheet with large corrugations shall be multiplied by 1.20.

iii) Semi-corrugated asbestos cement sheets shall be multiplied by 1.10

iv) Any other non-standard for sanitary and plumbing work, no separate Measurement shall be made and the cost shall be included in the Installation of pipes.

h) For painting pipes for sanitary and plumbing work, no separate measurement Shall be made and the cost shall be included in the installation of pipes.

i) Unless specifically started on the schedule of items, all painting, varnishing or Polishing of wood shall be measured and paid on the area treated. For Measurement of uneven surfaces, equivalent Main area shall be measured as Per Clause 17.2 (Table ii) of IS: 1200 unless specified otherwise.

6.0.0 **I.S. CODE**

Important relevant IS Codes for this Sections are listed below:

IS:348 : Specification for French Polish

IS:427 : Specification for Distemper, dry colour as required .

IS:428 : Specification for distemper oil emulsion, colour as required.

IS:1477(I&II) : Code of practice for painting of ferrous metal in buildings.

IS:2328(I&II) : Code of practice for finishing of wood and wood based materials.

IS:2329 : Specification for Aluminium paints for general purposes in dual containers.

IS:2395 : Code of practice for painting concrete masonry and plaster.

IS:2932 : Specification for enamel, synthetic, exterior, type-1.

IS:5410 : Specification for cement paint, colour as required.

# FLOOR FINISHES AND ALLIED WORKS

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1.0 **SCOPE**

This specification covers furnishing, installation, finishing curing, testing, protection, maintenance till hanging over various type of floor finishes and allied item of work as listed below:

a) **In Situ Finishes**

i) Integral Finish to concrete base

ii) Red Oxide of Iron finish

iii) Terrazzo finish

iv) Granolithic finish

v) Patent stone

vi) Metallic Hardener like “Ironite” finish

vii) Mastic Asphalt finish

viii) Chemical Resistant finish

b) **Tiled finishes**

i) Terrazzo tile

ii) Chequered tile

iii) Glazed tile

iv) Tesserae (Mosaic etc.)

v) Chemical Resistant

vi) Rubber, Vinyl etc.

vii) Stone Slab

1.0.1 **BASE**

The base to receive the finish is covered under other relevant specification.

1.0.2 **SEQUENCE**

Commencement, scheduling and sequence of the finishing works shall be planned in detail and must be specifically approved by the Engineer in view the activities of other agencies working in the area. However, the Contractor for the finishing items shall remain fully responsible for all normal precautions and vigilance to prevent any damage what so ever till handing over.

## 2.0 INSTALLATION

### 2.0.1 SPECIAL MATERIALS

Basic materials are covered under Specification "properties Storage and Handling of Common Building Materials" Special materials required for individual finishing items are specified under respective items. In general, all such materials shall be as per relevant I.S. Codes where available. In all cases these materials
Shall be of the best quality available indigenously, construction schedule.

The materials for finishing items must be procured from well reputed specialised manufacturers and on the basis of approval of samples by the Engineer. The materials shall be ordered, procured and stored well in advance to avoid compulsion to use substandard items to maintaining in the construction schedule.

### 2.0.2 WORKMANSHIP

Only workers specially experienced in particular items of finishing work shall be engaged, where such workers are not readily available, with the Engineer's permission, experienced supervisors recommended by the manufacture shall be engaged in particular cases where the Engineer so desires the Contractor shall get the finishing items install by the manufacture.

### 2.0.3 PREPARATION OF THE BASE SURFACE

The surface to the treated shall be thoroughly examined by the contractor. Any rectification necessary shall be brought in the notice of the Engineer and his approval shall be taken regarding method and extent of such rectification work.

For all types of flooring, skirting, dado and similar locations, the base to receive the finish shall adequately roughened by chipping, taking out joints and cleaning thoroughly all dirt's, grease etc., with water and hard brush and detergent if required, unless otherwise directed by the manufacturer of any special finishing materials or specifically indicated in this specification under individual item.

To prevent soakage of water from the finishing treatment the base shall be thoroughly soaked with water and all excess water mopped up. The surface shall be done dry where adhesives are used for fixing the finishes.

Prior to Contractor Commencement of actual finishing work the approval of the Engineer shall be taken as per the acceptability of the surface.

## 2.1 IN SITU FINISHES

### 2.1.1 INTEGRAL FINISH TO CONCRETE BASE

While the surface of the concrete laid as per specification for Cement Concrete has been fully compacted and levelled but the concrete is still'green'a thick slurry made with neat cement shall be applied evenly and worked in with iron float. When the slurry starts to set it shall be pressed with iron floats to have a firm compact smooth surface without trowel mark of undulations. This finish shall be as thin as possible by using 2.2kg, of Cement per Sq.M.of area.

The surface shall be kept in shade for 24 hours and then cured for at least 7 days continuo sly by flooding with water. The surface shall not be subjected to any load or abrasion till 21 days after laying.

As desired by the Engineer the surface, while still 'green' shall be indicated by pressing strings, the marking shall be of even depth, in straight lines and the panels shall be of uniform and symmetrical patterns.

### 2.1.2 RED OXIDE OF IRON FINISH

It shall consist of an under bed and a topping over already laid and matured concrete base.

a) **Thickness**

Unless otherwise specified the total thickness of the finish shall be minimum 50 mm for horizontal and 25mm for vertical surface of which the topping shall (not less than 10mm) while the topping shall be of uniform thickness the under bed may vary in thickness to provide necessary slope. The vertical surface shall project out 6mm from the adjacent plaster or other finishes. Necessary cutting into the surface receiving the finish shall be done to accommodate the specified thickness.

All junctions of vertical with horizontals shall be rounded neatly to uniform radius of 25mm.

b) **Mix**

**i) Underbed**

The underbeds for floors and similar horizontal surface shall consist of a mix of 1 part cement, 2 parts coarse and 4 parts 10 mm down graded stone chips by volume. For vertical sand similar surface the mix shall consist of 1 part cement to 3 parts coarse sand by volume.

**ii) Topping**

For the topping cement, screened through a fine mesh and red oxide of iron pigment powder similarly screened shall be dry mixed thoroughly in right proportions to produce the desired colour when laid. The mix shall then be prepared with 1 part cement (mixed with pigment) and 3 parts coarse volume. The whole quantity required for each visible area shall be prepared in one batch to ensure uniform colour.

c) **Laying**

The under bed shall be laid in panels of mixing area 5 Sq.M. each and no side shall be more than 2.5m long. For outdoor locations the maximum area shall be 2.0 Sq.M. The forms for the panels shall have perfectly aligned edges to the full depth of the total thickness of finish. If specified aluminium or glass dividing strips shall be used.

The panels shall be laid in alternate bays or in chequered board pattern. No panel shall be cast in contact with another already laid, until the contraction of the latter has taken place. The under bed shall be laid, compacted, levelled and brought to proper grade with a screed or float. The topping shall be placed after about 24 hours while the under bed is still somewhat 'green' but firm enough to receive the topping. The surface of the under bed shall be roughened for better bonding. The topping shall be rolled for horizontal stress and thrown and pressed for vertical areas to extract all superfluous cement
And water to achieve a compact dense mass fully boned with the under bed.

The topping shall then be levelled up by trowel ling and finished smooth with a slurry made with already prepared cement and pigment mixture. About 2.0kg of the mixture shall be consumed/per Sq.M. for horizontal surface and 1.0 kg, for vertical surface. The surface shall be cured for seven days by keeping it moist.

d) **Polishing**

About 16 hours after laying when the surface has hardened sufficiently it shall be polished with polishing stone till a smooth shiny surface to the satisfaction of the Engineer, is achieved. The finish shall washed and cleaned just before handing over.

2.1.3 **TERRAZO FINISH: IN SITE**

It shall consist of an underbids and a topping laid over an already laid and matured concrete base.

a) **Thickness**

Unless, otherwise specified the total thickness of the finish be minimum 550mm for horizontal and 25mm for vertical surface of which the topping shall be not less than 10mm. While, the topping shall be of uniform thickness the under bed may vary in thickness to provide necessary slopes. The vertical surface shall project cut 6mm from the adjacent plaster or other finish. Necessary cutting into the surface receiving the finish shall be done to accommodate the specified thickness.

All

b) **Mix**

i) **Under bed**

The under bed for floors and similar horizontal surface shall consist of mix of 1 part cement, 1 ½ parts sand and 3 parts stone chips by volume. For vertical surface the mix shall consist of 1 part cement to 3 parts sand by volume. The sand shall be coarse. The stone chips shall be 10mm down well graded. Only sufficient water to be added to give a workable consistency.

ii) **Tapping**

The mix for the tapping shall be composed of cement colour pigment, marble chips. Proportions of the ingredients shall be such as to produce the terrazzo of colour texture and pattern approved by the Engineer. The cement shall be white or grey or a mixture of two to which pigment shall be added to achieve the desired colour. To 3 parts of this mixture 1 part marble powder by volume shall be added and thoroughly mixed dry. To 1 part of this mix 1 to 11/2 parts of marble chips by volume shall be added and thoroughly mixed dry again.

The pigment must be stable and non fading. It must be very finely ground. The marble powder shall be from white marble and shall be finer than IS Sieve No.:30. The size of marble chips may be between 1 mm to 20mm.

Sufficient quantity to cover each visible area shall be prepared in one lot to ensure uniform colour. Water to make it just workable shall be added to quantity that can be used up immediately before it starts to set.

c) **Laying**

The under bed shall be laid in panels. The panels shall not be more than 5 Sq.M. in area of which no side shall be more than 2.5 M long, for exposed location the maximum area of panel shall be 2.0 Sq.M. The panel shall be laid

in alternate bays or chequered board pattern. No panel shall be cast in contact with another already laid until the latter has contracted to the full extent.

Dividing strips made of aluminium or glass shall be used for forming the panels. The strips shall exactly match the total depth of under bed plus topping.

After laying, the under bed shall be levelled compacted and brought to proper grade with a screed or float. The topping shall be laid after about 24 hours while the under bed is still somewhat 'green' but firm enough to receive the topping. A slurry of the mixture of cement and pigment already made shall be spread evenly and brushed in just before laying the topping. The topping shall be horizontal areas and thrown and pressed for vertical area to extract all superfluous cement and water and to achieve a compact dense mass fully bonded with the under bed. The surface of the topping shall be trowel led over, pressed and brought to a smooth dense surface showing a minimum75% area covered by marble chips inan even pattern of distribution.

d) **Curing**

The surface shall be left for curing for about 12 to 18 hours and then cured by allowing water to stand on the surface or by covering with wet sack for four days.

e) **Grinding and polishing**

When the surface has sufficiently hardened it shall be watered and ground evenly with rapid cutting coarse grade (no. 40) grit blocks, till the marble chips are exposed and the surface is smooth. Then the surface shall be thoroughly washed and cleaned. A grout with already prepared mixture of cement and pigment shall be applied to fill up all pinholes. The surface shall be cured for 7 days by keeping in moist and then ground with fine grit blocks (no:120). It shall again be cleaned with water, the slurry applied again to full up any pinholes that might have appeared and allowed to be cured again for 5 days. Finally, the surface is ground a third time with very fine grit blocks (no:320) to get smooth surface without pinhole. The grinding shall be done by a suitable machine. Where grinding machine can not be used hand grinding may be allowed when the first rubbing shall be with carborundum stone of coarse grade (no:80) and final rubbing and polishing with fine grade (no:120). The surface shall be cleaned with water, dried and covered with solid free, clean sawdust if directed by the Engineer. The final polishing shall be positioned till before handing over the surface shall be dusted with oxalic acid at the rate of 0.33 gm. Per/Sq.M. water sprinkled on to it and finished by buffing with felt or Hessian bobs. The floor shall be cleaned with soft moist rag and dried. However, all excess wax polish to be wiped if and the surface to be left glossy but not slippery.

2.1.4 **GRANOLITHIC FINISH**

Granolithic finish shall either be laid monolithically over base concrete or separately over hardened base concrete.

a) **Thickness**

The finish shall be average 20 mm and minimum 12 mm thick, unless specified otherwise.

b) **Mix**

The mix shall consist of 1 part cement: 1 part coarse sand 2 parts coarse aggregate by volume. The coarse aggregate shall be very hard like granite and well granted between 6mm and 12mm. Minimum quantity of water to get workability shall be added.

c) **Laying of Monolithic Topping**

The concrete base shall be laid as per specification "cement concrete" and levelled up to the required grade. The form shall remain sufficiently protruding to take the finish.

With in about 3 hours of laying the base while it is still fully "green" the topping shall be laid evenly to proper thickness and grade. If considered necessary the surface of the base shall roughened by the Engineer, mechanical vibrators of suitable design shall be used to press the topping firmly and work vigorously and quickly to secure full bond with concrete base.

The latency brought to the surface during compression shall be removed carefully without disturbing the stone ships. The surface shall then the lightly trowel led to remove all marks. When sufficiently set, hand trowel ling shall be done to secure a smooth surface without disturbing the stone chips.

For large areas the laying shall be in panels of maximum 16 Sq.M. area. The panels shall be laid in chequered board pattern.

d) **Laying of Topping Separately on Hardened Base**

The base concrete shall be prepared as stated in clause 2.0.3 and a slurry of neat cement applied just prior to laying the Granolithic concrete mix (1:1:2). The method of compaction etc., shall be same as monolithic topping.

e) **Curing**

Immediately after laying, the finish shall be protected against rapid drying. As soon as the surface head hardened sufficiently, it shall be kept continuously moist for at least 10 days by means of wet gunny bags or pouring of water on the surface. The floor shall not be exposed to heavy traffic during this period.

f) **Grinding**

If grinding is specified, it shall start only after the finish has fully set, Clause 2.1.3 © shall be followed. However, the ultimate polish required shall be decided upon by the Engineer.

g) **Finishing**

Where specified, sodium silicate or magnesium or zinc silica fluoride treatment shall be done. The number of coats to be applied shall be as specified in the Schedule of items. The concentration and method of application of the solutions shall be as specified in IS:5481.

2.1.5 **PATENT STONE**

It shall consist of an under bed and a topping laid on an already laid and matured concrete base.

a) Thickness

The patent stone finish shall have thickness as stipulated under clause 2.1.2(a) except that the topping shall be 6mm thick.

b) Mix

i) Under bed

The mix shall be as stipulated under clause 2.1.3 (b)

ii) Topping

The mix for the topping shall consist of 1 part cement and 1 part fine sand by volume.

c) Laying

The Patent Stone finish, including the under bed shall be laid in alternate bays or in chequered board pattern. No panel shall be as in contact with another already laid till the concentration of the latter has already taken place.

The maximum area of each panel shall be 3 SQ.M. of which no side shall be more than 2 M long.

Unless otherwise specified the total thickness of the finish shall be minimum 50 mm horizontal and 25mm for vertical surface of which the topping shall (not less

than 10mm) while the topping shall be of uniform thickness the under bed may vary in thickness to provide necessary slope. The vertical surface shall project out 6mm from the adjacent plaster or other finishes. Necessary cutting into the surface receiving the finish shall be done to accommodate the specified thickness.

All junctions of vertical with horizontals shall be rounded neatly to uniform radius of 25mm.

e) **Mix**

i) The underbids for floors and similar horizontal surface shall consist of a mix of 1 part cement, 2 parts coarse and 4 parts 10 mm down graded stone chips by volume. For vertical sand similar surface the mix shall consist of 1 part cement to 3 parts coarse sand by volume.

ii) For the topping cement, screened through a fine mesh and red oxide of iron pigment powder similarly screened shall be dry mixed thoroughly in right proportions to produce the desired colour when laid. The mix shall then be prepared with 1 part cement (mixed with pigment) and 3 parts coarse volume. The whole quantity required for each visible area shall be prepared in one batch to ensure uniform colour.

f) **Laying**

The under bed shall be laid in panels of mixing area 5 Sq.M. each and no side shall be more than 2.5m long. For outdoor locations the maximum area shall be 2.0 Sq.M. The forms for the panels shall have perfectly aligned edges to the full depth of the total thickness of finish. If specified aluminium or glass dividing strips shall be used.

The panels shall be laid in alternate bays or in chequered board pattern. No panel shall be cast in contact with another already laid, until the contraction of the latter has taken place. The under bed shall be laid, compacted, levelled and brought to proper grade with a screed or float. The topping shall be placed after about 24 hours while the under bed is still somewhat 'green' but firm enough to receive the topping. The surface of the under bed shall be roughened for better bonding. The topping shall be rolled for horizontal stress and thrown and pressed for vertical areas to extract all superfluous cement
And water to achieve a compact dense mass fully boned with the under bed.

The topping shall then be levelled up by trowel ling and finished smooth with a slurry made with already prepared cement and pigment mixture. About 2.0kg of the mixture shall be consumed/per Sq.M. for horizontal surface and 1.0 kg, for vertical surface. The surface shall be cured for seven days by keeping it moist.

g) **Polishing**

About 16 hours after laying when the surface has hardened sufficiently it shall be polished with polishing stone till a smooth shiny surface to the satisfaction of the Engineer, is achieved. The finish shall washed and cleaned just before handing over.

2.1.6 **TERROZO FINISH: IN SITE**

It shall consist of an underbids and a topping laid over an already laid and matured concrete base.

f) **Thickness**

Unless, otherwise specified the total thickness of the finish be minimum 550mm for horizontal and 25mm for vertical surface of which the topping shall be not less than 10mm. While, the topping shall be of uniform thickness the under bed may vary in thickness to provide necessary slopes. The vertical surface shall project cut 6mm from the adjacent plaster or other finish. Necessary cutting into the surface receiving the finish shall be done to accommodate the specified thickness.

g) **Mix**

i) **Under bed**

The under bed for floors and similar horizontal surface shall consist of mix of 1 part cement, 1 ½ parts sand and 3 parts stone chips by volume. For vertical surface the mix shall consist of 1 part cement to 3 parts sand by volume. The sand shall be coarse. The stone chips shall be 10mm down well graded. Only sufficient water to be added to give a workable consistency.

ii) **Tapping**

The mix for the tapping shall be composed of cement colour pigment, marble chips. Proportions of the ingredients shall be such as to two produce the terrazzo of colour texture and pattern approved by the Engineer. The cement shall be white or grey or a mixture of two to which pigment shall be added to achieve the desired colour. To 3 parts of this mixture 1 part marble powder by volume shall be added and thoroughly mixed dry. To 1 part of this mix 1 to 11/2 parts of marble chips by volume shall be added and thoroughly mixed dry again.

The pigment must be stable and non fading. It must be very finely ground. The marble powder shall be from white marble and shall be finer than IS Sieve No.:30. The size of marble chips may be between 1 mm to 20mm.

Sufficient quantity to cover each visible area shall be prepared in one lot to ensure uniform colour. Water to make it just workable shall be added to quantity that can be used up immediately before it starts to set.

h) **Laying**

The under bed shall be laid in panels. The panels shall not be more than 5 Sq.M. in area of which no side shall be more than 2.5 M long, for exposed location the maximum area of panel shall be 2.0 Sq.M. The panel shall be laid in alternate bays or chequered board pattern. No panel shall be cast in contact with another already laid until the latter has contracted to the full extent.

Dividing strips made of aluminium or glass shall be used for forming the panels. The strips shall exactly match the total depth of under bed plus topping.

After laying, the under bed shall be levelled compacted and brought to proper grade with a screed or float. The topping shall be laid after about 24 hours while the under bed is still somewhat 'green' but firm enough to receive the topping. A slurry of the mixture of cement and pigment already made shall be spread evenly and brushed in just before laying the topping. The topping shall be horizontal areas and thrown and pressed for vertical area to extract all superfluous cement and water and to achieve a compact dense mass fully bonded with the under bed. The surface of the topping shall be trowel led over, pressed and brought to a smooth dense surface showing a minimum 7% area covered by marble chips in a even pattern of distribution.

i) **Curing**

The surface shall be left for curing for about 12 to 18 hours and then cured by allowing water to stand on the surface or by covering with wet sack for four days.

j) **Grinding and polishing**

When the surface has sufficiently hardened it shall be watered and ground evenly with rapid cutting coarse grade (no. 40) grit blocks, till the marble chips are exposed and the surface is smooth. Then the surface shall be thoroughly washed and cleaned. A grout with already prepared mixture of cement and pigment shall be applied to fill up all pinholes. The surface shall be cured for 7 days by keeping in moist and then ground with fine grit blocks (no:120). It shall again be cleaned with water, the slurry applied again to full up any pinholes that might have appeared and allowed to be cured again for 5 days. Finally, the surface is ground a third time with very fine grit blocks (no:320) to get smooth surface without pinhole. The grinding shall be done by a suitable machine. Where grinding machine can not be used hand grinding may be allowed when the first rubbing shall be with carborundum stone of coarse grade (no:80) and final rubbing and

polishing with fine grade (no:120). The surface shall be cleaned with water, dried and covered with solid free, clean sawdust if directed by the Engineer. The final polishing shall be positioned till before handing over the surface shall be dusted with oxalic acid at the rate of 0.33 gm. Per/Sq.M. water sprinkled on to it and finished by buffing with felt or Hessian bobs. The floor shall be cleaned with soft moist rag and dried. However, all excess wax polish to be wiped if and the surface to be left glossy but not slippery.

2.1.7 **GRANOLITHIC FINISH**

Granolithic finish shall either be laid monolithically over base concrete or separately over hardened base concrete.

h) **Thickness**

The finish shall be average 20 mm and minimum 12 mm thick, unless specified otherwise.

i) **Mix**

The mix shall consist of 1 part cement: 1 part coarse sand 2 parts coarse aggregate by volume. The coarse aggregate shall be very hard like granite and well granted between 6mm and 12mm. Minimum quantity of water to get workability shall be added.

j) **Laying of Monolithic Topping**

The concrete base shall be laid as per specification “cement concrete” and levelled up to the required grade. The from shall remain sufficiently protruding to take the finish.

With in about 3 hours of laying the base while it is still fully “green” the topping shall be laid evenly to proper thickness and grade. If considered necessary the surface of the base shall roughened by the Engineer, mechanical vibrators of suitable design shall be used to press the topping firmly and work vigorously and quickly to secure full bond with concrete base.

The latency brought to the surface during compression shall be removed carefully without disturbing the stone ships. The surface shall then the lightly trowel led to remove all marks. When sufficiently set, hand trowel ling shall be done to secure a smooth surface without disturbing the stone chips.

For large areas the laying shall be in panels of maximum 16 Sq.M. area. The panels shall be laid in chequered board pattern.

k) **Laying of Topping Separately on Hardened Base**

The base concrete shall be prepared as stated in clause 2.0.3 and a slurry of neat cement applied just prior to laying the Granolithic concrete mix (1:1:2). The method of compaction etc., shall be same as monolithic topping.

l) **Curing**

Immediately after laying, the finish shall be protected against rapid drying. As soon as the surface head hardened sufficiently, it shall be kept continuously moist for at least 10 days by means of wet gunny bags or pouring of water on the surface. The floor shall not be exposed to heavy traffic during this period.

m) **Grinding**

If grinding is specified, it shall start only after the finish has fully set, Clause 2.1.3 © shall be followed. However, the ultimate polish required shall be decided upon by the Engineer.

n) **Finishing**

Where specified, sodium silicate or magnesium or zinc silica fluoride treatment shall be done. The number of coats to be applied shall be as specified in the Schedule of items. The concentration and method of application of the solutions shall be as specified in IS:5481.

2.1.8 **PATENT STONE**

It shall consist of an underbed and a topping laid on an already laid and matured concrete base.

**d) Thickness**

The patent stone finish shall have thickness as stipulated under clause 2.1.2(a) except that the topping shall be 6mm thick.

**e) Mix**

i) Underbid

The mix shall be as stipulated under clause 2.1.3 (b)

ii) Topping

The mix for the topping shall consist of 1 part cement and 1 part fine sand by volume.

**f) Laying**

The Patent Stone finish, including the under bed shall be laid in alternate bays or in chequered board paten. No panel shall be as in contact with another already laid till the concentration of the latter has already taken place.

The maximum area of each panel shall be 3 SQ.M. of which no side shall be more than 2 M long. A cement group shall be applied and worked into the surface to receive the finish, the under bed then laid, compacted and levelled to proper grade with a screed or float. The topping shall be applied evenly on the under bed while it is not fully set but firm enough and rolled and pressed to get full bond. The topping shall be trowel led to a dense finish to the satisfaction of the Engineer. All trowel mark shall be mopped out with a soft cloth to give a clean smooth surface.

After the surface is sufficiently set, the finished floor shall be kept moist for 7 days for curing. If desired the finish shall be polished as directed by the Engineer.

2.1.9 **METALLIC HARDENER LIKE "IRONITE" FINISH**

This will consist of a topping (incorporating iron particles) to bond with concrete base while the latter is "Green">

a) **Thickness**

Unless otherwise specified the metallic hardener finish shall be of 12 mm depth.\

b) **Material**

The hardening compound shall be uniformly graded iron particles free from non-ferrous metal impurities, oil, grade, sand soluble alkaline compounds or other injurious materials. When desired by the engineer, actual sample shall be tested.

c) **Mix**

Proportion of the metallic hardener shall be as specified or as indicated by the manufacturer. However, in absence of any such direction 1 part metallic hardener shall be mixed dry with 4 parts cement, by weight. To this mixture 8 mm nominal size stone chips shall be added in proportion of1part cement (mixed with hardener) to 2 parts of stone chips by volume and uniformly mixed.

Minimum quantity of water shall be added to make it workable.

d) The concrete floor shall be laid as per specification :Cement Concrete" and

levelled up to the required grade. The forms, if any shall remain sufficiently projecting to take the finish the surface shall be roughened by wire brush as soon as possible.

The finish shall be laid while the concrete under bed still very "green" within about 3 hours of laying of the latter. The finish shall be of uniform thickness and even dense surface without trowel marks, pin holes etc. This topping layer shall be pressed firmly and worked vigorously and quickly to secure full bond with the concrete base. Just when the initial set starts the surface shall b e finished smoothened with steel trowel.

2.1.10 **MASTIC ASPHLAT FINISH**

This is a one layer treatment on concrete or brick base.

a) **Thickness**

The thickness shall be as specified in the drawing or schedule of items.

b) **Materials**

Bitumen shall be industrial bitumen of the graders 90/15 and 74/15 conforming to IS:702.

Mineral filler shall be dry stone dust passing through 75 micron IS Sieve,

Fine aggregate shall be crushed and graded natural lime stone or other hard-work.

Coarse aggregate shall be crushed siliceous stone or other approved aggregate 6 mm stone chips shall be used for finish up to 20mm thick &10mm chips for thicker finish.

c) **Composition**

Bitumen mastic shall conform to IS:1195 and shall be either brought to site blocks weighing about 25 Kg. Or prepared at site. If brought in blocks, these shall be remelted in mechanically agitated mastic cookers and coarse aggregate, preferably, preheated fed in successive portions until the complete change is thoroughly incorporated. At no stage during the remelting and mixing process, shall the temperature exceed 205 deg.C.

d) **Laying**

The hot mastic shall be laid on dry base surface cleaned thoroughly by wire brushing and sweeping. The mastic shall be levelled and when cooled to some extent shall be finished with a wooden float with addition of small quantity of fine sand if required. No load shall be allowed till the finish has cooled to normal temperature.

The mastic shall be laid in suitable panels of about 15 Sq.M. in area each formed by formers. Succeeding panels be laid over lapping the finish panel so as to melt its edges and form a continuo finish without joint.

2.1.0 **CHEMICAL RESISTANT IN SITU FINISH**

Chemical resistant in situ finish shall be as epoxy resin with suitable filler material over a primer or called for in the Schedule of item. The minimum thickness shall be 6mm. About its performance the Engineer shall have to be fully satisfied by test results and examination of similar treatment already in Existence. The Contractor shall get it done by a specialised manufacturer, get guarantee of performance from the organization and pass it on to the Owner in addition to his own guarantee.

2.2.0 Tiled Finish

These shall include finish tiles, stone slabs and similar manufactured or natural items over already laid and matured base of concrete or masonry by means of an underbed or an adhesive layer.

2.2.1 Terrazzo Tile Finish

The finish will consist of manufacture terrace tile and an underbed.

a) Thickness

The total thickness including the underbed shall be minimum 40 mm for floors 30 mm for walls unless otherwise specified.

The skirting, dado and similar vertical surfaces shall project out 6 mm uniformly from the adjacent plaster or other wall finishes. The necessary cutting into the surface receiving the tiled finished, to accommodate the specified thickness shall be done.

b) Tiles: Terrazzo

The tiles shall, unless specifically permitted in special cases by machine made under quality control in a shop. The tile shall be pressed hydraulically to a minimum of 140 Kg. per Sq. Cm.

Each tile shall bear on its back permanent and legible trade mark of the manufacturer. All angles of the tiles shall be right angles all arises shape and true, colour and texture of the wearing face uniform throughout. Maximum tolerance allowance length and breadth shall be + or _ 1 mm and the thickness + 3 mm. Face of the tile shall be plane, free from pin holes and other blemishes.

The tiles shall be composed of a backing and topping. The topping shall be of uniform thickness not less than 10 mm.

The total thickness including the topping shall be as specified but not less than 20 mm in any case.

The topping shall be as specified under clause 2.1.3 (b)

The tile shall be cured at the shop for at least 14 days before delivery to the site. First grinding shall be given to the tiles at the shop before delivery. Tiles shall be packed properly to prevent damage during transit and storage. The tiles must be carefully stored to prevent staining by damp, rust, oil, and grease or other chemicals.

Tiles made in each batch shall be kept and used separately so those colours of each area of the floormay remain uniform.

The manufacturer shall supply along with the tiles the grout mix containing cement and pigment is exact proportions as used in topping of the tiles. The containers for the grout mix shall be suitably marked to relate it to the particular type and batch of tiles.

c) Mix: Underbed

Underbed shall be same as CI. 2.1.2 (b) (1).

d) Laying

The underbed mortar shall be evenly spread and brought to proper grade and consolidated to a smooth surface. The surface shall be roughened for better bond. Before the underbed had time to set and while it is still fairly moist but firm, cement shall be hand dusted over it or a cement slurry applied and the tiles shall immediately be placed upon and firmly pressed by wooden mallet on to the underbed until it achieves the desired level. The tiles shall be kept soaked for about 10 minutes just before laying. The joints between tiles shall be as close as possible and not more than 1.5 mm wide.

Special care shall be taken to check the level of the surface and the lines of the joints frequently so that they are perfect.

When tiles are required to be cut to match the dimensions these shall be sawn and edges rubbed smooth. The location of cut tiles shall be planned in advance and approval of the Engineer taken.

All the junction of horizontal surface with vertical surface the tiles on the former shall enter at least 12 mm under the latter.

After fixing, the floor shall be kept moist and allowed to mature undisturbed for 7 days. Heavy traffic shall both be allowed.

If desired dividing strips as specified under Clause 2.1.3 © may be used for dividing the work into suitable panels.

c) Grinding and Polishing

Procedure shall be same as Clause 2.1.3 © 2. Grinding shall not commence earlier than 14 days after laying of tiles.

2.2.2 The finish shall consist of manufactured grey or coloured cement tiles or terrazzo tiles with chequred face and an underbed laid over concrete or brick surface.

a) Thickness

Thickness shall be same as in clause 2.2.1 (a)

b) Tiles: Chequred

The tiles shall have chequres not less than 2.5 cm c/c and not more than 5 cm c/c. Depth of grooves shall be not less than 5 mm. The grooves shall be uniform and straight.

The tiles shall conform to clause 2.2.1 (b) except that these may have the topping interrezzo or plain grey cement of colour pigment added to cement as specified.

c) under bed

As per Clause 2.2.1 ©

d) Laying

As per Clause 2.2.1 (d)

e) Grinding and Polishing

As per Clause 2.2.1 (e) except that the tiles shall be ground and polished by hand after laying taking special care in polishing the grooves properly and uniformly.

2.2.3 Glazed Tiles Finish

This finish shall be composed of glazed earthen ware an under bed laid over a concrete or masonry base.

a) Thickness

The total thickness shall be between 20 mm and 25 mm including the under bed.

The tile finish on vertical surface shall project out 6 mm uniformly from the adjacent plaster or other wall finishes. The necessary cutting into the surface receiving the finish, to accommodate the specified thickness shall be done.

b) Tiles: Glazed

The tiles shall be of earthenware, covered with glaze white or coloured, plain or with designs, of 150 mm x 150 mm nominal sizes and 10 mm thick unless otherwise specified. The tolerance shall be + or - 1.5 mm for length and breadth and + or – 0.5 mm for thickness specials like internal and external angles, beads, covers, cornices, corner pieces etc., shall match. The top surface of the tiles shall be glazed with a gloss or matt unfading stable finish as desired by the Engineer. The tiles shall be flat and true to shape. The colour shall be uniform and fractured section shall be fine grained in textures, dense and homogenous. The tiles shall be strong and free from flaws like cracks, craze, spaces, crawling, etc., and other imperfections. The edge and the underside of the tiles shall completely free from glaze and the underside shall have ribs or indentations for better anchorage with the fixing mortar.

The coloured tiles, when supplied, shall preferably come from one batch to avoid difference in colour.

c) Mix: Under bed

The mix for the under bed shall consist of 1 part cement and 3 parts coarse sand y weight mixed with sufficient water or any other mix if specified.

d) Laying

Same as Clause 2.2..1 (d)

e) Finishing

The joints shall be cleaned and flush pointed with white cement and cured for 7 days by keeping it wet. The surface shall be cleaned with soap or suitable detergent, washed fully and wiped with soft cloth to prevent scratching before handing over.

2.2.4 Tesserae Finish (Mosaic etc.)

This finish consists of manufactured vitreous, glass, ceramic or similar hard small pieces set in an under bed over a concrete or masonry surface, already laid.

a) Thickness

The total thickness including the under bed shall be between 16 mm and 23 mm.

b) Tessa Rae Finish

These shall usually be 6 mm thick small piece of ceramic vitreous china, thinted glass or similar hard weaing, strong, and durable material in desired shapes and sizes and patterns.

The supply shall come in the desired pattern in full or sections conveniently for handling, stuck topieces of strong thick paper on the surface to be exposed. The gum used for this purpose must be water soluble and non-staining. The sections shall be properly marked to avoid mistakes and master drawing shall be available at the site for guidance.

c) Mix: Underbed
Same as Clause 2.2.3 ©

d) Laying

The specification for laying if given by the manufacturer of the item shall be followed provided it is approved by the Engineer, otherwise Clause 2.2.3 (d) shall generally be followed. However, instead of grey cement the slurry shall be made with white cement to fix the panels. The paper mounted patterns in sections shall be carefully placed and pressed in position true to lines and levels. Earliest possible the paper shall be peeled off and surface examined and cleaned, joints flush pointed with white cement and cured for 7 days by keeping it wet.

2.2.5 Chemical Resistant Tiled Finish

This shall include all varieties of special tiles used for specific chemical resistance function and an underbed over already laid concrete or masonry.

a) Tiles

The chemical resistant tiles as detailed in the Schedule of items shall be of the best indigenous manufacture unless otherwise specified and shall be resistant to the chemical described in the Schedule of items. The tiles shall have straight edges, uniform thickness, plain surface, uniform non-fading colour and textures.

Glazed tiles if permitted to act as chemical resistant Finish shall be considered under Clause 2.2.3

Usually the chemical resistant tiles shall not absorb water more than 2% by weight. The tiles shall have at least compression strength of 700 Kg/cm$^2$. The surface shall be abrasion resistant and durable.

b) Laying

The mortar used for setting or for underbed the tiles shall be durable and strong. The group which shall be to the full depth of tile shall have equal chemical resistant properties. Joints shall be pointed if so desired. The setting and fixing shall be according to the manufacturer's specification approved by the Engineer.

2.2.6 Rubber, Vinyl or Vinyl Asbestos Tiles Finish

This shall include various types of tiles manufactured item rubber, vinyl, etc, set with a adhesive on concrete or masonry base. An underbed may be required to secure desirable surface and grade.

a) Thickness

The thickness of the tiles shall be mentioned in the Schedule or in drawing.

b) Tiles

Unless otherwise, desired the tiles shall be squares of approved dimensions. The tolerance shall be + / - 1.5 mm.

The face of the tiles shall be free from porosity, blisters, cracks, embedded foreign molters or either physical defects which affect appearance or serviceability. All edges shall be cut true and square. The colour shall be non fading and uniform in appearance, insoluble in water and resistant to alkalies, cleaning agents and usual, floor polishes.

Each tile shall be marked on the back legibly and indelibly with manufacturer's trade mark, the thickness, sizes, batch number and date of manufacturer.

Tiles shall be delivered securely packed and stored in clean, dry well ventilated place at a temperature near about to that the tiles shall be called upon to stand ultimately. Adhesive to be used for sticking the tiles shall be approved by the tile manufacturer. The adhesive shall have a short drying time and long life in addition to toughness.

c) Mix: Underbed

The under bed where required to make up the specified thickness or to give the required grade or to get the right type of surface shall be composed of 1 part like putty: 1 part cement: 4 parts coarse sand with just sufficient water to make it workable.

d) Laying

The tiles shall be kept in the room to be tiled for at least 24 hours to bring them to the same temperature as the room. For air-conditioned space, the air-conditioning shall be completed before tiling is taken up.

The surface to receive this finish shall be firm even textured but not too smooth, without undulations and other deficiencies. If an underbed is laid the same shall be cured for at least 7 days by keeping it moist and then fully dried.

The surface shall be thoroughly cleaned. All loose dust particles shall be removed. Oil and grease if any shall be completely cleaned by use of detergent.

The adhesive shall be applied to fully dry surface in desired thickness uniformly. The adhesive shall also be applied to the backs and edges of the tiles and allowed to surface dry. The tiles shall be placed neatly on the surface exactly to the approved pattern and set with a suitable tool. If the edges tend to curl, weights are to be used to keep the edges down. Special care shall be taken to avoid formation or air pockets under the tiles. The joints shall be very fine. Any adhesive squeezed out through the joints shall be removed immediately.

c) Finishing

If any adhesive mark is there on the surface a soft cloth soaked in solvent shall be used to wipe it off. The surface shall be cleaned with soft soap, dried and polished with as approved type of polish just before handing over.

2.2.7 Stone slab finish: Marble, Stone and Similar Fine Grained Stone

a) Thickness

The underbed shall be minimum 12 mm and average 20 mm thick. The slabs may be 25 mm., 30 mm or 40 mm thick as specified.

b) Stone Slab

The stone slabs shall be made from selected stock which are hard, sound, homogenous and dense in texture and free from flaws. Angles and edges shall be true, square, free from chipping and surface shall be plane. The slabs shall preferably by machine cut to the required dimensions. Tolerance or + / - 5 mm in dimensions and + / - 2 mm. in thickness will be allowed. Unless specified the slabs shall be minimum 300 mm x 300 mm.

The stone slabs shall come from specific regions and in specified quality with top surface fine chisel dressed. All sides shall also be fine chisel dressed to the cull depth to allow finest possible joints.

The slabs shall be delivered to the site well protected against damages and stored in dry place under cover.

c) Mix: Underbed

Same as Clause 2.2.1 ©

d) Laying

The sides and top surface of the slabs shall be machine rubbed or table rubbed with coarse sand stone and washed clean before laying.

The underbed mortar shall be evenly spread and brought to proper level on the area under each slab. The slab shall be laid over the underbed, pressed and tapped down with wooden mallet to the proper level. The slab shall then be lifted and the underbed corrected as necessary and allowed to stiff on a little. Next, a thick cement slurry shall be buttered with slurry of cement, grey/white/mixed with pigment matching the colour of the stone slabs. The slab shall be gently laid and tapped with wooden mallet to bed properly to a vary find joint and to the required level. All surplus cement slurry shall be removed and the surface mopped clean with wet soft cloth. The laid finish shall be cured for 7 days by keeping it wet.

e) Polishing, Finishing

Fine chiselling shall be done to remove the slight undulations that usually exist at the joints. The polishing and finishing shall be done as specified under Clause 2.2.1 (e). However, the joints shall be so fine in the case of stone slabs that grouting shall not be called for.

2.2.8 Stone Slab Finish: Sand Stone and Similar Coarse Grained Stone Finish

Generally Clause 2.2.7 shall be followed except that the workmanship and finish shall not be fine as which are explained hereunder.

The slabs shall be rough chiselled or fine chiselled as specified. Tolerance may be allowed up to + / - 6 mm for rough finish, but no sharp unevenness and shall be allowed. For fine chiselling the unevenness shall be limited to + / - 2 mm.
The sides shall be chisel dressed at least to half slab depth so that the maximum deviation from straight line shall be within 25 mm. Beyond this depth the edge may be slightly splayed.

The joint thickness shall be kept limited to 5 mm in case of rough finish and 3 mm in case of fine finish unless wider joints are specified. The joints shall be grouted with white or coloured cement.

3.0.0 ACCEPTANCE CRITERIA

The finish shall be checked specially for:

a) Level, Slope, Plumb as the case may be

b) Pattern and symmetry

c) Alignment of joints, dividing strip etc.

d) Colour, texture

e) Surface finish

f) Thickness of joints

g) Details at edges, junctions etc.

h) Performance

i) Precautions specified for durability

4.0.0 RATES

Rates shall be for the complete finishing work including necessary forms, underbed, sticker and preparation of the surface including cutting and chipping to receive the finish but exclusive of the base unless specially included in Contract.

The dividing strips in case of in situ terrazzo finish shall be included in the rates. Similarly, indentations, lay in desired patterns and in panels shall be inclusive in the rates.

All necessary cutting tiles, slabs, etc., cost of specials if any shall be included in the rates. No extra shall be paid for rounding corners and edges. Unless, specifically mentioned otherwise, same rules will apply to floor skirting, dado, treads, nosing etc.

5.0.0 METHOD OF MEASUREMENT

The finished surface shall be measured for area. Any opening less than 0.1Sq.M. (and 0.05 Sq.M. in case of marble finish only) shall not be taken into account neither any extra shall be paid for it.

For terrazzo finish, either in situ or tiled shall be paid at the same rate unless mentioned separately in the Schedule of Items.

Except in case of in situ terrazzo finish and unless mentioned in the Schedule dividing strips shall be measured in length.

6.0.0 I.S. CODES

Important relevant codes for this section:

IS:777 : Glazed earthen ware tiles

| | | |
|---|---|---|
| IS:1196 | : | Code of practice for laying bitumen mosaic flooring. |
| IS:1197 | : | Code of practice for laying of rubber floors. |
| IS:1237 | : | 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 site terrazzo floor. |
| IS:3641 | : | PVC asbestos floor tiles. |
| IS:4660 | : | Specification for acid resistant bricks |
| I:5516 | : | Code of practice for laying of flexible PVC Sheet and tile Flooring |
| IS:5491 | : | Code of practice for laying site Granolithic floor topping. |

# GLASS AND GLAZING

| REV. NO. | PRAPARED | APPROVED | DATE |
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## 1.0 SCOPE

The work in general shall consist of supplying and supplying fixing all glass and glazing including all clips, putty, mastic cement etc., whatever required as shown on drawings and specification, supply of metal glazing beads and neoprene gaskets shall not be included in this scope.

This shall also include the fixing of all glass and glass supplied by the Owner at his site stores.

## 2.0 INSTALLATION

### 2.1 General

The Contractor shall supply and install all glass and glazing as required for various doors, windows, sashes, ventilators and fixed louver, miscellaneous glazing and partitions, unless otherwise stated from approved manufacturer like Hindustan Pilkinton or equivalent, having uniform refractive index and free from flaws, specks and baubles. The glass shall be brought to site in the original packing from the manufacturer and cut to size at site. The cut edges shall be straight and free from chips, spalls or any other damages.

**Materials**

a) Glare reducing or heat absorbing glass shall be “Calorex” of Hindustan pilkington or approved equivalent and special care shall be taken to grind smooth and round off the edges before fixing or as specified in schedule of items

b) Clear glass shall be flat drawn sheet glass and shall be at least 4 mm thick. Sheet glass for doors shall be minimum 5.5 mm thick or as specified in schedule of items

c) Wired glass shall be thick rolled glass with centrally embedded 24c, wire mesh of Georgian type. This may be of clear or colored glass, as shown in drawings or schedules.

d) Obscure glasses shall have a cast surface in one side.

e) Colored and floured glass shall be as per approved sample.

f) In general, the party shall conform to IS : 400 and be of best quality from approved manufacturer. It shall be brought to site in the manufacturer’s original packing; Quick setting putty glass is used where it shall be non-setting type. Type and thick of glasses shall be as per schedule of items.

g) Neoprene gasket with snap-fit glazing heads shall be fixed as per manufacturer's instructions and shall sit snugly against glass to give a leak proof installation.

**2.3 Glazing, Setting and Finish**

All glazing clips, bolts, nuts, putty mastic cement etc., as required shall be supplied by the contractor.

All glass shall be thoroughly cleaned before putting in position. Each be supplied shall be held in place by special glazing clips of approved type. As specified in relevant I.S: Codes, four glazing clips shall be provided per glass pane, except for large panes were six or more clips shall be sued as per Engineer's instruction. All holes that may be necessary for holding the clips glazing heads and all other attachments shall be drilled by the Contractor.

Glass panes shall be set without springing and shall be bedded in putty and back puttied, except where molding or gasket are specified, putty, mastic cement etc., shall be smoothly finished to the even line and figured glass shall be set with smooth side out.

Where glass will be supplied by Owner, the contractor shall cut it to size and fix them in the same as specified above.

Necessary glazing clips, putty, mastic cement etc., shall be supplied by the contractor. The Contractor shall be responsible for damage of Glass supplied by the owner. During handing, transportation, fixing etc., maximum wastage allowance shall be 5%

After completion of glazing work, the contractor shall remove all dirt stains, excess putty etc., clean the glass panes and leave the work in perfectly acceptable condition. All broken cracked or damaged glass shall be replaced by new ones at the contractor's own cost.

**3.0 ACCEPTANCE CRITERIA**

a) All installation shall be free from cracked, broken or damaged glass. Edges of large panes of thicker glass and heat absorbing glass shall be inspected carefully for chipped, cracked or underground edges.
b) Glazing shall be carefully done to avoid direct contact with metal frames .
c) Al glass be embedded in mastic or fixed by neoprene gaskets to give a leak proof installation.
d) At completion, the shall be free from dirt. Stains, excess putty etc. to the complete satisfaction of the engineer.

**4.0 RATES**

a) Rates shall be unit retes for supply and/or installation of different kinds of glass mentioned in the Schedule of items.
b) No separate payment shall be made for glazing clips, mastic Cement, putty, nails etc., for drilling holes in frames for inserting glazing clips.
c) No separate payment shall be made for cutting of glass to required size. Edge finishing etc., if the glass is supplied by the contractor.
d) Payment shall be made for cutting of glass to required size edge finishing etc., if the glass is supplied by the owner.
e) No separate payment shall be made for cleaning the glass after installation.

**5.0 METHOD OF MEASUREMENT**

a) All supply and /or installation of glass shall be measured for actual area of work done.
b) When glass is supplied by the owner, the cutting of glass shall be measured for actual length of cut edges.

**6.0 I.S. CODES**

Following are some of the important I.S. Codes relevant to this Section ;

IS: 3548 – Code of practice for glazing in building.

IS: 1083 – Code of practice for fixing and glazing metal doors, windows & ventilators.

# METAL DOORS, WINDOWS, VENTILATORS, LOUVERS ETC.

| REV. NO. | PREPARED | APPROVED | DATE |
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## 1.0.0 SCOPE

The work in general shall consist of supplying and/or erecting and installing of all metal doors, windows, ventilators, glazed partitiorts, etc., as shown on drawings, with all materials complete excluding supply of glass and glazing. The scope of work shall also include the assembly and erection of all doors, windows, louvers, glazed partitions, etc., for which fabricated materials shall be supplied by the Owner from the store of site. Supplying and/or fixing of all door and window accessories and hard ware is also included in the scope.

## 2.0.0 INSTALLATION

### 2.1.0 Materials

Steel sections used for fabrication of doors, windows etc., shall be standard rolled steel sections specified in IS: 1038 and IS: 1361 or as specified in drawings and schedules.

Steel sheets for frames, shutters, louver blades etc., shall be of gauge mentioned in drawings and schedules.

Aluminum sections for fabrications doors, partitions etc., shall be extruded sections conforming to IS : 1048 and 1940 or as manufactured by Indian Aluminum Company Limited or approved equivalent. The alloy used shall conform to IS Designation He 9-wp of IS : 733.

Hardware and fixtures shall be as specified in " Schedule of Fixture" and the best quality from approved manufacturers shall only be used. The Tendered shall specifically state the particular manufacturer's materials he proposes to use "schedule of Fixtures" is for the purpose of stating the minimum requirement and improper alignment or faulty operation due to inadequate strength of Hardware of fixing shall entirely be the Contractor's responsibility.

All Hardware and fixtures shall be able to withstand repeated use Door closures shall conform to IS : 3564 and shall be suitable for doors weighing 61-80 kg unless otherwise stated in schedule. Each closer shall be guaranteed against manufacturing defect for one year and any defect found within this period shall be rectified or the closer replaced free of charge. Concealed door closures shall be either floor mounted of transom mounted. Suitable for installation with metal doors. It shall conform to the performance requirements and endurance test stated in IS : 3564- Appendix A.

The contractor shall submit samples of each type of hardware to the Engineer The approved samples shall be retained by Engineer for comparison of bulk

supply. The samples shall be returned to the contractor towards the end for incorporation in the job.

The mastic for caulking shall be of best quality from a manufacturer approved by the Engineer in general, the for fixing of metal frames shall be as per IS : 1081 and /or as approved by the Engineer.

**2.2.0 Fabrication**

**2.2.1 Steel Doors, Windows, Ventilators, Louvers etc.**

**a) Door Frames**

Frames shall be fabricated from 16 g sheets. They shall be mortised, reinforced, drilled and lapped for hinges and lock and bolt strikes, where necessary, frames shall be reinforced for door closures. Welded construction with mired corners shall be used. Rubber door silencers shall be furnished for the striking lamb. Loose "T" masonry anchors shall be provided. Frames shall finish flush with floor and adjustable floor anchors shall be supplied. Frames shall be brought to site with floor ties/weather bats installed in place.

**b) Double plate Flush Door Shutters**

Door shutter shall be 40 mm thick, completely flush design and shall comprise of two outer sheets or 18 G steel sheets, rigidly connected and reinforced inside with continuous vertical 20 C stiffeners, spot welded in position at not more then 150 mm on centers.

Both edges of doors shall be joined and reinforced full height by steel channels placed immediately inside and welded to the door faces. Top and bottom of doors shall be reinforced horizontally as shown on drawing by steel channels running full width of door. Doors shall not have more then 2.5 mm clearance at jambs and heads, shall be reinforced at corners to prevent sagging or twisting. Pairs or double doors shall have meeting – stile edges beveled or rebated. Where shown on drawing or called for in the schedule of items. The doors shall be sound deadened materials.

Doors shall be mortised, reinforced, drilled and tapped in shop for hinges, locks and bolts. They shall also be reinforced for closures. Push-plates and other surface hardware where necessary, any drilling and tapping required for surface hardware shall be done at site. Where shown in drawing, provision shall be made for fixing glazing, vision panels, louvers etc., glazing moldings shall be of 18 G steel or extruded aluminum sections with profiles shown in drawings and suitable for

fixing 6 mm glass. Louvers blades shall be v or z shaped and made out of 16 g sheets.

**c) Single Sheet door shutters**

Single sheet doors shall be made from best quality 18 G mild steel sheets, and shall present a flush surface on the outside. The inside shall be stiffened with semi-tubular edge and central stiffening rail which shall convey the lock and other furniture. The frames shall be made from best quality 16 G mild steel sheets.

Whenever required as shown on drawings, provisions for fixing glass panes, louvers etc., shall be made.

The manufacturing shall be done as specified in 2.2.1 (b) “Double plate Flush Door Shutters”.

**d) Sliding Doors**

Sliding doors shall be double plate or single plate construction as called for in drawing and schedules made out of 18 gauge steel sheets with adequate stiffeners. The Contractor shall specify the weight of the door in his shop and submit the manufacture’s catalogue of the sliding gear he proposes to use. Where shown on drawing or call for in the Schedule of items, the Contractor shall make provision for openings to the door for mono- rail beams. Doors shall make positively to exclude rain water from seeping in when called for in schedule, sliding doors shall withstand specified under all ambient conditions.

**e) Door Threshold**

Door threshold shall be provided as shown on drawings. Doors without threshold shall have Boston tie of approved type.

**f) Steel Windows, Sashes, Ventilators etc.**

These shall conform in all respects to IS : 1038 and IS : 1361 latest editions and as shown on drawings. The details as called for in the above codes shall be applicable for coupling mullions, transoms, weather bars, pivot arrangements for ventilators, etc., or as shown on drawings or called for in the Schedule of items

All welds shall be dressed flush on all exposed and contact surfaces.

Where composite unit openings are shown on drawings ,the individual window units shall be joined together, with requisite rooms and mullions

as shown on drawings. All windows shall be outside glazed fixed with putty or metal glazing beads as shown on the drawings and/or specified, under Schedule of items.

All welds shall be dressed flush on all exposed and contact surfaces.

Where composite unit opening are shown on drawings, the individual window units shall be joined together, with requisite rooms and mullions as shown on drawings. All windows shall be outside glazed fixed with putty or metal glazing beads as shown on the drawings and/or specified under Schedule of items. Where aluminum glazing beads are specified, they shall be extruded aluminum channel :3 mm x 9.5 mm x 1.6 mm (India: section No. 2209) unless otherwise shown on drawings, Aluminum beads shall be given one coat of zinc chromate primer before fixing to windows.

**2.2.2 Aluminum Door, Windows and Frames**

Extruded sections shall have a minimum 3 cm wall thickness. All sections shall be approved by the Engineer before fabrication is taken up. Doors, frames mullions, transom etc., shall be anodized in a bath of sulfuric acid to provide a mullions, coating of minimum 0.6 mm thickness. The anodized materials shall then be sealed by immersing in boiling water for 15 minutes. A protective transparent coating shall be applied to the sections before shipment from the factory.

All work shall be fitted and shop assembled to a fist class job, and ready for erection. Shop joints shall be made to hair lines and then welded or braced by such method as will produce a uniform color throughout the work, work on the above, other then described, shall be carefully fitted and assembled with neat joints with concealed fasteners. Wherever possible, joints shall be made in concealed Locations and on edges of doors filed connections of all works may be made with concealed screws of other approved type of fasteners Glazing beads shall be snap fit type without visible screws and shall be of size to accommodate 6 mm thick glazing. All work shall be adequately braced and reinforced as necessary for strength and rigidity.

**2.2.3 Shop Coat or paint**

The shop paint for steel doors, Widows etc., shall be lead of zinc chromate primer paint from approved manufacturer. All surfaces shall be toughly cleaned of rust, grease, loose, mill scales etc., and even one coat of shop paint.

Portions like mullions, transoms etc., which will be inaccessible after assembly of units shall be given an extra coat of paint before assembly.

Where called for in the schedule of items, all steel doors, windows, etc, shall be hot dry galvanized to give a coating weight of 1-1/2-2 or per sft. One coat zinc chromate primer coat shall than be applied as shop paint.

Portions of aluminum frame which come in contact with masonry construction, shall, before shipment from work shop, be protected with a heavy coat of alkali paint. Aluminum coming in contact with other incompatible metals shall be coated with zinc chromate primer.

**2.4.0 Handing & Storage of Fabricated Material**

All metal doors, windows, etc., shall be packed and crated properly before dispatch, to ensure that there will be do no damage to the fabricated materials boarding into wagons and trucks shall be done with all care to ensure safe arrival of materials at site in undamaged condition.

When taking delivery of items supplied by Owner, the Contractor shall satisfy himself that the items supplied are upto the specified standard. Any defect detected shall promptly be brought to the notice of the Engineer.

All metal doors, windows etc., shall be stored under cover in a way to prevent damage or distortion. Special care shall be taken to prevent staining of aluminum products by rest, mortar etc.,

**2.5.0 Assembly & Erection at Site**

In general, the fixing of steel doors, windows, ventilators, louvers, etc., shall conform to IS : 1081 and as shown on drawings. The Contractor shall assemble and install all steel doors, windows, sashes, fixed metal louvers, etc., including transoms and mullions for composite units in respective places as shown on drawing, keeping proper lines and levels, and in approved workman like manner, to give trouble free and leak-proof installations. The installation shall be done according to the instructions of the manufacturer and/or as approved by the Engineer. If required by the Engineer, the installation shall have to be carried out under the supervision of the manufacturer's staff. The Contractor shall take every precaution against damage of the components during installation. Necessary holes, chases, etc., required for fixing shall be made by the Contractor and made good again as per original, after installation, without any extra charge.

After installation of steel doors, windows, etc., all abrasions to shop- coat of paint shall be retouched and made good with the same quality or paint used in shop – coat.

All coupling mullions, shall be well bedded I mastic. The Contractor shall bring to the site the mastic cement in original sealed containers of

manufacturer and shall apply it as per the instructions. For all frames supplied by either the Owner or the contractor, mastic shall be supplied by the contractor and caulking done properly as per drawings, specifications and as per instructions of the Engineer.

Door shutters, partitions hardware fixtures etc., shall be fixed only after major equipments have been installed rooms.

Wherever required nylon cords of approved quality shall be supplied alone with pivoted sashes and shall be of adequate length to terminate one meters from the floor. Lose ends of cords shall end in metal or plastic pull as approved by the Engineer.

## 3.0.0 ACCEPTANCE CRITERIA

### 3.1.0 For fabricated items

a) Over all dimensions shall be within $\pm$ 1.5 mm of the size shown on drawings.

b) Mullions, transoms etc., shall be in one length and permissible devotions from straightness shall be limited to $\pm$ 1.5 mm from the axis of the member.

c) Door and window shutters shall operate without jamming. The clearance at head and jamb for door shutters shall not exceed 1.5 mm. For double leaf doors, the gap at the meeting stiles shall not be more then 1.5 mm.

d) Door leaves shall be under cut where shown on drawings.

e) Doors, windows, frames, etc., shall be on a true planes, free from warp or buckle.

f) All welds shall be dress flush on exposed and contact surfaces.

g) Correctness of location and smoothness of operations of all shop installed hardware and fixtures.

h) Provision for hard ware and fixtures to be at site.

i) Glazing beads shall be cut with mired corners.

j) Glazing clips, fixing devices etc., shall be supplied in adequate numbers.

k) Shop coats shall be properly applied.

l) Exposed aluminum surfaces shall be free scratches, stains, and discoloration. Anodized surfaces shall present a uniform and pleasing look.

**3.2.0 For installed Items**

a) Installation shall be at correct location , elevation and general, on a true vertical plane

b) Fixing details shall be strictly as shown on drawings.

c) Assembly of composite units shall be strictly as drawings with mastic caulking of transoms and mullions, gaskets, weather strips etc., complete.

d) All frames on external walls shall be mastic caulked to prevent leakage through joint between frames and masonry.

e) All openble section shall operate smoothly without jamming.

f) Locks, fasteners etc., shall engage positively keys shall be non-inter changeable.

g) Cutting to concrete or masonry shall be made good and abrasions to shop paint shall be touched up with paint of same quality as shop paint.

h) Aluminum doors, windows, etc., shall be free from scratches, stain or discoloration.

**4.0.0 INFORMATION TO BE SUBMITTED**

**4.1.0 With Tender**

a) Names of manufacturers for doors, windows etc.,

b) Manufacturer's catalogue for all hardware and fixtures proposed to be used.

**4.2.0 After Award**

a) Before starting fabrication of all metal doors, etc., the contractor shall submitted detailed fabrication drawings to the engineer for approval. The fabrication shall be started only after approval of drawings.

b) He shall submit a program of work to be done for the approval of the Engineer.

c) Before bulk supply he shall submit for the approval of Engineer samples of all bought out items and samples of each type of fabricated items. The samples shall be retained by the Engineer for comparison of bulk supply and returned to contractor towards the end for final incorporation in the job.

## 5.0.0 RATES

Rates shall be unit rates for the complete work including supply installation and painting. All mullions and transoms, vision panels, louvers to doors, glass and glazing including glazing beds, weather stripping, fixing devices hinges, aldrops, lower bolts, mortise locks etc., shall be included in the rates. The rates shall also including cutting and/or grouting to concrete and jamming of frames and making good concrete and masonry and other related work. Only items specifically mentioned under 6.0.0 or in the Schedule of items shall be separately measured.

## 6.0.0 METHOD OF MEASUREMENT

a) Supply and installation including painting of doors shall be measured in $m^2$. The types shall be as shown on drawings and described in Schedule of Items.

b) Supply and installation including painting of windows shall be measured in $m^2$.

c) Supply and installation including painting of louvers shall be measured for area of opening in which the louver is to be installed.

d) Insulation between door faces shall be measured for actual area and paid separately over the basic rate doors.

e) Door closures shall be measured in actual numbers used, if not specifically included in the description of door item in the schedule.

## 7.0.0 I.S.CODES

Following are some of the important I.S Codes as relevant to this section :

| | | |
|---|---|---|
| Steel doors, windows and ventilators | - | IS : 1038 |
| Steel windows for industrial buildings | - | IS : 1361 |

| | | |
|---|---|---|
| Aluminum doors windows and ventilators | - | IS : 1948 |
| Aluminum windows for industrial buildings | - | IS : 1949 |
| Steel door frames | - | IS : 4351 |
| Code of practice for fixing and glazing of metal (Steel and aluminum doors windows ventilators. | - | IS : 1081 |

# ROLLING STEEL SHUTTERS AND GRILLS

| REV. NO. | PRAPARED | APPROVED | DATE |
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## 1.0 SCOPE

This specification covers the design, supply of materials fabrication, delivery and erection of Rolling Shutters / Grills with motor dive and /or mechanical operation including all accessories as here in after specified.

## 2.0 INSTALLATION

### 2.1 Components

a) Slots for rolling shutters shall be made tested bright cold rolled annealed M.S.Strips, not less then 0.9 mm thick shutters up to 3.5 M wide and above, machine rolled at 75 mm rolling centers, interlocking with each other. The profile will be such as to prevent excessive deflection under specified wind load.

b) Rolling grills shall be constructed out of 6 mm dia. Rods at 35 mm on centers running horizontally flexible connected with vertical links spaced not more then 200 mm centers. Alternatively, rolling grills shall be made from perorated slates of approved design reinforced with 6 mm rods.

c) End locks shall be heavy type M.C.I/C.I. and shall be provide at each end of alternate slots unless specified otherwise in the Schedule.

d) Bottom bars shall be finished with two angles not less then 6 mm thick for external shutters. When shown on drawings, a flexible weather strip shall be applied to make tight contact with the floor.

e) Guides shall be of such depth as to retain the shutter under a wind pressure of 100 Kg/Sq.M. or as specified in Schedule.

f) Shafts shall be of steel pipe of sufficient size to carry the torsional load with a maximum deflection of $1/360^{th}$ of span. Grease packed ball bearings or bushings shall be provided for smooth trouble free operation.

g) Hoods shall be formed of not less then 20 gauge steel, suitable reinforced to prevent sag.

h) Locks shall be slide bolt and hasp, or cylinder lock operable from one or both sides. Provision securing hand chin with pad – lock provision for removable handle for hand cranks etc., shall be made as described in Schedule or as described by the Engineer.

i) Power unit shall be suitable for 3 phase, 50 cycle, 400 volts A.C. power supply and shall be either floor or wall mounted unit. The motor shall be of sufficient capacity to move the shutter in either direction as a speed of 0.3 meters per second. In addition to the gear motor each standard power unit shall include a

magnetic brake, a reversing starter with built – in overload protection, a geared limit switch and one push button station located inside the building unless otherwise standard in Schedule or Drawings.

j) Operating chins shall be of tested quality, heavily galvanized and with all ends rounded to assure smooth operation and hand protection.

k) Reduction gears shall be high strength gray cast iron, machine moulded from machine out patterns.

**2.2 Manually Operated Shutters/ Grills**

Manually operated shutters shall be easily operable by one person. The speed of operation shall be about 0.3 meters per second. In general, manually operated shutters shall be push pull type for opening upto 9 Sq. meter in area. Larger shutters shall be either chain and gear operated or crank and gear operated. The crank handle shall be removable. All shutters shall be lockable from one or both side as described in Schedule or as desired by the Engineer.

**2.3 Power Operated Shutters/Grills**

These shall be operable from a push button station conveniently located beside the door or as shown on drawings. One emergency hand chin/crank operation shall also be provided for use in case of failure of the electric system. Where called for in Schedule externally mounted shutters shall be operated by control mechanism located inside the building.

**2.4 Shop Coat**

Shurrers shall be painted with one coat of red lead or zinc chromate primer. Where specified, doors shall be galvanized and subsequently paints one coat of zinc chromate for adhesion of field coat.

**2.5 Erection**

Door shall be installed by the manufacturer or his authorized representative and all work shall be as per manufacturer's instructions. Any drilling or cutting to concrete, masonry etc. shall be made good after erection of shutters and all abrasion to shop coat shall be touched up. All electrical work shall be in strict accordance with the latest Indian Electricity Rules.

**3.0 ACCEPTANCE CRITERIA**

**3.1 Shop Inspection**

After completing the manufacture of the different components of the rolling shutter, an arrangement for shop inspection by the Engineer shall be made to check the conformity with approved shop drawings.

### 3.2 Field Inspection

After installing the shutters, the Contractor shall test the performance of the shutter in the presence of the Engineer. The doors shall be smoothly operable under all ambient conditions. All control and locking devices shall give fault-free performance.

### 3.3 Guarantee

The Contractor shall give one year's guarantee for the successful operation of the shutter. This shall be supported by a separate and unilateral guarantee from the manufacturer of the shutters.

## 4.0 RATES

Rates shall be unit rates for complete items for supply and /or erection of rolling shutters, including all drives, accessories, hardware etc. No extra payment shall be made for cutting, drilling welding grouting etc. to structure for installation of the shutters.

The rates shall include the mounting of controls, wire and wiring from the nearest junction box, conduit and other electrical connections.

## 5.0 METHOD OF MEASUREMENT

a) Rolling shutters or grilling shall be measured for area of opening in which they shall be installed. Attractively, shutters shall measure for actual number of different sizes used.

b) Unless included in the main item, whether stripping at bottom bar and mullions shall be measured separately for length.

c) Cylinder locks shall be for actual numbers used. Pad locks shall be supplied by others.

## 6.0 I.S.CODE

IS: 6248 - Metal rolling shutters and rolling grills.

# ROOF WATER PROOFING INSULATION AND ALLIED WORKS

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1.0.0 SCOPE

This specification covers furnishing installation, repairing finishing, curing, testing, protection, maintenance till handing over of roof water – proofing, insulation and allied works for buildings and at locations covered under the scope of the contact.

2.0.0 INSTALLATION

2.1.0 Grading Underbed

The surface to receive the underbbed shall be roughened and thoroughly cleaned with wire brush and water. Oil patches if any shall be removed with detergent. The surface shall be soaked with water and all excess water removed out before laying of the underbed.

The underbed shall not be laid under direct hot sun and shall be kept in shade immediately after laying so as to avoid quick loss of water from the mix and separation from the roof surface. The underbed shall be cured under water for at least 7 days.

The underbed shall be laid to provide an ultimate run off gradient not less than 1 in 130 and as directed by the Engineer. Upto and average thickness of 25 mm the underbed shall usually be composed of cement and sand plaster. For higher thickness the underbed shall be made with cement concrete.

The Underbed shall be finished to receive the waterproofing treatment direct or insulating of the case may be.

2.1.1 Plaster

The grading plaster shall be average 25 mm thick maximum. It shall consist of cement and coarse sand in the ratio 1:4 normal by volume. The sand and cement shall be thoroughly mixed dry and then water added. Each batch of mix shall be consumed before the initial set starts.

The plaster shall be fully compacted in the desired grade in continuous operation. The surface shall be even and reasonably smooth.

2.1.2 Concrete

The concrete shall be used where the sub grade is more than average 25 mm thick. It shall consist of cement concrete 1:2:4 normal mix by volume with 12 mm down stone chips and coarse sand. The aggregate shall be mixed dry and minimum quantity of water shall be added to made the mix workable.

The mix shall be laid to proper grade, fully consolidated and surface shall be smooth and even.

2.2.0 Insulation

The Tendered shall along with tender send specifications of insulating materials he proposes to use and the proposed method of laying. Before bulk supply, the contractor shall send samples of insulating material to the Engineer, and after approval of the samples, the Contractor shall procure and transport the bulk material to the site. Whenever asked by the Engineer, the Contractor shall furnish test certificates from testing laboratory on the insulating and other properties of the materials.

After laying the insulation the surface shall be made ready as required to receive, the water proofing treatment. If any plastering is used of shall be not lower than of cement sand by volume and not that of 12 mm and it shall be cured for seven days.

2.2.1 Foam Concrete

This shall be of light weight foam concrete of average 50 mm thickness or as specified or as shown on drawings. This may be laid in situ in suitable panels or in pre cast blocks. The insulating properties shall be such that the thermal conductivity shall not exceed 0.125 Kcl/m/$m^2$ h degree C. The weight of the insulating material shall be from 0.3 to 0.5 gm/$cm^3$.

Before starting the laying of foam concrete samples shall be prepared at site and got tested for approval of the Engineer.

The foam concrete laid shall be sufficiently strong to make the usual work load and standard loads expected on the roof. Any damaged portion shall be removed and replaced forth with. Approval of the Engineer shall be taken before laying the waterproofing over the insulation.

While laying the foam concrete, samples from each batch of the mix shall be kept for test if so desired by the Engineer.

2.2.2 Expanded Polystyrene Blocks

The expanded polystyrene block insulation shall be fire retardant quality and shall have a maximum thermal conductivity of 0.26 Kcl m/$m^2$ h degree C. It must be strong enough to withstand without deformation the work load and standard loads expected on the roof.

The Contractor shall lay the expanded polystyrene block as per manufacturer's approved specification. Only specifically experienced workers shall be used for this work. If the

Engineer is not satisfied about the efficiency of the workers the Contractor shall secure manufacturer's supervision at no extra cost to the Owner.

2.3.0 Fillets

Fillets at junction of roofs and vertical walls shall be provided with the same insulating material as provided for the main roof insulation. The fillets shall be 150 mm x 150 mm in size unless otherwise shown on drawings or instructed by the Engineer.

Where there is no insulation over roof slab, fillets shall be cast-in situ cement concrete (1:2:4) normal mix by volume.

2.4.0 Water proofing

Water proofing treatment shall be laid by a specialist firm with long experience in the particular trade.

2.4.1 Bituminous Water Proofing

The waterproofing treatment for roofs with Bitumen Felts shall be done following relevant IS:1346. Bitumen felts shall conform to IS: 1322 and Bitumen Primer to IS:3384.

The bonding materials shall consist of blown type conforming to IS:702 or residual bitumen to IS:73 or a mixture of the two to withstand local conditions of prevailing temperature or gradient of roof surface. The Contractor shall convince the Engineer that the bonding material proposed to be used is suitable for the particular job.

The Contractor shall state the source from where he proposed to procure the materials. Samples of the self finished felt shall be submitted in advance to the Engineer along with test certificates for his review. Test certificates for the bonding materials shall also be submitted and samples, if desired by the Engineer, shall be provided for confirmatory tests. Samples of pea sized gravel shall be submitted if instructed by the Engineer.

Minimum overlaps of 100 and 75 mm shall be given at the end and sides of strips of felt and properly bonded with bitumen. Joints in successive layers of felt shall be staggered.

Normal treatment with one layer of felt, heavy treatment with two layers of felt or Extra Heavy treatment with three layers of felt shall be indicated in the Schedule of items. Brief details of the various treatments shall be as follows:

a) Normal Treatment: Four courses:

1) Hot applied bitumen at the rate of 1.2 kg/$m^2$ Min.

2) Hessian base self finished felt, type 3, grade 1.

3) Hot applied bitumen at the rate of 1.2 Kg/$m^2$ Min.

4) Pea sized gravel at the rate of 0.006 $m^3/m^2$.

b) Heavy Treatment: Six Courses:

With Hessian base felt

1) Hot applied bitumen at the rate of 1.2 kg/$m^2$ Min.

2) Hessian base self-finished felt, type 3, grade 1.

3) Hot applied bitumen at the rate of 1.2 Kg/$m^2$ Min.

4) Hessian base self – finished felt, type 3, grade 1.

5) Hot applied bitumen at the rate of 1.2 Kg/$m^2$ Min.

6) Pea sized gravel at the rate of 0.006 $m^3/m^2$.

Or

With fibre base felt

1) Hot applied bitumen at the rate of 1.2 kg/$m^2$ Min.

2) Fibre base self-finished felt, type 2, grade 2.

3) Hot applied bitumen at the rate of 1.2 Kg/$m^2$ Min.

4) Fibre base self-finished felt, type 2, grade 2.

5) Hot applied bitumen at the rate of 2.5 Kg/$m^2$ Min

6) Pea sized gravel at the rate of 0.008 $m^3/m^2$.

c) Extra Heavy Treatment: Eight courses

With fibre bases felt

1) Hot applied bitumen at the rate of 1.2 Kg/$m^2$ Min.
2) Fibre base self – finished felt, type 2, grade 1.
3) Hot applied bitumen at the rate of 1.2 Kg/$m^2$ Min
4) Fibre base self-finished felt, type 2, grade 1.
5) Hot applied bitumen at the rate of 1.2 Kg/$m^2$ Min.
6) Fibre base self-finished felt, type 2, grade 1.
7) Hot applied bitumen at the rate of 2.5 Kg/$m^2$
8) Pea sized gravel at the rate of 0.008 $m^3/m^2$.

Or

With Hessian base felt

1) Hot applied bitumen at the rate of 1.2 kg/$m^2$ Min
2) Hessian base self-finished felt, type3, grade 1.
3) Hot applied bitumen at the rate of 1.2 Kg/$m^2$ Min.
4) Hessian base self-finished felt, type 3, grade 1.
5) Hot applied bitumen at the rate of 1.2 Kg/$m^2$ Min.
6) Hessian base self-finished felt, type 3, grade 1.
7) Hot applied bitumen at the rate of 1.2 Kg/$m^2$
8) Pea sized gravel at the rate of 0.006 $m^3/m^2$.

However, in special cases, more courses or a combination of fibre bass and Hessian base felts may be asked for

The surface to receive the waterproofing treatment must be cleaned and dried satisfactorily and the Engineer's approval taken before starting the work. If any existing

water proofing treatment is being augmented the pea sized gravel or any other existing top course shall be completely removed and all damaged felts or other defects repaired.

The Engineer may instruct the Contactor to lay part of the stipulated courses at the first instance to be followed later on with the balance courses. This interim finish shall be done with hot bitumen shall be applied to start with after repair of all damages to the already laid course.

After completion the surface shall be cleaned taking care that loose gavels, felt cuttings etc., do not find their way into rain water down comers.

2.4.2 Water proofing by epoxy resin based application

Exposed surfaces of cement concrete, lime concrete or brick work to be treated for waterproofing by the resin based application shall be thoroughly cleaned and the epoxy resin based material to be applied as directed by the manufacturer. The material shall not have any adverse effect on the surface on which it is applied and must stick to it uniformly to make a strong durable bond. It shall not be affected by short duration from fire, sun, light, traffic. The application shall be resistant to growth of fungus and proof against salt petre action. If desired by the Engineer, a sample shall be prepared in advance and tested for waterproofness for 48 hours under 300 mm depth of standing water. The Contractor shall arrange the demonstration by providing free the materials and labours for the application. This item shall carry a guarantee as specified under the relevant item in the Schedule.

2.4.3 Flashing

Unless otherwise stated flashing shall be done in the same way as the water proofing except that the last layer, instead of being finished with pea-sized gravel, shall be finished with two coats of bituminous primer. The flashing shall be extended upto the vertical surfaces as sown on drawing. The flashing shall end in grooves in vertical walls. The grooves shall be at least 65 mm deep and caulked with waterproof mastic cement. The minimum overlap with horizontal roofing felt shall be 100 mm.

Where specified on drawings or directed by the Engineer, metal flashing shall be provided. The metal flashing shall be done as shown on the drawings. The materials shall be 18 G or 22 G.I. sheets, as specified on the drawings and / or as directed by the Engineer.

3.0.0 ACCEPTANCE CRITERIA

The surface level shall be such as to allow quick draining of rains with out leaving any pool any where. The finishing course shall be fully secured and shall have an even

density. There shall not be any bubble formation or crushed or squeezed insulation or underbed.

The Contractor shall give a guarantee in writing for all works executed under this specification supplemented by a separate and unilateral guarantee from the specified agency for the roof water-proofing treatment work. The guarantee shall be for materials and workmanship for 5 years in case of normal treatment, 10 years for heavy treatment and 20 years for extra heavy treatment. The mode of execution of the guarantee shall be acceptable to the Owner.

4.0.0 RATES

Rates shall be for complete work as detailed in the specification unless any particular portion is specifically excluded in the Schedule of items.

5.0.0 METHOD OF MEASUREMENT

The method of measurement for various items of works shall be in general as per IS: 1200 and in particular, as specified below:

5.1.0 Garding Underbed

a) Plastering

a) All plastering etc., shall be measured on actual area laid

b) For openings, sleeves, pipes, etc., whose sides are not plastered, as deductions shall be made for openings upto 0.1 Sq.m in area each, and full deductions shall be made for openings above 0.1 Sq.M each.

c) No extra shall be paid for finishing around openings, sleeves, pipes, ducts, inserts, etc.,

d) Sides of plasters, projections, etc., shall be measured for actual size.

e) No measurements shall be made for rounding and chamfering junctions, corners, etc.,

ii) Concrete

Actual volume of work shall be measured in Cum and deducions for openings, conduits, pipes ducts, etc., made but no deductions shall be made for openings upto 0.1 Sq.M in area shuttering shall not be paid for separately.

5.2.0 Insulation / Water proofing / flashing

a) These shall be measured on actual area laid in Sq.M. No deductions shall be made for openings, pipes, sleeves, etc., upto 0.1 Sq.M in area each
b) If cast-in situ insulation is done, no separate payment shall be made for from work, etc.,
c) No separate payment shall be made for laps in waterproofing flashing etc.
d) No separate payment shall be made for finishing round roof drains.
e) No separate payment payment shall be made for rounding, chamfering etc., of junction, corners etc.,
f) No separate payment shall be made for cutting grooves and keying the flashing in the groove.
g) Metal flashing shall be measured in Sq.M of finished area done.
h) No payment shall be made for cutting, wastages, materials left over etc., which shall be the property of the Contractor.
i) Fillets shall be measured for actual work done in R.M.
j) No separate payment shall be made for plastering or similar items required for laying the water proofing felt.

6.0.0 I.S CODES AND STANDARD

| | | | |
|---|---|---|---|
| a) | IS:73 | : | Paving Bitumen |
| b) | IS:702 | : | Industrial Bitumen |
| c) | IS:1203 | : | Methods of testing tar and bitumen |
| d) | IS:1322 | : | Bitumen felts for waterproofing and damp proofing |
| e) | IS:1346 | : | Code of practice for waterproofing of roofs with bitumen felts |
| f) | IS:3384 | : | Bitumen primer for use in water-proofing and damp proofing |

# FALSE CEILING

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## 1.0 SCPOE

The work under this Section shall include the supply and installation of suspended ceiling using insulation/acoustic boards/plain asbestos sheet. Aluminium panels, plaster of pairs boards, 'Prespex' etc., together with the materials labour and equipment. The work shall also include providing of openings in the ceiling for lighting, air conditioning diffusers etc., as shown on drawings or instructed by the Engineer.

## 2.0 INSTALATTION

## 2.1 Suspension system

## 2.2 GENERAL

Suspension system shall consist of the grid supporting the ceiling panels, intermediate runner supports for the grid if any and hangers, wall angles etc., required to suspend the grid or the runners from structural walls, slabs and beams or trusses proved factory made handing system as approved by the Engineer may be used.

All member of the suspension system shall be of sufficient strength and rigidity to carry the ceiling boards or sheets in a true and level plane without exceeding a deflection of $1/360^{th}$ of their span. All joint s in ceiling panels shall run straight and cross joint shall be at perfect right angles. Angle moulds where shown in drawings shall be suitable anchoring device. For installation including welding of the suspension system shall be included in the rate. All MS sections used for supports etc. shall be given one coat of synthetic enamel paint over a coat of red lead primer. All wood supports shall be painted with two coats of Solignum or other approved wood preservative before erection.

### 2.1.2 METAL GRID SUSPENSION SYSTEM

Aluminium grid ceiling system shall be "Bead lock" as manufactured by W.A. BEARDSHALL AND Co or Ajit India Ltd, or approved equal, Steal grid ceiling system shall be "jolly snap Grip" as manufactured by Anil Hardboards Ltd, or approved equal.

The Contractor shall ensure that the frame to support the ceiling is designed for its structural strength to withstand the weight of ceiling boards to be fixed, live load of 75 $Kg/Cm^2$ , and other loads such as that of air-conditioning ducts, grills, electrical wiring and lighting fixtures, thermal insulation, etc., as shown on the drawings. The Contractor shall also submit a detailed drawings to shown the grid work, sizes of grip members method of suspension position of openings for air-conditioning and lighting, access doors etc.

Angles cleats or other suitable fixing device be fixed to the structural beam or slab above for fixing of hangers Main runners shall be hung by M>S flats, angles rods or 12g or heavier galvanised tie wire hangers at maximum 1.2 m centres. Extra hangers shall be provided at light fixtures that are supported from the ceiling system. The spacing of main and cross runners shall be as shown on drawings. Turn buckles shall be provided in M.S. rods for adjustment in levels.

The cross-trees shall intersect main runners in pattern shown on drawing and positively locked together with intersection clips. All parameter areas shall have angles mouldings fixed to vertical wall surfaces and end trees shall rest on the moulding, unless otherwise shown on drawings.

As the work of false ceiling may be interconnected with the work of air-conditioning ducts and lighting, the contractor shall fully cooperate with other agencies entrusted with the above works and who may be working simultaneously. The Contractor shall provide necessary openings in the false ceiling work for air-conditioning lighting and other fixtures. Additional framing, if required for the above openings shall also be provided at no extra cost to the Owner. Removable or hinged type inspection or access trap door shall be provided at locations specified by the owner.

## 2.2. CEILING PANELS

### 2.2.1 MATERIALS

Ceiling panels shall be of best quality materials in thickness and properties call for in the “Schedule of Item”. The Contractor shall submit test certificates to the Engineer for approval before bulk supply. The Ceiling panels may be of the following types manufactured by reputed manufacturers:

a) Plaster of Pairs boards
b) Expanded polystyrene insulation boards
c) Fibre insulation boards
d) Wood particle boards
e) Perforated Aluminium Panels
f) Mineral wood Ceiling tiles
g) Glass fibre reinforced polystyrene sheets
h) Flat asbestos sheets

Acrylic plastic sheets, translucent or figured glass sheets, moulded plastic louvers, etc., if used shall be from approved manufacturers and thickness specified in schedule.

### 2.2.2 INSTALLATIONS OF CEILING PANELS

Installation of Ceiling panels shall be strictly as per manufacturer’s instruction.

For exposed grid ceiling system, the hold down clips shall be used at the rate of maximum one per 1.2 meter length of perimeter. These shall however be omitted in access panels which shall be located as per the instruction of the Engineer.

For concealed grid ceiling system, tiles shall be fixed to the supporting grid in manner shown on drawing or as specified by the manufacturer, where V joints in tiles are called for in drawings, these shall be in true lines. Where flush surface is required, the joints shall be filled with approved filler material and finished to give a neat uniform surface. Where shown on drawings and schedule finished to give a neat uniform surface. Where shown on drawings and schedule of items, 6 mm thick cement : sand (1:3) plaster shall be applied on the under surface of ceiling boards and finished in a true and even surface without undulations suitable for subsequent painting. Special care shall be taken to neatly finish the ceiling at junctions with walls, light fixtures diffusers etc.

## 3.0 SAMPLES

Samples of acoustic panels and metal suspension system components as noted below shall be submitted for Architects approval:

Acoustic panels: 3 samples approximately 300mm square each.

Suspension system: 3 short sections each of main and secondary system

## 4.0 SHOP DRAWINGS

Shop drawings shall be submitted for approval as required and approval obtained prior to delivery of ceiling components. Shop drawings shall be co-ordinated with all related work and shall shown the following information:

a) A reflected ceiling plan of areas indicated to receive the ceiling showing electrical and mechanical features.

b) Typical intermediate framing for support where required.

c) Hanger fastening details

d) Acoustical-unit support at ceiling penetrations

e) Details of splicing methods for main and cross runners

f) A table indicating load bearing capacity of main and cross turners.

g) A note stating that the suspension system member furnished will not deflect more than 1/360 of a 1.2 meter span under the indicated loadings.

## 5.0 FINISHING

**5.1** It is essential that the false ceiling work should be firm and in perfect line and level and all boards free from distortion, bulge and other defects. All defective boards and other material shall be removed from site immediately and replaced, and ceiling restored to original finish to the satisfaction of the Owner.

5.2 The workmanship expected is of the highest order. The joints for aluminium frame work shall be interlocking type so that when the cross member is in place, it cannot be lifted out.

5.3 The fibre board ceiling shall finally be painted with two coats of fire resistant paint of approved manufacture and colour after filling all joints with painters putty.

**6.0 RATES**

Shall be units rates complete items called for in the "Schedule of Items". No extra payment will be made for arrangement for lighting fixtures, air conditioning, diffusers, access panels, etc. The rate shall include all cutting and wastage from standard size sheets, boards, runners etc.

**7.0 METHOD OF MEASUREMENT**

a) Actual area of work done shall be measured.

b) No deduction will be made for opening up to .25 sq.m . in area each.

c) Where a rigid steel framework is required to support the ceiling, it shall be measured and paid separately under relevant item in the Schedule of Items.

**8.0 IS CODES**

IS:2441: Code of practice for fixing ceiling coverings.

# CARPENTRY AND JOINERY

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## 1.0 SCPOE

This shall include supply, fitting and fixing of timber framers to doors and window with M.S. holdfasts, panelled or flush doors, windows, shutters, partitions, wall panelling, pelments, shelves, furniture, etc. as shown in drawings, including a prime coat of approved paint, varnish, or fixing of decorative plastic laminate where called for in the schedule. This shall also include the supply and fixing of all hardware and fixtures shown in drawing or specified in the "Schedule of Fixtures".

## 2.0 INSTALLATION

## 2.1 MATERIALS

**a) Timber**

Unless otherwise specified, all timber shall be best quality well seasoned C.P teakwood free from large or loose, knots cracks or other defects. Where specified, timber shall be treated with approved wood preservative before fuse. Before starting the carpenters work, the Contractor shall have the rough timber approved by the Engineer.

b) **Plywood**

Plywood shall be commercial quality or with decorative surface veneer. Unless specifically permitted otherwise, the adhesive used in plywood shall be phenol-formaldehyde of B.W.R. grade conforming to IS:848.

**C) Decorative laminated Plastic Sheet s**

The colour, pattern, finish and texture shall be approved by the Engineer and the bulk supply procured in sheet sizes which will ensure the least number or joints in one surface.

**d) Flush Doors**

Flush doors shall be hollow or solid core doors with commercial or decorative faces and hardwood edges. The core for solid doors shall be of block board or wood particle board. Manufacture's literature and test certificates shall be submitted for the approval of the Engineer. The Contractor shall give a guarantee that the adhesive used in phenol formaldehyde of BWR grade conforming to is:848. The thickness shall be as specified in the "Schedule of Items".

**e) Panel Doors**

Panel door shall be of teakwood frame unless otherwise noted and panels with teakwood/commercial, ply/teakwood particle board as per "Schedule of item". Other considerations shall be as mentioned in item (d) above.

**f) Fixtures**

Fixture for doors, windows, furniture, etc., shall be as shown on drawing or specified in the "Schedule of Fixture". These shall be of heavy type, best quality and from approved manufacturer.

## 2.2 WORKMANSHIP

### 2.2.1 GENERAL

The work shall be done by skilled carpenters as per details shown on drawing or instructed by the Engineer.

Framing timber and other work shall be close-fitting with proper wood joinery, accurately set to required lines or levels and rigidly secured in place. The surface of frames etc., which will come in contact with masonry after fixing, shall be given two coats of approved paints before fixing external door and window frames. Special care shall be taken to match the grain of timber or plywood which will be subsequently polished. Screwing or nailing will not be permitted to the edge of plywood and particle board. The edge of all plywood, blackboard and particle board shall be finished with teakwood lipping unless otherwise shown on drawings.

Fixing to frames and partitions shall generally be with 40mmx6mmx300mm long M.S holdfasts bifurcated at end and grouted with 1:2:4 cement concrete. The gap between masonry and external door and window frame shall be caulked with poly-sulphide mastic. MS grills or guard bars shall be provided to windows where called for in the drawings or Schedule of items.

### 2.2.2 FINISH

All carpentry work after finishing shall be sand papered smooth. A prime coat paint shall be given after inspection of the Engineer to all surfaces other than those which shall be subsequently polished or covered with laminated plastic sheet.

### 2.2.3 SURFACE TREATMENT

When shown on drawings or called for in Schedule, decorative ply or laminated plastic sheets shall be boned under pressure to the surface to be finished. The adhesive used shall be of approved brand and brought to site in sealed containers. The rate of application and the length of time for which the pressure is to be applied shall be as per the manufacture's instructions. The edges of sheets shall be protected by teak lipping or be levelled as shown on drawings.

## 3.0 ACCEPTANCE CRITERIA

### 3.1 Door and window shutters

All frames shall be squire and flat at the time of delivery and shall be checked for dimensions and corner angles. After fixing they shall be on fine vertical plane. All external door and window frames shall be caulked with mastic.

### 3.2 Door and window shutters

Shall be of proper size, shape and design and tree of warp. When fixed to frames, these shall operate smoothly without jamming and all latching or locking devices shall engage properly without undue pressure.

### 3.3 Partitions, Panelling, Pelmets, Furniture, etc.

#### 3.3.1 GENERAL

These shall conform to drawings in all details. No unsightly nail mark etc., shall be permitted. Plywood grains shall be matched to give a uniform and pleasing appearance.

#### 3.3.2 Partition

Shall be checked for rigidity of fixing, plumb and horizontal as well as vertical alignment.

#### 3.3.3 Pelmets

Shall operate smoothly without jamming and locks, bolts and double ball catches shall engage securely. Single ball catches shall not be used.

#### 3.3.4 Drawers

Shall operate smoothly and have back stops to prevent them from being pushed too far. Locks shall engage securely.

#### 3.3.5 Loose Furniture

When placed on a level surface tables tops etc., shall be horizontal and the pieces stand stably on legs or supports.

## 4.0 RATES

Rates shall be unit rates including preservatives, shop coats, primers varnishing, polishing etc. against items mentioned in schedule. No separate payment will be made for fixing caulking etc., unless separately provided for in Schedule.

## 5.0 METHOD OF MEASUREMENT

### 5.1 Door and Windows Frames, Handrails etc.

Wood work in frames handrails etc., shall be measured for the volume of timber used, i.e., the minimum theoretical rectangular section from which the shape can be obtained, multiplied by the length of timber required. In computing the length, timber required for tenons, scarves, embedding to walls over the finished length shall be added. Mitred pieces shall be measured along the longest length.

### 5.2 Holdfasts

Shall be measured for actual number used.

### 5.3 Door and Windows Shutters

Shall be measured for actual outer area of shutters for different thickness and types described in Schedule.

### 5.4 Glass & Glazing

Shall be measured separately in actual numbers used for different sizes and types described in Schedule.

### 5.5 Fittings and Fixtures

Shall be measured separately in actual numbers used for different sizes and types described in Schedule.

### 5.6 MS Grills & Guard Bars

Shall be measured and paid separately under relevant items.

### 5.7 Partitions, Panelling, etc.

Shall be measured for actual area excluding door shutters. Pelmets shall be measured for length of different types enumerated in the Schedule.

### 5.8 Pelmet, Shelves etc.

Shelves shall be measured for actual area of finished surface. Pelmets shall be measured for length of different types enumerated in the Schedule.

### 5.9 Furniture

Shall be measured for actual number of each type.

## 6.0 IS CODES

Some be measured for actual number of each type.

IS:4021 - Timber door, window and ventilator frames.

IS:1003 - Timber panelled and glazed shutters.

IS:2919 - Wooden flush door shutter (Cellular and hollow core type).

IS:2202 - Wooden flush door shutter(solid core type).

# WATER SUPPLY WORKS

| REV. NO. | PREPARED | APPROVED | DATE |
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## 1.0 SCOPE

This section includes supply of all materials, labour and incidentals for water supply for residential, business and industrial and other types of buildings. The water supply system of a building or premises covers service pipes and the necessary connecting pipes, fittings, control valves and all appurtences in or adjacent to the building or premises.

### 1.0.1 MATERIALS

All materials, fittings, fixtures and appliances shall be of the best quality conforming to relevant Indian Standard and shall be procured from approved manufactures. Unless, specifically allowed by the Engineer, the Contractor shall submit samples of fittings and fixtures which will be retained by him for comparison when bulk supplies are received at the site. Ultimate choice of type mode and manufacturer lies completely with the Engineer.

It shall be the responsibility of the Contractor to procure the materials selected by the Engineer. Hence, orders are to be placed with the manufacturers in time, so that the materials are available at the site well ahead of their requirement.

The materials brought to the site, shall be stored in a separate secured enclosure away from the building materials. Pipe threads, sockets and similar items shall be specially protected till final installation. Brass and other expensive items shall be kept under lock and key. Fragile items shall be checked thoroughly when received at the site and items found damaged shall not be retained at the site.

### 1.0.2 PIPES AND PIPE FITTINGS

Under scope of this Specification, pipes and pipe fittings may be any or a combination of the following type:

a) Cast Iron

b) Steel : Lined, coated with bituminous composition out coated with cement concrete or mortar or galvanised.

c) Reinforced Concrete

d) Prestressed Concrete

e) Asbestos cement

f) Lead (Not to be used for portable water)

g) P.V.C.

h) Cooper

i) Brass

j) Wrought iron

**1.0.3 Water Reservoirs**

Water reservoirs like pressed steel tanks and G.I. tanks shall come under scope of this specification. Reservoirs made of concrete masonry of fabricated steel shall be covered by respective work specifications.

**1.0.4 RELATED WORKS**

All works, like earth work, masonry, concrete, steel work, cutting holes, chases, repairs and rectification associated directly with installation of water supply system shall come under scope of the Contractor unless specifically excluded. These works are not detailed out in this Specification.

**1.0.5 REGULATION**

This work which is required to be carried out under the scope of this section. Shall be executed by a licensed plumber only (engages by the contractor) and he shall obtain all necessary sanctions, permissions, certificates etc., from Municipal and/or other local Authorities and shall abide by the rules of such Authorities. The fee pard to the Authorities shall be reimbursed by the Owner.

**2.0 INSTALLATION**

While basis layout may be available in the drawings provided by the Owner, the details might have to be supplemented by the Contractor for approval of the Engineer.

Special attention shall be given by the Contractor to economy symmetry layout is very important. Fittings meant for operation shall be located and oriented to allow easy reach and operation, Maintenance, repairs and replacements of pipes, fittings and fixtures must be conveniently possible.

**2.1 PIPES LINES**

**2.1.1 LAYING**

In addition to fulfilling the functional requirements shall all pipelines shall be laid true to line, plumb and level. Any deviation shall need approval of the Engineer. Meticulous care shall be taken to avoid chances of airlock and water hammer.

Pipes shall be laid on continuous unyielding surface or an reliable supports at least one near each point and spacing as directed by the Engineer. The support must be strong, neat and shall have provisions for securing the pipes in every

direction and easy maintenance. Pipes shall be encased or concealed in masonry or concrete if shown on drawing or directed by the Engineer.

**2.1.2 BACK FLOW**

The layout of pipe work shall be such that there is no possibility of back flow towards the source of supply from any eastern or appliances, whether by siphon age or otherwise. All pipe works shall be so laid of fixed and maintained as to be to remain completely water-tight, thereby avoiding waste of water damage of property and the risk of contamination of water conveyed.

**2.1.3 CONTAMINATION.**

There shall be no cross connection whatsoever between a pipe of fitting for conveying or containing whole some water and a pipe or fitting for containing impure water or water liable to contamination or of uncertain quality of water which has been used for any purpose.

No piping shall be laid or fixed so as to pass into or through any sewer, scour outlet or drain or any manhole connected there with.

**2.1.4 UNDERGROUND PIPINGS**

Underground piping shall be laid at such a depth that it is not likely to be damaged by traffic and other loads frost, where applicable.

The size and depth of the trench shall be as approved by the Engineer. Back-filling shall be done with selected fine earth, Unless otherwise permitted, in 150mm layers and carefully consolidated. Special care shall be taken while filling in the civinity of the pipe to avoid damage. Before backfilling the laid pipe shall be fully tested and approved.

Where the pipe rest on rock it may be bedded on a layer of fine selected material or concrete to avoid local point support.

The trench shall be so treated by gradient and filling in the area that it does not act as drainage channel.

**2.1.5. CONCEALED PIPING**:

Where desired by the engineer or shown on the drawings the pipes shall be concealed in masonry or concrete of the structure. The contractor may coordinate with the building contractor for leaving the chases, opening, conduits as necessary. However, the contractor will rectify if required the chases, opening, conduits, supplement and make good after laying and testing of the concealed pipelines.

**2.1.6 JOINTING OF PIPES**

Jointing of pipes shall be completely leak proof and durable instruction of the manufacture shall be followed unless desired otherwise by the Engineer. However, usually recommended practices are stated below for guidance.

a) **Cast Iron**

i) **Spigot and Socket Joints**

**Lead joint:**

The joint is made by first caulking in clean spun vain up to depth and filling the remainder by running in mol tern lead taking care that no dross enters the joint and then thoroughly caulking the lead. The lead need not extent into the joint further than the back of the groove formed in the socket. After completing the joint it shall not be allowed to move. For rectification the joint shall. be completely redone.

ii) **Flanged Joints:**

Flanged joints shall be made jointing rings of good quality, smooth and hard compressed fibre board of thickness not lees than 1.5 mm and of such width as fit inside the circle of bolt. Diagonally opposite bolts shall be tightened in pairs in pairs and stages so that degree of all bolts in a joint are similar. Damaged gaskets shall be replaced.

b) **Steel**

Plain ended steel pipes maybe jointed by welding. Screwed and socketed joints shall be carefully tightened. Care shall be taken to remove any burr from the ends of the pipes. Jointing compound, if used, shall be lead free and approved by the Engineer.

c) **G.I Pipes**

Threads shall be cut with sharp tools, and before jointing all scales shall be removed from pipes by suitable means. The screw/thread of the pipe shall be cleaned out and the joint made by screwing the fittings after treating the thread with approved pipe jointing compound. Once a joint has been screwed up it shall not be backed off unless thread are relearned and new compound applied.

d) **Asbestos Cement Pipes**

Socket and spigot ended pipes shall be jointed by caulking with tarred gaskets and grouted with 1:3 cement sand mortar

e) **Lead**

Lead and lead alloy pipes shall be jointed with wiped solder joints.

f) **Concrete**

Concrete pipes may be socket and spigot ended, collar or band jointed. Joint shall be effected by caulking with 1:3 cement sand mortar.

g) **P.V.C**

Manufacturer's instruction shall be followed. For heating approved equipment with adequate control shall be used.

h) **Tyton Joint**

The manufacture's instruction shall be strictly followed in making such joints. Tyton joints shall be made by push-on type specification stipulated by; the pipe manufacturer. The tools specified by the pipe manufacturer shall be used to secure the joint fully.

Where the pipe rests on rock it may be bedded on a layer of fine selected material or concrete to avoid local point support.

The trench shall be so treated by gradient and filling in the area that it does not act as a drainage channel.

**2.1.7 PAINTING**

Where mentioned in the Schedule, underground steel and cast iron pipes shall be given 2 coats of bituminous paint on the outside after laying. When painting is to be done ground G.I. pipes shall be given a coat of zinc chromate primer. C.I. and M..S. pipes shall be given one coat of lead or zinc Chromate primer. Top Coats shall be minimum 2 coats of best quality paint.

**2.2.0 STORAGE TANK- PRESSED STELL TANCK**

Unless otherwise mentioned, water storage tanks shall be pressed steel tanks of nominal size and capacity as mentioned in the Schedule and fabricated with all flanges external, all flanges internal, or button flange internal and side flanges external, as shown on drawings or schedule of items. The fabricator shall supply 6 prints of fabrication drawings to the Engineer for prior approval showing thickness of plates, method of jointing the plates all supports, stays, gussets etc., pads, cleats etc., required for supporting the tanks shall be supplied by the manufacturer. Inlet, overflow vent pipes, manholes etc., shall be arranged and provided as shown on drawing or mentioned in the schedule. Unless otherwise specified, the outlet pipe shall be 50 mm above the bottom of the tank and there

shall be a 150 mm free board at the top of the tank.

All tanks shall be supplied with mosquito-proof covered top with manhole not less than 450 mm diameter. Tanks deeper than 1.00 Meter shall be provided with M.S. internal access ladder adjacent to the manhole water level indicator shall be provided if asked for. Two coats of anti-coats of anti-corrosive paint over a suitable primer shall be applied to both internal and external surface of tanks paint if used shall not impact any taste or odour to water and of lead free composition.

Erection of tanks shall be in accordance with detailed drawings and manufacture's instructions, The two finishing coats of paints shall be applied to outside after erecting is complete.

**2.2.1 G.I. WATER**

G.I. water tanks shall be produced from a reputed manufacturer. The design shall be good enough to withstand the loads safely, Galvanised iron water-storage tank shall be made of minimum 2mm thick galvanised iron sheet. Plain sheets shall be fixed at the corner to angle iron frames by means 6mm rivets at 40mm pitch for tanks up to 100 litters capacity and 8mm rivets at 35mm pitch for tanks for tanks above 1,000 litters capacity. Tanks above 1,000 litters shall have 20mm. Dia. Galvanised iron stay rods, one fixed to angle framing at top and two in the body of the tank for extra strength. Holes for riveting shall be drilled and not punched white lead shall be applied to the joints before riveting.

In case it is desired by the Engineer that corner of tank should be welded instead of riveted then the sheets shall be welded to from a tank will not have angle iron frame.

Tanks shall have 400mm dia. Holes at the top with hinged covers. The covers shall be made of galvanised iron frame. The cover shall be just loose but close fitting to keep out dust and mosquito and will not be airtight. It shall be complete With likable arrangement.

Tanks shall be provided with rising main inlets of 40mm dia. Galvanised iron pipe or as shown on Drawing and 25 mm dia. G.I. overflow pipe. The rising main shall be connected to the tank with a ball valve near the top which disconnects the supply when rank is full up to the point of overflowing.

The ball valve permits the entry of water when the tanks is empty and disconnects The supply when the tank is full. It consists of a hollow floating ball made of copper, plastic or hand rubber. 110mm in diameter, attached to an arm which is so pivoted that the end near the pivot closes the orifice of the main when the ball is raised to the required height of water in the tank and opens the main as soon as the ball drops with the fall of water level as it is drawn off through the distribution pipes. The ball valves shall be fixed to the tank independent of the inlet pipe and

1st in such a position that the body of the ball valve cannot submerge when the tank is full up to the water line. The ball valve shall be so adjusted as to limit the level of the water line. The level of the water in the tank to 75mm below the lip of the overflow pipe. Free surface shall be about 150mm above the maximum water filled level.

**2.2 VALVE, COCKS, TAPS**

All valves, stop cocks, taps etc., shall conform to relevant Indian Standard Specification and shall be of best quality from approved manufacturers. These shall be suitable for working pressures mentioned in the Schedule. Nominal size and material shall be as per schedule.

**2.3 PROTECTION**

Open end of each pipe shall be protected during installation by suitable covers of plugs so that the ends, thread. Sockets or spigot are not damaged and no foreign material can find its way into the pipe line.

Fittings and fixtures liable to be misused or stolen during the construction phase shall be fitted only before testing and handing over.

**3.0 TESTING AND ACCEPTANCE**

**3.1 INSPECTION BEFORE INSTALLATION**

All pipes, fittings, and appliance shall be inspected, before delivery at the site to see whether they conform to accepted standards. The pipes and fittings shall be inspected on site before laying and shall be sounded to disclose cracks. Any defective items shall be clearly marked as reflected and forthwith removed from the site.

**3.2 TESTING OF MAIN AFTER LAYING**

After laying and pointing, the main shall be slowly and carefully charged with water, so that all air is expelled from the main by providing a 25 mm inlet with a stop-cock, allowed to stand full of water for a few days if time permits, and then tested under pressure. The test pressure shall be 5 kg/$Cm^2$ or double the maximum working pressure, whichever is greater. The pressure shall be applied by means of manually operated test pump, or in the case of long mains or mains of a large diameter, by a power driven test pump, provided that the pump is not left unattached. In either case due precaution shall be taken to ensure that the required test pressure is not exceeded. Pressure causes shall be accurate and shall preferably have been recalibrated before the test. The pump having been stopped, the test pressure shall maintain itself without measurable less for at least five minutes. The end of the main shall be closed by fitting a water-tight expanding plug and the plug shall be secured by struts resist the end thrust of the water pressure in the mains.

**3.3 TESTING OF SERVICES PIPES AND FITTINGS**

The service pipes shall be slowly and carefully charged with water allowing all air to escape avoiding all shock or water hammer. The service pipe shall then be inspected under working conditions or pressure and flow when all draw-off taps are closed, the service pipes shall be absolutely water-light. All piping, fittings and appliances shall be checked for satisfactory support and protection from damage, corrosion and frost.

**4.0 RATES**

Rates shall be unit rates for the complete work as mentioned inn the specification unless any particular portion is specifically excluded in Schedule of Items.
If any material, fillings or fixture are provided by the Owner free, The Contractor shall have to take delivery, kept in safe custody and be responsible till fitted and handed over.

**5.0 MEASUREMENT**

For method of measurement regarding works under scope of the specification IS:1200 (part-XVI) latest edition shall be followed unless contrary to the following.

**5.1 TRENCHES**

Unless particular items are included in the schedule, no separate measurement shall be made to lead, lift, de-watering, dressing, sorting, backfilling consolidation etc., that may be required in this connection.

**5.2 CONCRETE MASONRY**

Unless particular items are included in the schedule, no separate measurement shall be made to lead, lift, de-watering, dressing, storing, backfilling, consolidation etc., that may be required in this connection.

**5.3 SOILING**

No separate measurement should be made for dressing and remaining the surface. The soling shall be measured on cross area of the work under the item.

**5.4 PIPE WORKS**

No separate measurement shall be made for special, supports and fixtures, cutting chases, holes and rectification unless specially indicated in the Schedule of items. If the special are separately indicated in the Schedule the measurement for there shall be over and above the measurement of the pipe work as mentioned below:

The pipes of different nominal bores shall be measured separately.

The pipes work shall be measured in inclusive of sockets specials, fittings etc., in position.

**5.5 FIGGINGS AND FIXTURES**

Measurement for fittings and fixtures where applicable shall be in number No separate measurement shall be made anchors unless they from a separate item in the Schedule.

**5.6 CHASES, HOLES**

If items for cutting and remarking of chases, holes and similar works are included in the Schedule the measurement shall be on gross length, area or volume as appropriate.

**5.7 PAINTING**

Painting pipe works shall be measured on the basis of length for different nominal diameters of pipes. Painting of steel work may be on the basis of weight or area otherwise as mentioned against the particular items.

5.6 **I.S. CODES**

Important relevant IS Codes for this Specification are listed below:

Latest editions shall always be consulted.

IS:2065 : Code for practice for water supply in buildings

IS:1172 : Code of basis requirements for water supply drainage and sanitation.

IS:1200 (pt.xvi) : Laying of water and sewer lines including accusant items.

IS:1239 (pt.I&III) : Specification for Mild Steel Tubes and Mild Steel Tubulars and other wrought steel pipe fittings (10 mm to 15mm nominal diameter)

IS:1536 : Specification for Centrifugally cast (Spun) iron pressure pipes for water gas sewage

IS:1537 : Specification for vertically cast iron pressure pipes for water, gas and sewage

IS:3486 : Specification for Cast iron spigot and socket drain pipes (80 mm To 250mm nominal diameter

IS:3589 : Specification for Electrically welded steel pipe for water, gas and sewade (200mm to 2000mm nominal diameter)

IS:784 : Prestressed concrete pipes

IS:458 : Concrete pipes (with or without reinforcement)

IS:783 : Code of practice for laying of concrete pipes

IS:1592 : Asbestos cement pressure pipes

IS:1626 : Asbestos cement pressure pipes, gutters and fittings (Spigot and Socket type)

IS:404 : Lead pipes

IS:3076 : Low density polyethylene pipes for portable water supplies

IS:4984 : High density polyethylene pipes for portable water supplies

IS:2501 : Copper tubes for general purposes

IS:4047 : Brass tubes for general purposes

IS:1230 : Cast iron rain water pipes and fittings

IS:804 : Rectangular pressed steel tanks

# DRAINAGE AND SANITATION

| REV. NO. | PRAPARED | APPROVED | DATE |
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## 1.0 SCOPE

1.1.0 This section covers the layout and construction of drains for roof water, surface water and sewage together with all fittings and fixtures and inclusive of ancillary works, such as connections, manholes, manholes and inspection chambers used within the building and from the building to the connection to a public sewer or to treatment work. Septic tank and soak pit dispersion trenches.

## 2.0.0 INSTALLATION

### 2.0.1 General

All pipe lines, Locations of fittings and fixtures, etc., shall be as per drawings or as directed by the Engineer, Correctness of lines, plumb, orientation, symmetry and levels shall be strictly ensured. All items shall be fully secured against movement in any direction and so located as to allow easy maintenance.

All pipe lines, fittings and fixtures shall be installed leak proof. When the works under scope of this specification linked up with works executed by others, the connections shall be such as to prevent any splashing or emission of foul odour and gases.

### 2.1.0 Rainwater Down corners

Rainwater down corners shall be standards Cast Iron of Asbestos Cement pipes. In case where specifically desired. M.S. pipes may also be M.S. pipes shall be painted outside with two coats or anti corrosive paints under a coat of primer.

Rainwater down corners shall run along and be secured to walls, columns etc., where desired by the Engineer these may have to be installed in chase cut in the structured . All pipes shall be wall secured and supported by adequately strong brackets. The brackets may be wrought iron clevis type, split ring type of perforated strap iron type as approved by the Engineer. For vertical runs each pipe shall hang freely on its brackets fixed just below the socket. Suitable spacer blocks shall be provided against the vertical surface to which the pipe is fixed.

All bends and junction shall be supplied with water tight clean outs.

Proof and floor drains and vard gullies shall be installed. If required by cutting into the structure and grouted with 1:2:4 cement concrete. All gutters shall be provided with removable grating.

All horizontal pipes shall have a minimum fall of 1 in 100.

### 2.1.0 Gutters

The gutters shall be made of G.I. of A.C. All gutters shall be supplied by reputable specialized firms. Each section shall be sufficiently rigid, edges and

corners straight and the slopes perfectly uniform G.I. gutters shall have the edges strengthened by suitable means.

Unless noted otherwise the gutters shall have a minimum fall of in 120. Adequate number of string supports shall be provided so that there is no deflection even when the gutter is full. Each point must have a support. Unless otherwise specified the supports shall be fabricated M.S. brackets. All junctions shall be thoroughly water tight. The joints may be made by riveting, bolting or soldering. All joints between successive lengths of gutters shall have on overlap of at least 5 cm. The drop in the overlap shall always be in the direction of the fall of the gutter. Ends of gutters shall be closed water tight. Junction with rainwater down corners shall be made fully watertight and secured.

**2.2.0 Soil and Drainage Pipes**

**2.2.1 Gradients**

If not specified the minimum gradients of solid and drainage pipes line shall be as follows:

100 mm nominal dia: 1in 35

150 mm nominal dia: 1in 65

230 mm nominal dia: 1in120

300 mm nominal dia: 1in 200

**2.3.2 Relation with water supply pipe lines**

Unless specifically cleared by the Engineer, under no circumstances shall special drainage and soil pipes be allowed to come close to water supply pipelines.

**2.3.3 Laying**

Each separate pipe shall be individually set for line and for level. Where lengths of sewer or drain pipes are laid in trench, properly ; painted sight rails shall be fixed across the trench at a height ,equal to length of the bonding rod fixed across trench at a height, equal to length of the bonding rod to be used, above the required invert level of the drain or sewer at the point where the sight is fixed. More sight rails shall be required at manholes, change of gradient and intermediate positions if the distance for sighting is more then 50 ft. The foot of the wall of the pipe. Each pipe shall be separately and accurately boned between sight rails.

**2.3.3 Support and protection on Pipelines**

All pipes shall be laid with sockets leading uphill, preferably the pipe shall rest on solid and even foundations for the full length of the barrel. However, the

pipe manufacturer's instruction as approved by the Engineer shall be followed in the matter of support and jointing.

To achieve full and continuous support, concrete for bedding and packing is the best. Where pipes are not bedded on concrete, the floor shall be left slightly high and carefully placed so that the pipe barrels rest on undisturbed ground. If anywhere the excavation has been carried too low packing shall be done in concrete. Where laid on rock or very hard ground which cannot be easily excavated to a smooth surface, the pipes shall be laid on a cradle of fine concrete floor of gravel and crushed stone over laid with concrete or on a well consolidated gravel and crushed stone bed as desired by the Engineer. PVC or similar pipes shall be laid directly on stable soil.

The minimum support and protection for glazed stoneware pipes shall be as follows:

a) When cover is less then 2 meter below ground level and where pipes are unavoidably exposed above ground surface, the pipes shall be completely encased or surrounded with concrete.

b) Where pipes are laid on soft solid with the maximum water table rising above the invert of the pipe, the sewer shall be bedded on concrete.

c) Where the pipes have to be laid on soft solid with the maximum water table rising above the invert of the pipe, but below the top of the barrel the pipe sewer shall be hunched.

d) Where maximum water table is likely to rise above the top of the barrel or wherever the pipe is laid on soft soil the pipe sewers shall be completely encased or surrounded with concrete.

Vitrified clay pipe shall be laid on a bed of 150 mm thick cement concrete (1:3:6) nominal mix by volume.

Cast iron pipes and concrete pipes may be supported on suitable concrete or brick support, where specified. The supports shall be located close to ends. Spacing of intermediate supports shall be as decided by the Engineer, Pipes shall be secured to the supports by approved means.

Anchoring of pipes where necessary shall be achieved by suitable concrete encasing designed for the expected thrust.

**2.3.4 Entry into Structure.**

For entry of the pipelines into any building of structure suitable conduit after the structure or sleeves shall be used. The conduits and sleeves shall be such as to allow easy repairs and replacement of the pipes when openings of chases are required to be made in the structure for entry of pipe lines, After laying of the pipeline the opening and chases shall be mended.

**2.3.5 Ducts**

Where solid waste and ventilating pipes are accommodated in ducts, access to cleaning areas shall be provided. Connection to drain shall be through a gully with sealed cover to guard against ingress of sewer gas, vermin or backflow.

**2.3.6 Traps and Ventilating pipes**

Pipes are carrying of the waste from water a closets and water a closed and waste water and overflow water from baths, wash basins, sinks to drains shall be trapped immediately beneath such fixtures. Traps shall have minimum water seal of 50 mm and shall be ventilated whenever such ventilation is necessary to maintain water seal of the trap.

Ventilating pipes shall be carried up vertically the drain to a height of at least 600 mm above the outer covering of the roof of the building or as shown on drawings. All vertical venting, anti – syphonage and similar pipe shall be covered on top with a cowl. The cowl. Shall be made of G.I. unless desired otherwise by the Engineer.

**2.3.7 Manhole and Inspection Chambers**

The maximum distance between manholes shall be 30 meter unless specially permitted otherwise. In addition , at every change of alignment gradient or diameter there shall be a manhole or inspection chamber. The distance between manhole or inspection chamber and gully chamber shall not exceed 6 meters unless desired otherwise. Manhole shall be constructed so as to be water tight under test. The bending at the sides shall be carried out in such a manner as to provide no lodgment for any splashing in case of accidental flashing of the chamber. The channel or drain at the bottom of chamber shall be plastered with 1:2 cement , sand mortar and finished smooth the grade. The channels and drains shall be shaped and laid to provide smooth flow.

Connecting to existing sewer lines shall be through a manhole.

Manholes shall be provided with standard G.I. covers. The covers shall be close fittings so as to prevent gases from coming out suitable heavy duty covers shall be used where necessary as decided by the Engineer.

2.3.8 **Cutting of Pipes**

Manufacture's instructions shall be followed for cutting of pipes where necessary. Suitable and approved tools shall be used for the cutting so as to leave surface clean and squat to the axis of the pipe.

**2.3.10 Jointing**

Jointing of laid pipes shall be so planned as to avoid completely any movement or strain to the joints already made. If any joint is suspected to be damaged it shall be opened out and redone.

All joints between pipes, pipes and fittings and manholes shall be gas –tight when above ground and watertight. When underground Method of jointing shall be as per instructions of the pipe and fittings manufacturer and as approved by the Engineer. However , in the absence of any instruction available from the manufacturer the methods as detailed here under shall be used.

**a) Cast Iron Pipes**

Socket and spigot pipes shall be jointed by the cast lead joints. The spigot shall be centered in the socket of the next pipe by tightly caulking in sufficient turns of tarred gasket or hemp yarn to have unfilled half the depth of socket. When the gasket or hemp yarn has been caulked tightly a jointing shall be placed round the barrel and tightened against the face of the socket to prevent air lock. Molten lead shall then be poured in to fill the remainder of the socket and caulked with suitable tools right round the joint to make up for shrinkage of the molten metal on cooling and shall be finished 3 mm behind the socket face.

Joint in cast iron pipes with special jointing arrangements like 'Tyton' joints etc., shall follow the instructions of the manufacturers.

In special cases if fanged joints are accepted by the Engineer the joints shall be made lead-proof by inserting approved type of rubber gaskets. The bolts shall be secured in stages to avoid uneven strain.

**b) Concrete Pipes**

Care shall be taken to place the collar centrally over the joint.

**c) Glassed Stone water Pipes**

Tarred gasket or hump yarn soaked in thick cement slurry shall first be placed round the spigot of each pipe previously laid . The pipe shall then be adjusted and fixed in the correct position and the gasket caulked tightly so as not to fill more then ¼ of the total depth of the socket. The remainder of the socket shall be filled with a stiff mixture of cement mortar of 1:1 proportion. Then the socket is filled, a fillet shall be formed round the joint with a trowel, forming an angle of 45 deg. With the barrel of the pipe. The newly made joints shall be protected, unit set and shall be covered with damp cloth or other suitable materials.

**d) Vitrified clay Pipes**

The shall be made from refractory clay mixed with crushed pottery and stone and burnt at a height temperature. These shall be hard, compact and glazed to make them acid resistant and impervious, and shall be obtained from approved manufacturer.

Special care shall be taken in handing these pipes. The pipes shall not be jointed until the earth has been partly refilled over the portion of the pipe between the joint holes. Before laying the second pipe, the socket of the first pipe laid shall be thinly painted all round on the inside with cement slurry (1 part of cement and 2 parts of clean, sharp sand ). A ring of rope yarn (closely twisted heap or jute dipped in neat cement paste or tar or bitumen, shall be inserted in the socket or pipe and driven home with caulking tools. The rope shall fully encircle the spigot with a slight overlap and shall not occupy more then one fourth of the total depth of the socket. Where the spigot end of the pipe is made for receiving the gasket, it shall be wrapped with two or three turns of tarred spun, as close to the end as possible, before inserting into the socket. The joint shall then be completely filled with cement mortar (1:1 ) which shall have very little water and leveled to from a splayed fillet at a an angle of 45 degrees with the outside pipe. Special care shall be taken so that any excess mortar etc., left inside the pipe joints is neatly cleaned off immediately after each joint is made . A semi-circular wooden scrapper or a rubber disc to which a long handle is fixed could be used for this purpose.

**e) Lead Pies**

No lead pipes shall be used unless specifically mentioned in the specification. The joints in lead pipes shall be made as wiped solder joint. The minimum and the maximum length of the wiped solder joints shall be 8 cm, and 9cm respectively. The solder shall generally consist of two parts of lead and one part of tin.

**f) Polythylene Pipes**

The joints shall be thermo-welded or bolted as per manufacturer's instructions.

**g) Jointing Cast Iron Pipes with Stoneware Pipes**

Where any cast iron soil pipe, ventilating pipe or trap is connected with a Stoneware or semi-vitrified waste pipe or drain communicating with a sewer, the beaded spigot end of such cast iron soil type, waste or ventilating pipe or trap shall be inserted in to a socket of such stoneware pipe or drain and the joint made with motar consisting of one part of cement and one part of clean shape sand after placing a ratted gasket or hemp yarn soaked in neat cement slurry round the joint and inserted in it by means of a caulking tool.

**h) Jointing Stone ware with Cast Iron Pipe**

Where any water closet pan or earth ware trap connected to such a pan is to be jointed with a cast Iron soil socket, shall always be of a flexible nature. Such joint shall be made with admixture of bitumen and chopped asbestos fibre.

**2.4.0 Trenches and other excavations**

Width of the trench at the bottom shall be such as to provide 200 mm clearance on either side of the pipe for facility of laying and jointing.

Excavated material, shall be stacked sufficiently away from the edge of the trench and the side of the spoil bank shall not be allowed to endanger the stability of the excavation. Spoil may be carted away and used for filling the trench behind the work.

Turf, top soil or other surface materials shall be set aside, turf being carefully rolled and stacked for use in reinstatement.

All excavation shall be properly timbered, where necessary.

Efficient arrangements for dewatering during excavation and keeping it dry till backfilling shall be made to the satisfaction of the Engineer, Sumps for dewatering shall be located away from the pipe layout.

Where the excavation proceeds through roads necessary permissions shall be secured by the Contractors from the appropriate authorities.

Special care shall be taken not to damage underground services, cables etc. These when exposed shall be kept adequately supported till the trench is backfilled.

The backfilling shall be done only after the pipeline has been tested and approved by the Engineer. Special care shall be taken under and sides of the pipe during hand packing with selected material. At least 300 mm over the pipe shall also be filled with soft earth or sand. Consolidation shall be done in 150 mm layers. The surface water shall be prevented from getting into the filled up trench. Traffic shall not be inconvenienced by heaping up unduly the backfilling material to compensate future settlement. All future settlements shall be made good regularly to minimize inconvenience of traffic where applicable.

**2.5.0 Fixtures**

The Tenderer shall mention in his type and make of the fixtures he intends to enclose manufacturer's current catalogues. In the absence of any such agreement, the Engineer shall be at liberty to choose any type and make.

All fixtures and fitting shall be of approved quality and type manufactured by well known manufacturers. All items brought to the site must bear

identification marks of the type of the manufacturer. Procurements shall be made well in advance and inspected and approved, immediately by the Engineer. All fixtures shall be adequately protected, coved and plugged till handed over.

All fittings , gratings, fasteners, unless specified otherwise, shall be chromium plated. The connecting lead pipes and bonds shall weigh at leas 3 kg per 25 mm dia. Per meter length. Where PVC or similar pipes are allowed the Contractor shall produce the test reports and convince the Engineer about their durability.

Unless specified in the contract the fixtures shall be ass specified herein after.

**2.5.1 Water closet**

**a) Raised type**

It shall include glazed vitreous china basin with siphon, open front solid plastic seat and plastic cover, low level glazed stoneware flushing certain with valve less fittings, supply connections and necessary fittings. All fittings shall be chromium plated. Colour of basin , cistern, seal and cover shall be as desired by the Engineer.

b) **Squatting type**

It shall include glazed vitreous chin pan with integrated foot rests and high level cast iron flushing cistern with valve less fittings, supply connections and necessary fittings. All fittings shall be chromium plated. The foot rests shall be made of white glazed vitreous china with grooved surface. The flushing cistern shall be painted as desired by the Engineer.

**2.5.2 Urinals**

It shall consist of wall type glazed vitreous china urinals, cast iron automatic flushing cistern complete with supply connections, flush pipe PVC pipes, gratings, traps and all other necessary fittings. Automatic flushing shall be approximately once every five minutes for a number urinals located together may be served by cistern of adequate capacity. All fitting shall be chrome plated.

**2.5.3 Wash basin.**

It shall be made of glazed viterious china. The basin shall be flat back, wall hung by painted cast iron brackets and complete with pillar Cocks. PVC waste pipes with traps, perforated wasted waste complete with necessary fittings. All fittings, including facets shall be chromium plated. Hot and cold mixer waste

chin and waste washers shall be provided where specified in the Schedule of items.

**2.5.4 Sink**

It shall be made of glazed stoneware. It shall be wall hand by painted cast iron brackets and complete with one brass faucet with nylon washers, chin, waste washers, PVT waste pipes with traps, perforated waste with necessary fittings. All fittings including facets shall be chromium plated.

**2.5.5 Bathroom mirror**

It shall be made of the best quality 6 mm thick beveled glass and produced by a reputed mirror manufacturer. It shall be wall mounted with adjustable revolving brackets. The brackets, screws and other fitting shall be chromium plated, fixed type square edged installed mirrors shall be provided where indicated and flush with the wall face.

**2.5.6 Glass shelves**

Glass shelves shall consist of 6 mm thick clear glass with guard rails and shall be wall mounted with brackets. All brackets, guard and screws shall be chromium plated.

**2.5.7 Towel rail**

Towel rail shall be 20 mm dia . chromium plated MS pipes wall mounted with steel brackets. The brackets, screws etc, shall also be chromium plated.

**2.5.8 Soap holder**

It shall be made of chromium plated strong members. The holders shall be Wall mounted with chromium plated screws.

**2.5.9 liquid soap dispenser**

It shall be round and easily revolving with removable threaded nozzle. The body, bracket for wall mounting and screw shall be chromium plated.

**2.5.10Toilet roll holder**

It shall be made of glazed vitreous china with suitable cover cum cutter Wall mounting screws shall be chromium plated.

**2.5.11Installation**

All plumbing fitting and fixtures shall be installation in most workman like manner by skilled workers. These shall be perfect in level, plump , plane, location and symmetry. All items shall be securely anchored to walls and floors. All cuttings in walls and floors shall be made good by the Contractor.

**2.6.0 Septic tank & effluent disposal**

**2.6.1 Septic tank**

Septic tank shall consist of the tank itself with inlet and outlets there from complete with all necessary earthworks and back fitting. The details of septic tank shall be as shown on drawings. This items shall also including ventilatings pipe of at least 100 mm dia whose top shall be provided with a suitable mosquito proof wire mesh and cowl. Ventilating pipe shall extend to a height of about 2 meter when the septic tank is at least 15 meter away from the nearest building and to a height of 2 meter above the top building when it is located closer then 15 meter. Ventilating pipes can be connected to the normal soil ventilating system of the building where allowed.

**2.6.2 Effluent Disposal**

The effluent from the septic tank shall be disposed by allowing it into an open channel or a body of water if the concerned authority approves or in to a soak pit for absorption by soil or shall be allowed to be absorbed by soil through open pointed SW pipes laid in a trench filled with broken bricks.

2.6.3 **Soap pit**

The soak pit shall be complete as shown on drawings. The pit shall be lined with stone, brick or concrete blocks set in cement mortar (1:6 ) and filled with brick bats. Inlet pipe shall be taken down to a depth of 900 mm from the top as an anti – mosquito measure.

**2.6.4 Open joined SW pipe/Dispersion Trenches**

Minimum dia. Of the SW pipes shall be 150 mm nominal. The trench for laying the pipes shall be minimum 600 x 600 mm pipes. The joint of the pipes shall be left unsealed. The entire length of the pipe within the trench shall be buried in a 250 mm layer gravel or crushed stone of uniform size. On top of gravel/crushed stone layer is a 150 mm bed of well graded coarse aggregate. Ordinary soil is used for filling the top of trench.

**2.6.5 Commissioning Septic tank**

After the septic tank has been proved water tight and the seawater system is checked the tank shall be filled with water to its outlet level before the sewage is let into the tank. . It shall be seeded with well-digested sludge obtained from septic tank or sludge digestion tank. In the absence of digested sludge a small quantity of decaying organic matter such as digested cow- dung may be introduced.

**3.0.0 TESTING AND ACCEPTANCE**

### 3.1.0 Inspection before Installtion

All pipes, fittings and fixtures shall be inspected, before delivery at to see

Whether they conform to accepted standards. The pipes shall again Inspected on site before laying by sounding to disclose cracks. All defective Items shall be clearly marked and forthwith removed from the site.

### 3.2.0 Testing of Pipelines

Comprehensive tests of all pipe lines shall be made by simulating conditions of use. The method of actual testes shall be decided by the Engineer. All test data shall be recorded and submitted to the Engineer for review and instruction. The Engineer's description regarding tolerance shall be final.

General guidance are given below.

**a) Smoke test**

All soil pipes, waste pipes and vent pipes and all other pipes when above ground shall be approved gas tight any a smoke test conducted under a pressure of 25 mm of water and minted for 15 minutes after all trap seals have been filled with water. The smoke is produced by burning oily waste or tar paper or similar material in the combustion chamber of a smoke machine. Chemical smokes are not satisfactory.

**b) Water test**

For pipes other then Cast Iron Glazed ware and concrete pipes shall be subjected to a test pressure of at least 1.5 m head of water at the highest point of the section under tests. The tolerance figure of two liters per centimeter of diameter per kilometer may be allowed during a period of 10 (ten) minutes. The test shall be carried out by suitably plugging the low end of the drain and the ends of connections, if any , and filling the system with water. A knuckle bond shall be temporarily jointed in at the top end and a sufficient length of the vertical pipe jointed to it so as to provided required test head or the top end may be plugged with a connection to a hose ending in a funnel which could be raised or lowered till the required head is obtained and fixed suitably for observation.

Subsidence of test water may due to one or more of the following cases:

a) Absorption by pipes and joints
b) Sweating of pipes of joints
c) Leakage at joints or from defective pipes
d) Trapped air.

Allowance shall be made for (a) by adding water until absorption has ceased and after which the test proper should commence. Any leakage and the defective part of the work shall be cut out and made good.

**For cast iron pipes**

Cast iron sewers and drains shall be tested as for glazed water and concrete pipes. The drain plug shall be suitably strutted to prevent their being forced out of the pipe during the test.

**c) For straightness**

i) By inserting at the high end of the sewer or drain a smooth ball of a diameter 13 mm less then pipe bore. In the absence of obstruction. Such as yarn or mortar projecting through the joint, the ball with roll down the invert of the pipe end emerge at the lower end and

ii) By means of a mirror at one end of the line and lamp at the other. If the pipe line is straight, the full circle of light may be observed. The mirror will also indicate obstruction in the barrel if the pipeline is not straight.

**3.3.0 Tasting septic tank**

The septic tank shall be tested for water tightness. It shall be filled up with water and allowed to soak for 24 hours. Then , it shall be topped up and allowed to stand again for 24 hours and loss of level recorded. The fall shall not be more then 15 mm.

**3.4.0 Fixtures etc.**

All fixtures and fitting shall be connected by water tight joints. No dripping shall be accepted.

**4.0.0 RATES**

Rates shall be unit rates for the complete work as detailed out in the Specification unless any particular portion is specifically excluded in the Schedule of Items.

If any material fittings or fixtures are provided by the Owner free, the Contractor shall have to take delivery, keep in safe custody and be responsible till fitted and handed over.

**5.0.0 MEASUREMENT**

For method of measurement regarding work under scope of this Specification IS: 1200 ( part-XVI ) shall be followed unless contrary to the following:

**5.1.0 Trenches**

Unless particular items are including in the Schedule, no separate measurement shall be made for lead, lifted dewatering, dressing, storing, backfilling consolidation etc., that may be required in this connection.

**5.2.0 Concrete, masonry**

Unless lumped with other items in the Schedule the measurement shall be on gross area or volume basis as mentioned under relevant items.

**5.3.0 Pipe Work**

No separate measurement shall be made for special supports and fixtures, cutting chases, holes and rectification unless specially indicated in the Schedule of items. If the specials and separately indicated in the schedule, the measurement for these shall be over and above the measurement, of the pipe work as mentioned below:

The pipes of different nominal bores shall be measured separately. The pipe work shall be measured in length inclusive of sockets specials, fittings etc., in position.

**5.4.0 Fittings and fixtures**

Measurement for fittings and fixtures where applicable shall be in number for the complete item inclusive of anchors, brackets and fasteners required. However, in special cases anchors, brackets and similar items may be measured separately if included as such in the Schedule of items.

**5.5.0 Chases and holes**

No measurement shall be made for cutting chases, holes etc., and making good for any work within the scope of this specification and shall be inclusive.

**5.6.0 Painting**

All items likely to rust shall be painted with one coat of primer which shall not be measured separately. Where finishing coat of paints are supplied that shall be measured as indicated in the Schedule of items. Usually, painting of pipes shall be measured in length for each different nominal diameter without giving any extra allowance for specials sockets, etc.

**5.7.0 Septic tank, Soak pit**

Usually it shall be measured in number for the complete septic tank or soak pit as per drawings. All earthwork, backfilling masonry, concrete, manhole, pipes

and fittings including. In case, it is intended to pay for individual items the same shall be indicated in the Schedule and measured in number, length area or volume as appropriate.

## 6.0.0 CODES AND STANDARDS

### Some of the important Codes and Standards relevant to this specification

Shall be follow : Latest editions shall always be consulted.

IS : 1172 - Code of basic requirements for water supply drainage and Sanitation.

IS : 1200 (Pt: XVI) - Lying of water and sewer lines including appurtenant

IS : 1239 (Part I & II) - Mild steel Tubes and Mild steel Tubular and other wrought steel pipe fittings.

IS : 1536 - Centrifugally cast (Spun) iron pressure pipes for water gas Sewage.

IS : 1537 - Vertically cast iron pressure pipe for water, gas & sewage

IS : 3486 - Cast iron spigot & socket drain pipes.

IS : 1742 - Code of Practice for building drainage.

IS : 5329 - Code of Practice for sanitary pipe work above ground for Buildings.

IS : 2470 - Code of Practice for designs and construction of septic Tank for small and large installations.

IS : 3076 - Low density polyethylene pipes for potable water supplies

IS : 4984 - High density polyethylene pipes for potable water supplies.

IS : 1537 - Vertically cast iron pressure pipe for water, gas & sewage

IS : 1538 - Cast Iron fittings for pressure pipes for water, gas & sewage

IS : 1230 - Cast Iron rain water pipes and fittings

IS : 3889 - Centrifugally cast (spun ) iron spigot & socket soil waste and ventilating pipes, fittings and accessories

| | | |
|---|---|---|
| IS : 1729 | - | Sand cast iron spigot & socket soil, waste and ventilating pipes and accessories |
| IS : 1626 | - | Asbestos cement building pipes, gutters and fittings ( Spigot & socket types ) |
| IS : 458 | - | Concrete pipes ( with and without reinforcement ) |
| IS : 783 | - | Code of practice of laying of concrete pipes |
| IS : 784 | - | Prestressed Concrete pipes |
| IS : 651 | - | Salt glazed stoneware pipes & fittings |
| IS :4127 | - | Code of practice of laying of glazed stoneware pipes. |
| IS : 1726 | - | Cast Iron manhole covers & frames intended for use in drainage works |
| IS : 5961 | - | Cast Iron gratings for drainage purposes |
| IS : 5219 (Part I ) | - | 'P' & 'S" traps |
| IS :771 | - | Glassed earth-ware sanitary appliance |
| IS : 772 | - | general requirements of enamelled cast iron sanitary appliances |
| IS : 774 | - | Flushing Cistern for water closets & urinals (Valueless Siphonic type) |
| IS : 775 | - | Cast Iron brackets & supports for wash basins and sinks |
| IS : 2548 | - | Plastic water closed seats & covers |
| IS : 2527 | - | Code of practice for fixing rain water gutters and down-pipes for roof drainage |

# SUPPLY AND LAYING R.C.C. PIPES

| REV. NO. | PRAPARED | APPROVED | DATE |
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## 1.0 SCOPE

This specification covers the supply and laying of R.C.C Hume Pipes as per drawings and instruction of the Engineer. The entire work shall be carried out as per latest editions of Indian Standards IS:458 and IS:783.

## 2.0 Supply of PIPES

The Contractor shall supply the R.C.C Hume Pipes of various diameters along with complete fittings required for carrying out the work. All R.C.C Hume Pipes should conform to IS:458 and should be in a good condition. The Contractor must furnish, on being demanded by the Engineer, manufacturer's certification and/or test certificates from recognized authorities.

## 3.0 ALIGNMENT, LEVELS AND GRADE

The work shall be carried out in conformance to the alignments, levels, and grades specified in the drawings. The layout and levels shall be made by him at his own cost from one reference grid and bench mark given by the Engineer. He shall give all help in instruments, materials and men to the Engineer for checking and detailed layout and levels as and when required.

Making of reference layout and level pillars along the pipeline route and maintaining them
Upto completion of the work shall be the responsibility of the Contractor.

No extra payment shall be made for these.

## 4.0 LAYING OF PIPES

**a) General:**

The laying of R.C.C. Pipes shall conform to the Clause 9 of IS:783.

b) **Conditions for laying**:

The conditions for laying of pipes to suit the conditions at site and/or as per drawings and instructions of the Engineer shall be as classified below.

**i) Culvert Condition**

In this condition the pipe is laid under combankment and may project wholly or partly above the original ground surface.

**ii) Trench Condition**

In this condition the pipe is laid in a trench excavated for the purpose. The trench shall be refilled with thoroughly tampered earth after laying and jointing of pipes in approved manner.

**iii) Open Condition**

In this condition the pipe is laid such that it projects wholly or partly above original ground surface, there being no superimposal over burden on the pipe.

**c) Bedding & Supports**

**i) Culvert Condition**

In this condition the pipes shall be laid generally on First Class Bedding" as per Clause No. 4.3. of IS:783, unless directed otherwise.

**ii) Trench Condition**

In this condition the pipes shall be laid generally on "First Class Bedding" as per Clause No.4.2.3 of IS:783, unless directed otherwise.

**iii) Concrete Cradic Bedding**

If required by the drawing or so instructed by the Engineer, the pipes, shall be laid on Concrete cradles, conforming to Clause No.4.2.3 of IS:783 in case of trench condition and conforming to Clause 4.3.4 of IS:783 in case of culvert condition.

**iv) Open Condition**

In open condition the pipeline shall be supported over rigid pedestal constructed at intervals not greater than the length of one individual piece of pipe. As per drawings and instructions of the Engineer. In no case shall the joint between two pieces of pipe shall lie at center of the span between two supports. The pedestal shall be of rubble masonry, or brick masonry or plain/reinforced concrete with a properly shaped out top to receive the pipe.

**d) Handling of Pipes**

The pipes shall be handled with all possible care while loading, uploading, transporting and lowering them in position. The method of handling during all the stages of the work should be to the approval of the Engineer and should preferably employ mechanical means like use of chain pulley block an the like.

**e) Jointing of Pipes**

The Clause 10 of IS:783 shall be applicable for jointing of pipes and every possible care shall be taken. The Contractor to ensure that the joints made are leak proof, Curing of joints shall be done for a period of 10 days. No extra payment shall be made for making and curing of joints.

## 5.0 MEASUREMENT

R.C.C. Pipes shall be measured on running meter basis and paid for at the unit rate quoted by the Contractor. The rate shall include supply, laying in position, preparation of "First Class bedding", jointing with supply of all fittings, fixtures and joint materials, complete as per drawings and schedule of items.

Payments for excavation of trenches, backfilling of trenches, making of embankments, brickwork, rubble masonry work, plain and /or reinforced concrete work in concrete cradle beddings, pedestals for pipe supports and other associated works shall be made as per relevant unit rates quoted by the Contractor in the Schedule of Items.

# PREMOULDED BITUMINOUS JOINT FILLER AND SEALING COMPOUND

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**1.0 .0 SCOPE**

The work under this section sources supply of all materials and all operations required for sealing of joints in concrete.

**2.0 Material**

Premoulded joint fillers shall be of non-deteriorating and resilient type conforming to IS:1833. Sealing Compound shall be of grade "B" as per IS:1834, Bitumen shall conform to IS:3384.

**3.0 Fixing of Joint Filler**

3.1 The concrete surface shall be made clean , smooth and free from dirt or loose particles. When the surface is completely dry, a coat of hot blown bitumen conforming to IS:702 of grade 85/25 shall be given with brush or spray. When the bitumen is still hot, the premoulded joint filler fibre board shall be pressed against the surface held in position, till the time it automatically remains fixed in position. Where the joint filler has been specified in two layers, the second board will be fixed as above with a few jacking patches of bitumen between the two. After placing the filler in position, the surface of filler against which further concreting is to be done is given a coat of bitumen.

**4.0 Filling of Joint Sealing Compound**

**4.1** Before application of the sealing compound, the sides of the joints are sprayed of brushed with bitumen primer. The primer is then allowed to dry out thoroughly for at least 24 hours and then filled with a mix of 30% fine sand and 70% sealing compound by weight.

**5.0 Measurement**

5.1 Joint filler shall be measured in square meter and sealing compound in linea meters as per dimensions shown in drawings both correct to two decimal places.

# DEMOLITION AND DISMANTLING

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1.0 **SCOPE**

This specification defines the demolition, dismantling of reinforced concrete, plain concrete, brick work and structural steel work or any such other work. Any special requirement as shown or noted on the drawing shall govern provision of this specification.

1.1 **DEMOLITION**

The term demolition implies breaking up. This shall consist of demolishing whole or part of work including all relevant items as specified or shown on the drawings.

1.2 **DISMANTLING**

The term dismantling implies carefully removing without damage (up or down). This shall consist of dismantling one or more part of the buildings as specified or shown on the drawings.

2.0 **GENERAL**

2.1 **PRECAUTIONS**

2.1.1 All materials obtained from dismantling or demolition shall be the property of the "Owner" unless otherwise specified and shall be kept in surface custody handed over to the Engineer-in-Change.

2.1.2 The demolition shall always be planned before hand and shall be done in reverse order of those in which the structure was constructed. The scheme shall be got approved from the Engineer-in-Charge before starting the work.

2.1.3 Necessary propping and/or under – pinning shall be provided for the safety of the adjoining work or property before dismantling and demolishing is taken up and the works shall be carried out in such a way that no damage is caused to the adjoining work or property. Whenever specified temporary enclosures or partition shall also be provided.

2.1.4 Necessary precautions shall be taken to keep down, dust, nuisance.

2.1.5 Dismantling shall be done in a systematic manner. All materials which are likely to be damaged by dropping from a height of demolishing roofs, masonry etc. shall be carefully removed first. The dismantled articles shall be passed by hand, where necessary lowered to the ground (and not thrown) and then properly stacked as directed by the Engineer – in – Charge.

2.1.6 Where fixing is done by nails, screws, bolts etc. dismantling shall be done by taking out the fixing with proper tools and not by tearing or ripping off.

2.1.7 Any serviceable materials, obtained during dismantling or demolition, shall be separated out and stacked properly as directed by the Engineer-in Charge within a lead of 50meters. All unserviceable materials etc. shall be disposed off as directed by the Engineer-in-Charge.

2.1.8 The contractor shall maintain disconnected services whether temporary or permanent, if required.

2.2.0 **PAYMENT**

2.2.1 All works shall be measured in the decimal system, as fixed in its place, subject top
The following limits unless otherwise stated hereinafter:-

a. Dimensions shall be measured correct to a cm.
b. Areas shall be worked out correct to two places of decimal.
c. Cubic contents shall be worked out to the nearest 0.01.

2.2.2 Parts of work required to be dismantled and demolished shall be measured separately.

2.2.3 Measurement of all works except hidden work shall be taken before demolition or dismantling and no allowance for increase in bulk shall be allowed.

2.2.4 Specifications for deductions for voids, openings etc., shall be on the same basis as that employed for construction of the work.

2.2.5 The rate shall include the cost of all labour involved and tools used in demolishing including scaffolding. The rate shall also include the charges for separating out and stacking the serviceable material properly within a distance of 50 meters and disposing off unserviceable materials as directed by Engineer-in-charge.

3.0 **Roofs**

Ridges, heaps and valleys shall be girthed and included with the roof area. Corrugated or semi corrugated surfaces shall be measured flat and not girthed.

Supporting members, such as rafters, purlins, beams, joints, trusses etc. shall be measured in metric tonnes.

4.0 **Concrete and Brick Roofs and Suspended Floors**

Demolition of floors and roof of concrete or brick shall be measured in cubic

meters(M) beams, cantilevers or other subsidiary supports of similar materials, shall be included in the item. In measuring thickness of roofs provided with water proofing treatments with bitumen felts, the thickness of water proofing treatment shall be ignored.

5.0 **Walls and Piers**

5.1 Taking down walls and independent piers or columns of brick stone or concrete shall be measured in cubic metres (M). All copings, corbels, cornices and other projections shall be included with the measurements.

In measuring thickness of plaster, walls, the thickness of plaster shall be ignored.

5.2 Ashlar face stones, dressed stone work, precast concrete article etc. if required to be taken down shall be so stated, and measured separately in cubic meters (m).

5.3 Cleaning bricks, stacking for measurements including all extra handling and Removed and disposing rubbish as stated shall be enumerated in the thousand of cleaned bricks.

5.4 Cleaning stone obtained from demolished/dismantled stone masonry of any Description including ashlars facing, dressed stone slabs or flanging and precast concrete blocks including all extra handling and disposing of rubbish as stated shall be measured in cubic meters (m) of cleaned stone.

5.5 Honey comb work of cavity walls of bricks , stone or concrete as solid.

6.0 **Reinforced Concrete and Brick work**

Reinforced concrete structures and reinforced brick roofs and walls shall be measured in cubic meters and square metres as specified in schedule of rates and reinforcement if required to be salvaged, shall be stated.

Where reinforcement is required to be separated, scraped and cleaned, the work shall be measured separately in metric tonnes (MT) of salvaged steel.

7.0 **Steel and Iron Work**

7.1 All steel and iron work shall be measured in metric tonnes(MT). The weight shall be computed from standard tables unless the actual weight can readily to determined.

7.2 Riveted work, where rivets are required to be cut, shall be measured.

7.3 Marking of structural steel required top be re-erected shall be measured

separately.

7.4 In framed steel items, the weight of any covering material or filling such as iron sheets and expanded metal shall be included in the weight of the main article unless such covering is not ordered to be taken out separately.

# TYPE AND MAKE OF MATERIALS TO BE USED

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Only the follwing makes of materials are approved for use the contractor on this work. In case of items not listed here and also if products of listed vendors are not available in the market for some reason, advice of Projec Engineering Department, BHEL, Hyderabad shall be sought for suggesting alternate vendors.

All the material shall be got approved by site inchrge prior to their use

| | |
|---|---|
| 1. Mortice lock | Godrej/Harrison |
| 2. Hinges/tower bolt | ECIE/GARNISH/Everite |
| 3. GLUE | Movicol/Fevicol |
| 4. Door Handles | Godrej/ECIE/HARDIMA |
| 5. Screws | Nettle Fold/Guest keen william |
| 6. Hydraulic door closer | Everite/Prabhat/Garnish |
| 7. Double action hydraulic door closer | Everite/Prabhat/Garnish |
| 8. Ply Wood | Mysore/Seastic/National/Indian Plywood |
| 9. Teak wood | First class Indian Teak wood. |
| 10. Flush door shutter | Sitapur/Mysore with phenol formal dehyde resin |
| 11.Wooden panneled shutter | 1st class teak wood frame work with 12mm thk Nova teak/Novapan/Eco board. |
| 12. Prelaminate board | Novapan/Anchor/Bhutan/Ecoboard. |
| 13.Mirror | Modi/Atual/Swastic |
| 14. Sanitry ware | Hidustan/Nycer/Parry/Classica |
| 15. Plumbing fixture | Parco,Gem. |
| 16.False ceiling tiles | Nova teak/Jolly lotone/Armstrong |
| 17.Metallic false ceiling | Tracdek/Luxalon |
| 18.Interior Paints | ICI/Berger/Asian paints/Jenson&Nicolson Garware/Goodlac nerolac/ shalimar |
| 19. Exterior water proof | Snowcem. |
| 20.PVC tiles | Caliplast/Brite. |
| 21. Acid proof tiles | Coromandel. |
| 22.Floor tiles | Spartek/Kataria/Bell/Decora/Murudeshwar/ Regency/Cera. |
| 23.PVC tiles | Bhor. |
| 24.Gypsum Board | India Gypsum/Trac. |
| 25.Plate glass | Modi-Gurdian/Atual. |
| 26.Asbestos cement sheets &accessories. | Charminar/Everest/Visakha/Ramco |
| 27.Non shrink grout | Shrinkomp 30/Conbextra GP2/Pagel V12 |
| 28.MS Doors | Shaktimet. |
| 29. Polymeric Waterproofing | IWL Ltd. |

# FALSE FLOORING

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1.0 **SCOPE**

This specification covers furnishing, instalation, finishing, testing, protection and maintenance till handing it over of recoverable free access false flooring systems consisting of an assembly of panels mounted on adjustable pedestal and supporting steel grid system to provide an under floor space for the accommodation of flexible electrical cables and ground panles for Computer and Control room Equipment.

2.0 **FLASE FLOORING SYSTEM**

2.1 **Base**

The system shall be placed over a base of R.C.C. Floor slab and Beams as indicated in the drawing, Any grouting etc. that is necessary to fix the supporting structure shall be done by the false flooring contractor without any additional cost to the Owner.

2.2 **SUPPORTING STRUCTURE**

Pedestals shall be made of steel and will be of height as indicated in drawing. Pedestal shall be vertically true, located on centers to conform with size of pencil and shall be equipped with locking devices to prevent loss of finished elevation. Base of pedestal shall have integral load dispersion ribs to transmit load evenly to the base floor. Adjustment of pedestal shall be provided by threaded rod member and use of an elevating nut. The pedestal head shall prevent lateral shifting. Pedestal head shall be equipped with conducting grounding pad if so desired by Engineer-in charge. The grid channels shall be made of steel and shall be levelled to support the floor panel units.

2.3 **FLOOR PANELS**

The floor panels be made either of steel panels, die-cast aluminium or particle board treated with fire resistant chemicals as per schedule of items. Size of eachof panels shall be 600mmx600mm with all panel edgws finished to a tolerance of $\pm$ 0.2mm. All panels shall be completely interchangeable and easily removable with a suction lift tool, Panel shall be square to within a tolerance of $\pm$ 0.25mm on the diagram.

2.4 **STRENGTH**

Each 600mm x 600mm floor panel must be capable of supporting an uniform live minimum load load of 1220 kg/sq.M. or a contracted minimum load of 460kg applied through a phenolic caster 75mm in diameter and 45mm. Wide, or rolling minimum load of 460Kg. At any point with a maximum deflection of 2mm. The ultimate strength shall provide a 3.0 safety factor. Each pedestal shall be capable of carrying a 2,300 Kg. Axial without deformation of any part.

One additional pedestal shall be provided under floor stringer along front panel area of each control board for taking possible additional load that may occur from time to time.

2.5 **SURFACE FINISH**

All removable panels shall have the top surface finished with either « Decomet » polymer flooring 2mm. Thick or BHOR vinyl flooring 2mm thick or 2mm thick, ' Micalam' double wear high pressure fire resistance décorative laminate bonded to the surface with compatible high creep résistant adhésive.

2.6 **SKIRTING**

Skiriting shall be 150mm high and 2mm thick, completely matching with the false flooring surface finish materials and fixed to the wall surface as per manufacturers installation instructions.

2.7 **INSTALLATION**

The concrete sub floor shall be sealed with two coats of polyurethene paint to prevent moisture for contacting cables and to minise dust problem.

Any damage to the sub floor during installtion of the false flooring system shall be make be made godd by the Contractor without any extra cost to Owner.

All steel surface are to be protected by two coats of polyurethene paint over a compatible primer and any damage to the paint during installation shall be made good. Finished floor surface, when specified by the Engineer-incharge shall be protected by the Contractor with kraft paper taped and sealed at edges to prevent tearing. In case the loads exerted by the weight of machines are above the stated charecteristics of floor covering materials, the floor shall be protected by overlaying here after during installtion of machine or equipment. Such hard board shall be supplied by the Owner.

All installtion were of good flooring system shall be supervised by the manufacturer's raised representative.

3.0 **ACCEPTANCE CRITERIA**

The false flooring system shall be checked specially for :

a) Level.
b) Alignment of joints.
c) Thickness of joints.
d) Surface finish.
e) Colour and texture.
f) Details at edges junctions.
g) Performance.
h) Criteria specified for strength.

4.0 **I.S. CODES**

Important codes applied to this section are :

IS : 2571 : Code of practice for laying in situ concrete flooring.

IS : 3461 : 7 VC ( vinyl) asbestos floor tiles.

IS : 5310 : Code of practice for laying of flexible PVC sheet and tile flooring.

IS : 2046 : Specification for Decorative Thermosetting Synthetic Resin Bonded Laminated sheets.

5.0 **METHOD OF MEASUREMENT**

5.1 Actual area of work done shall be measured

5.2 No deduction shall be made for openings upto 0.25 sq.m in area each.

# 50 MM THICK PREMIX BITUMEN CARPET (HOT PROCESS) OVER WATER BOUND MACADAM ROAD SURFACES

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1.0 SPECIFICATION FOR 50MM THICK PREMIX BITUMEN CARPET (HOTPROCESS) OVER WATER BOUND MACADAM ROAD SURFACES

1.1 The work shall consist of construction, in a single course of 50mm thickness of compacted aggregates premixed with a bituminous binder, laid immediately after mixing, on a prepared base with a tack coat of bitumen and finished with a seal coat, in conformity with the lines,grads and cross section shown in the drawings or as directed by the Engineer.

1.2 Water Bound Macadam surface on which premix carpet is to be laid shall be thoroughly Swept, scraped clean and made free from dust or any other foreign matter. WBM surface shall have the desired gradient and camber.

1.3 Tack coat shall consist of application of single coat of low viscosity liquid bituminous material on the prepared road surface before laying the bituminous carpet. The binder used for tack coat shall be bitumen of a suitable grade conforming to IS:73.Bitumen shall be heated to the temperature appropriate to the grade used and shall be sprayed on the base at the rate of 15kg per 10 sq.m of area. The binder shall be supplied uniformly with the aid of sprayers. Tack coat shall be applied just ahead of the incoming bituminous construction.

1.4 The aggregates on the premix carpet shall consist of crushed stone which shall be clean, strong, durable of fairly cubical shape and shall be free from disintegrated pieces, organic or other deleterious matter. Aggregates shall be Hydrophobic and of low porosity.

1.5 The aggregates shall conform to the following grading.

| Sieve designation | Percent by weight Passing the sieve |
|---|---|
| 25mm | 100 |
| 20mm | 70-100 |
| 10mm | 35-60 |
| 4.75mm | 15-35 |
| 2.36 | 5-20 |
| .75micron | 0-4 |

1.6 The bituminous binder shall be straight run bitumen of suitable grade conforming to IS:73. The binder content for premixing shall be 4 (four) percent by weight of the total mix. The quantity of aggregates to be used shall be sufficient to yield the specified thickness after compaction.

1.7 Hot mix plant of adequate capacity shall be used for preparing the mix. The temperature of binder at the time of mixing shall be in the range of 150-160 C and that of aggregates in the range of 125-150C, provided the difference in temperature between the binder and aggregates at no time exceeds $25^0$C. Mixing shall be thorough to ensure that a homogeneous mixture is obtained, in which all particles of the aggregate are coated uniformly. The mixture shall be transported from the mixing plant to the point of use in suitable vehicles.The mix shall be spread immediately after mixing by means of a self-propelled mechanical paver with suitable screeds capable of spreading, tamping, and finishing the mixture to the specified lines, grade and cross section. In locations where the plant cannot operate, Engineer shall premix manual laying of the mix. The temperature of mix at the time of laying shall be in the range of 110 -135C.

1.8 After the spreading the mix, rolling shall be done by 8-10 smooth wheeled power rollers or other approved plant. Rolling should start as soon as possible after the material has been spread. Rolling shall be done with care to keep from unduly roughening the pavement surfaces. Rolling of the longitudinal jaunted shall be done immediately behind paving operation. After this, rolling shall commence at the edges and progress towards the centre longitudinally except that on super elevated portions, it shall progress from the lower to the upper edge parallel to the centre line of the road. The initial rolling shall be done as soon as it is possible to roll the mixture without cracking the surface by having the mix pickup on the roller wheels. The second or intermediate rolling shall follow the initial rolling as closely as possible and to be done while the paving mix is still at a temperature that will result in maximum density. The final rolling shall be done while the material is still workable enough for removal of roller marks.

1.8 When the roller has passed over the whole areaonce, any high spots or depressions which become apparent shall be corrected by removing or adding fresh material. The rolling shall then be continued till the entire surface has been rolled to compaction, there is no crushing of aggregates and all roller marks are eliminated. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceeding pass. The roller wheels shall be kept damp, if necessary to avoid bituminous material from sticking to the wheels and being picked up. In no case shall fuel, lubricating oil be used for this purpose. Rolling operations shall be completed in every respect before the temperature of the mix falls below $80^0$C. The edges along and transverse of bituminous carpet laid and compacted earlier shall be cut to the full depth so as to expose fresh surface which shall be painted with hot bitumen before the mix is placed against it.

1.9 Seal coat shall be applied for sealing the voids of the premix carpet surfaces laid

to the specified levels, grace and camber. Seal coat shall be premixed seal seat comprising a thin application of fine aggregate premixed with bituminous binder. The binder shall be bitumen if a suitable grade conforming to IS:73. The quantity of binder to be utilized, in terms of straight run bitumen, shall be 7Kg per 10 Sq.m of area. The fine aggregate shall be sand of fine grit and shall consist of clean hard, durable dry particles and shall be free from dust soft or flaky materials, organic or other deleterious substances. The fine aggregate shall pass 1.7mm sleeve and be retained on 180 micron sieve. The quantity used for premixing shall be 0.06cu.m per 10sq.m area.

1.10 The seal coat shall be applied immediately after the premix carpet is laid. Before the application, the premix carpet surface shall be cleaned free of any dusted or extraneous matter. Mixers of approved type shall be employed for mixing the aggregates with the binder. The binder shall be heated in boilers to the temperature appropriate to the grade of bitumen. Aggregates shall be dry and also suitably heated before the same are placed in the mixer. Mixing shall be continued till all the aggregates are thoroughly coated with the binder. The mix shall then be immediately transported form the mixing plant to the plant to the point of use and spread uniformly on the surface to be sealed. As soon as sufficient length has been covered with the premixed material, the surface shall be rolled with 8-10 tonne smooth wheeled power rollers. Rolling shall be continued till the premixed material completely seals the voids in the bituminous course and a smooth uniform surface is obtained.

# WATER BOUND MACADAM ROAD

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# 1.0.0 BOX CUTTING

## 1.1.0 EXCAVATION

After the earthwork in cutting, and the earth work in embankments have been done properly up to the final road level with gradient and camber as per drawings and proper consolidation of the filling is completed, earthwork in box cutting shall be taken in hand. Before starting of box cutting, the Contractor shall obtain Engineer's approval of cutting and embankment work.

The surface of the formation for a width equal to that of the sub base course shall be properly prepared before any further courses are laid. Surface shall be cut to a depth below the ground level equal to depth of sub base course due allowance being made for compaction. Preparation of sub grade also includes removal of any and all foreign substance accumulation and removing undulations up to 1500mm by filling and cutting as required. The sub grade shall be dressed parallel to the finished profile.

The box cutting shall be done in such a way, that width of cutting is exactly the clear distance between the edging blocks. The depth of cutting shall be the total thickness of consolidated soling and road metal ling. The formation shall have the same profile and camber as shown on drawing.

The excavated spoil shall be transported and utilized in filling of low areas or as directed by the Engineer. The filling shall be done in layers or as directed by the Engineer. The filling shall be done in layers of 150 mm and clods and lumps shall be broken and consolidation done to the satisfaction of the Engineer.

In case of presence of weak soil-pockets below the formation, the Contractor shall excavate and remove such soil to an extent as instructed by the Engineer. The extra depth shall then be filled up with 38mm down stone-metal and voids in metal shall be filled up with morrum. Then, the filling shall be rammed and rolled uniformly with a road-roller of 8 tonnes minimum weight. These operation of removing weak soil pockets and filling with stone-metal shall be done by the contractor and paid at the earthwork rates plus the cost of stone-metal only.

If by mistake the depth of box cutting is made than required, the Contractor shall make up the extra depth by metal consolidation, specified above, at his own cost.

## 1.2.0 ROLLING

After the box cutting is completed, the sub grade shall be compacted with powered roads rollers 8-12 tonnes. The roller shall run over the sub grade till the soil is evenly and densely compacted, to achieved a dry density of not less than 95% of maximum density as obtained from standard proctor compaction test. There shall be a minimum of five (5) roller passes. All the undulations on the

surface which develop due to rolling shall be made good with earth and quarry spills as approved by Owner and the sub grade re-rolled. The top of the sub grade shall be dressed evenly to the required camber and necessary drainage of rolling shall be provided. Care shall be taken to avoid excessive rolling of the formation, If, after rolling, the formation is higher than required, the excess earth shall be Removed by carefully cutting and dressing and the formation shall be rolled as specified above. In case after rolling the formation is depressed below the required level, the Contractor shall continue the process of filling and rolling as above till the correct level is attained up to a limit as decided by the Engineer at Contractor's cost.

**1.3.0 MEASUREMENT**

The actual volume of box cutting shall be measured in cubic meters (Cu.M) and paid at the unit rate tendered. The unit rate tendered shall include layout, excavating of earth in all lifts, disposing the excavated earth as specified up to 150 M lead and in all lift, rolling, bailing of water, if any, including all labour, tools and plants required for the work.

**2.0.0 EDGING**

**2.1.0 MATERIALS**

The edging shall be of cement concrete blocks and be of average 450mm deep, 100mm wide and suitable length and shall be of 1:2:4 nominal mix by volume (1part cement, 2 parts clean sharp coarse sand, 4 parts 10 mm down hard crushed graded stone aggregate). Cement, sand and stone aggregates shall-be as specified in Technical Specification for cement concrete (Plain and Reinforced). Concrete edging blocks shall be cast in moulds approved by the Engineer and cured for a minimum period of 28 days.

**2.2.0 LAYING**

After rolling of the box cutting is completed, trenches shall be cut for edging. The width of the trenches shall be minimum and just sufficient to insert the edging bricks. The clear width between the inside faces of the edging blocks shall be exactly the same as shown on drawing. The inside faces shall be in plumb and gap between the block shall not be more than 10mm.The top of the edging shall be at the same level as shown on drawings and the inside face shall be in a neat line.

The edging block is shall be thoroughly packed with a mixture of stone chips (50%) at the outside face. The laying and packing shall be done in a proper workman like manner acceptable to the engineer.

If, after consolidation of the road-metalling, any portion of the edging is found to be out of line and level, the Contractor shall take out the the blocks and really the same to the satisfaction of the Engineer at his own cost.

## 2.3.0 MEASUREMENT AND PAYMENT

The actual length of edging laid shall be measured in "Running Metres" (R.M) and paid at the unit rate tendered. The unit rate shall include excavating trenches, transporting and laying the blocks in line and levels and filling the outside face and ramming etc., including all labour, materials, tools and plants required for the work.

## 3.0.0 SOLING

## 3.1.0 MATERIALS

The soling shall be done with assorted rough stone-boulders or quarried stone. The stone shall be tough and it shall not flake or crumble when being rolled with a road-roller of 8 tonnes minimum weight. No stone shall be less than 75mm in thickness and shall be not more than the depth of soling as specified in drawings.

The width of stone shall not exceed twice its thickness. The filling of bigger voids shall be done with smaller pieces of stone. The smaller voids shall be filled with blinding material made with a mixture of small stones (50%) 25 mm down and moorum (50%).

The soling stone shall be laid on narrowest side closely on the formation so that minimum voids are left between the adjacent blocks. The bigger voids shall be filled up by wedging in smaller blocks of suitable size with hand hammer. The laying of blocks and wedging smaller block shall be such that the soling shall be a compact mass with minimum voids and shall not move when being rolled for consolidation.

Then the blinding material (50% small stone plus 50% moorum) shall be spread over the soling and worked into the voids by booms. The blinding materials shall be sufficient to fill up all voids and to produce an even surface after rolling. Excess use of building materials shall be avoided.

## 3.2.0 ROLLING

The stone soling shall be thoroughly consolidated with a smooth wheeled power roller of minimum 8 tonne weight, starting at edges and working towards the centre with a minimum of 10 passes.

The rolling shall be done in such a way that the whole soling shall given a compact base without any voids. After initial rolling is done, inspection shall be made to see if voids are still left in the soling. If all voids are not lifted up, further blinding material shall be added. The rolling shall be continued till there is no settlement or voids, and the surface is true and even. The finished soling shall give the correct thickness, gradient and camber as specified on drawings.

**3.3.0 BAD WORKMANSHIP**

If the Engineer finds that the soling done is not up to the specifications, the whole soling over the defective portion shall be taken out, re-laid and compacted with specified roller as specified above by the Contractor at his own cost.

**3.4.0 MEASUREMENTS AND PAYMENT**

The actual area of soling of (length of road multiplied by clear width between edging) shall be measured in square metres (Sq.M) and paid at the unit rates tendered which shall include supply and laying of soiling stone, smaller stone, mixing and spreading blinding materials, rolling as specified, watering etc. including all labour, materials and tools and plants required for the work.

**4.0.0 METALLING (WATER-BOUND MECADAM)**

**4.1.0 MATERIALS**

The road metal shall consist of 38mm down graded approved quality crushed stone. The metal shall be of close, tough durable and hard texture and shall not flake or crush under pressure. The metal shall be of granite., ballast or equivalent quality with high density and shall not absorb. When immersed in water for 24 hours, more than 1 percent own weight. In general, unless otherwise specified, the metal shall conform to the standards laid down by the “Indian Road Congress” regarding toughness, abrasion co-efficient of hardness, attrition loss and cementation values. The grading of the metal shall be such that not more than 55 by weight shall be retained on 38 mm sieve and not more than 50 to 60% retained on 25mm sieve, not more than 10 to 15% by weight retained on 20 mm sieve, but 100% shall be retained on 12mm sieve. Metal shall be screened, if so desired by the Engineer and fines from 12 mm to dust screened out and may be used as blind age if found suitable by the Engineer.

**4.2.0 LAYING**

The metal shall be laid to camber and profile in such a way that total thickness of loose metal over stone soling is not less than 120mm but more shall be used, if required to make the consolidated thickness at least 75 mm after rolling. While spreading the metal, proper profile and camber shall be maintained and checked with templates at every 6 to 7 metres. No rolling shall be done until laying has been approved by the Engineer.

**4.3.0 ROLLING**

**a. Dry Rolling:**

After metal have been laid and dressed as above, metal shall be rolled dry with a road – Roller of 8 tones minimum weight until well compacted and

there is no appreciable movement of the stone or no appreciable gap in front of the advancing roller and no lines of roller are left on the surface.

Excessive dry rolling should also be avoid. When the desired degree of compaction has been obtained by dry rolling, screenings of approved chipping 12mm down in size should be spread uniformly over the surface by bromming and this should be pushed into the interstics by rolling. Successive layers of screening being added till no more chipping are observed shall be rectified by removing stones up to a depth of 50 mm to 75mm, refilling the same, hand packing and re-rolling. No watering should be done till this process is complete.

The amount of screening used should be less than 1 Cubic Metre per 1000Sq.m . of road surface (3 c.f,t 1000Sq.f.t).Rolling operation has to be very carefully carried out. Rolling should be commencing from the edges of the road and working towards the centre. Roller should be passed equal and sufficient number of times on the metal spread at every stage so as to secure equal and thorough compaction. Speed of roller to be very slow and uniform and reversing shall be quick and free from jerks. As far as possible, the reversing process should be at different section of the length rolled during each successive trip.

**b. Wet Rolling (Water-bound Macadam):**

When the dry rolling has been completed to the satisfaction of the Engineer, the surface is to be watered an kept saturated and rolled a few times as specified above. Approved quality blind age (moorum) shall then be spread uniformly over the surface to a thickness of 20mm to 12mm. The roller wheels as well as the road surface should be continued until a slurry is formed over the entire surface and the same moves in the from of wave in front of the roller when the rolling operation may end and the surface allowed to dry. The finished surface shall be smooth and uniform and free from waviness and corrugations and as per specified profile and camber.

After 24 hours of rolling, the surface shall be sprinkled with a thin layer of sand not less than 2c.f.t per 100s.f.t. or 56 cu.m . pet 100sq.m of road surface. Traffic shall be allowed after four days of sprinkling the sand or as approved by the Engineer.

**4.4.0 BAD WORKMANSHIP**

The compaction and finish shall be as per specifications to the satisfaction of the Engineer. If the Engineer so desires, the defective portions shall be removed, metal re-laid and compacted as specified above by the Contractor at his own cost.

**4.5.0 MEASUREMENT AMD PAYMENT**

The actual area of metal ling (length of road multiplied by clear width between edging) shall be measured in square metre (Sq,m) and paid at the unit rate tendered. The unit rate shall include supply and laying of stone metal of 75mm consolidated thickness and blinding materials and sand, rolling, watering etc. including all labour, materials and tools and plants required for the work.

# *RUBBLE MASONRY*

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**1. Random rubble Masonry :**

**1.1 Stone :**

Stone shall be of approved quality . it shall be sound, uniform in colour and free from decay and weathering. Stone with round surface shall not be used. Unless otherwise approved stones from one single quarry shall be used for any one work

**1.2** Stone shall be hammer- dressed on the face and side. The 'busing' on the face shall not project more then 20 mm on an exposed face and 15 mm on the face to be plastered.

**1.3 Mortar:**

The mortar to be used for jointing shall be as specified on the schedule of rates.

**1.4 Laying :**

All stones shall be wetted before use. They may laid at random without being brought up to any level except at plinth, window sills and roof level and top legal in case of compound wall. The bond shall be obtained by fitting in closely the adjacent stones and by using bound stones. Face stones shall extend and bond well in to the backing . proper breaking of joints shall be done. Their height shall not be grater then the breadth at that face or the depth inward. Interior filling of carefully laid, hammered down with a wooden mallet into position and solidly bedded in mortar. No hollow space shall be left anywhere in the masonry. Chips not more then 20% of quality of stones in hearting wherever necessary to avoid thick upward about 50 to 200 mm shall be firmly embedded to from a bond between successive courses. The masonry in a structure shall be carried regularly.

**1.5 Bond Stone :**

Bond or through stone running right through the thickness of wall shall be provided in the walls having thickness upto 60 mm. If the walls are thick then 600 mm, two or more bond stones overlapping each other by at least 150 mm shall be stones shall be provided for every 0.5 sq.m. of wall surface.

**1.6 Quoins :**

The quoins shall be of selected stones neatly dressed to the required angle and shall be of the same height as the course in which they occur and laid header and stretcher alternately. No quoin stone shall be less then 0.o3 Cu.M.

**1.7 Joints :**

Stones all be so laid that all joints are full of mortar. Face joints shall very from 12 mm to 25 mm thick, but not less then 12 mm. Joints shall be struck/flush/and finished with C.M.! :3 at the time of laying when plastering and pointing is not required. Joings shall be raked to a depth of 20 mm during construction, if walls

are to be plastered or pointed. For the faces of walls which are not to be plastered stone surfaces shall be cleared of mortar dropping to give uniform appearance.

**1.8 Curing**

Green work shall be protected front rain by suitable coverage. Masonry work shall be kept constantly wet for a minimum perior of 10 days.

**1.9 payments :**

Stone masonry shall be measured in cubic metres (m3 ). The rate shall include cost of all operations involved at all the stages of work.

**2.0 Exposed Coursed Rubbic Masonry:**

**2.1 Stone :**

Stone shall be type specified. It shall be hard, sound and free from decay and weathering.

**2.2 Dressing:**

Face stone shall be hammer dressed and to be squared on all sides and joints so as to give them ret angular block shape. The bed joint shall be rough chisel dressed, true and 'Squares' for the least 75 mm back from the face and the side joints for at least 40 mm, such that no portion of the dressed surface is more then 6mm from a straight edge placed on it. The "Bushing " on the face shall not project more then 40 mm on exposed face.

**2.3 Mortar:**

The mortar to be used for jointing shall be as specified in schedule of rates.

**2.4 Laying:**

All stones shall be wetted before use. The stones shall be laid in horizontal courses and each course shall be of equal height.

Into the work for length not less then twice their height. The hearting or interior filling of the wall shall consist of flat bedded stones carefully laid on their proper beds solidly bedded in mortar. Chips not more then 10% of quantity of stone masonry may be used where necessary to fill interstices between adjacent stones to avoid thick beds or joints of mortar.

The mensonry in structure shall be carried up regularly, but where breaks are unavoidable, the joint shall be raked at an angle not exceeding 45. teething shall not be allowed.

**2.5 Bond Stone :**

Same as for random masonry given under para 1.5 except that a bond stone or a set of bond stones shall be inserted 1.5 mm apart, in every course.

**2.6 Quoins :**

The quoins shall be of the same height as the course in which they occur, shall be formed of stones at lest 0.5m long, laid stretcher and header alternately They shall be laid square on their beds, which shall be rough chisel dressed to depth of at least 100 mm.

**2.7 Jointing & Pointing :**

All bed joints shall be horizontal and all side joints vertical. All joints shall be full of mortar. Face joints shall not be more then 12 mm thick unless otherwise specified. The joint shall be either flush or struck with c.m. 1:3. Raised or cut pointing if specified in items, shall be done with c.m. 1:3 using wooden mould/template of minimum 12mm depth for uniformity.

**2.8 Curing :**

Same as per “Random Rubble” given in para 1.8.

**2.9 Payment :**

Same as for “Random Rubble” given in para 1.9.

# CHAIN LINK FENCING

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**1.0.0 SCOPE**

The work under this specification covers the supply and fixing of galvanised steel chain link fencing with galvanised steel posts and chain link fabric.

**2.0.0 MATERIAL**

The fencing shall consist of 80 mm 50 mm nominal diameter galvanised steel pipe posts, galvanised steel chain link fabric and galvanised steel binding wires. The galvanised steel chain link fabric shall conform to IS 2721. The mesh size of fabric shall be 50 mm. The diameter of mesh wire and line wire shall be 3.15 mm and 4.0 mm respectively. 1'6 gauge galvanised wires shall be used for binding the fabric to the stretched bars and posts. The pipe posts shall conform to IS: 1161 and shall be of medium grade and galvanised.

**3.0.0 FIXING**

The Gl pipe posts shall be embedded in plain cement concrete not leaner then 1:4. 8 foundations. The height of posts above top of foundations and spacing of post shall not be more then 3 m. the chain link fabric shall be fixed to the fencing posts with the help of stretcher galvanised bars (25 X 6 flats) which will be bolted to the lugs welded to the post. The stretcher bars shall be provided in the lapping of fabric also.

**4.0.0 RATE**

The rate for fencing shall include the cost of labour and all materials such as fabric. GI stretcher bars, line wires, fabric bolts, nuts, binding wires, involved.

# BC : 16 : SHEETING WORK IN ROOF AND SIDING

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## 1.0.0 SCOPE

This specification covers the technical requirements for the furnishing of all labour, materials, supervision, tools, equipment and services necessary for or incidental to the fabrication and installation of asbestos cement, C.G.I., Fibreglass reinforced plastic roofing and siding in accordance with the drawings and as specified herein.

## 2.0.0 MATERIALS

Corrugated asbestos- cement sheets shall be composed of a combination of asbestos fibre and hydraulic cement with no more then 1 weigh percent of organic fabric.

Asbestos cement roofing and siding shall be of the following types as indicated on the Contract drawings: -

a) Corrugated sheet
b) Trafford sheet and
c) 'S' Type Louvres

Corrugated asbestos-cement sheets shall be 6 mm thick unless otherwise directed by the Engineer or specified in the Schedule of Items.

Flashing shall be G.I. sheet metal, aluminium, etc.

The thickness of C.G.I. sheets very with purlin spacings. Spacings shall not be greater then the following for the sicknesses mentioned:

| Thickness of CGI sheets | Spacing of Purlins |
|---|---|
| 0.63 mm 24 G | 1.6 m |
| 0.80 mm 22 G | 1.8 m |
| 1.0 mm 20 G | 2.0 m |
| 1.25 mm 18 G | 2.4 m |
| 1.60 mm 16 G | 2.8 m |

Fibreglass reinforced plastic sheets shall be translucent translucent or opaque as shown on drawings. These sheets be shatterproof and should not crack, chip or rot.

The sheets shall have uniform ; thickness, translucency (if specified ) and strength. The sheets shall be of approved manufacture and shall match the roofing profiles.

Wherever necessary and as shown on the drawing, caulking shall be non-hardening and non – staining type.

The Contractor shall also supply all necessary louvers special fittings, fasteners, Flashing, caulking and bituminous paint required for installation of the sheets in strict accordance with manufacturer's instructions.

Roof & siding sheets shall be capable of withstanding 200 kg/sq.m wind loads.

**3.0.0 INSTALLATION**

**3.1.0 Storage of materials**

All materials shall be stored by the Contractor in proper way to prevent any damage.

**3.2.0 Workmanship**

The erection shall be according to the best construction practice to give a water-tight finish to the satisfaction of the Engineer. Fixing of gutters and downpipes shall be according to the relevant Indian standard specification.

Aasbestos sheets of profiles as stated in the drawings shall be fixed with minimum, 150 mm end alp and side laps as per manufacturer's specification Unless otherwise specified in the drawing hook bolts or j-bolts shall be 8mm diameter placed at 300 mm centres maximum. 6 mm dia galvanised iron seam bolt and nut with G.I. flat washers and bitumen washers shall be used for stitching ridge cappings, corner pieces, Ventilators, north light curves, etc.

a) <u>C.G.I.Sheeting</u>

Side laps shall be 2 corrugations for roof and one corrugation for side sheeting .end laps shall be minimum 150 mm for roof and 100 mm for side sheeting. In ridges and hips where plain sheets are used, the end laps shall be minimum 100 mm. Holes in C.G.I. sheets shall preferably be made on the ground; the sheets should be placed on trestles and holes punched in the ridge of the corrugation from the outside inward for obtaining proper seating of limpet washers. Sheets shall be secured to sheet framing by 8 mm dia. Galvanised iron hooks or j-bolts and maximum 305 mm apart. the length of the hook of j-bolts shall be to suit the sections of the bearers. Sheets shall also be bolted at the ends at every third corrugation with 6 mm dia. Galvanised iron seam bolts and G.I. flat washers and bituminous washers.

b) <u>Fibreglass reinforced plastic Sheeting</u>

These shall be of thickness and profile as mentioned in the Schedule of Items. Colour and light transmittance shall be as mentioned on drawings and or Schedules. Where used in conjunction with C.G.I. or Asbestos Sheeting, the end and side laps and fixing device shall be same as used for general sheeting. Where used in lieu of glass, the fixing shall be by means of timber or metal glazing beads as completely watertight and able to withstand the designed wind-pressure as mentioned in schedule.

**4.0.0 SAMPLES**

Samples of different types of sheets with method of fastening shall be submitted for approval.

**5.0.0 ACCEPTANCE CRITERIA**

The Installation shall present a neat appearance and shall be checked for water-tightness. The following shall be checked.

a) Side and end laps
b) Absence of cracks, holes or damages of sheet
c) Spacing of bolts
d) Provision of double washers (G.I. and asbestos or bituminous washers)
e) Proper installation of flashings., etc.

**6.0.0 RATES**

Rates shall be unit rate for complete item described in the Schedule of Items including all wastages.

**7.0.0 METHOD OF MEASUREMENT**

a) No allowance shall be made for laps.

b) Roofing and side sheeting shall be measured for flat ares of work done Corrugated of trailors sheeting shall be measured flat and not girthed. Openings less then 0.1 sq.m. shall not be deducted.

c) Special features like flashings, ridge pieces, corner pieces, north-light curves, etc. shall be length of installation.

d) Gutters and downcomers shall be measured for length along their centre lines and bends, junctions, shoes, ends, etc. shall not be paid separately.

e) S-type asbestos louvers shall be measured for area of opening for which it is installed.

f) Curved asbestos roofing sheets shall be measured for area of curve.

g) Asbestos ventilators, roof lights, etc. shall be measured for actual numbers used.

h) Structural supports to sheeting work shall be measured and paid separately under relevant item.

i) Glazing to asbestos roof lights shall be measured and paid separately.

**8.0.0 CODES AND STANDARDS**

The following are some of the important I.S. codes relevant to this section:-

| | | |
|---|---|---|
| IS: 459 | : | Unreinforced corrugated and semi corrugated asbestos Cement sheets |
| IS : 2096 | : | Asbestos cement flat sheets |
| IS :3007 | : | Code of practice for laying asbestos cement sheets |
| IS : 730 | : | Fasteners for corrugated sheet roofing. |
| IS :8869 | : | Washers for corrugated sheet roofing. |
| IS :3451 | : | Fibre reinforced translucent sheets. |

# TANK PADS

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1. **SCOPE**

This specification description the technical requirements for the materials and construction of tank of tanks pads of sand fill or Murrum fill construction.

2. **REFERENCE STANDAREDS**

| | |
|---|---|
| IS 383 | Aggregates – Coarse and fine, from natural sources for concrete. |
| IS 2720 | Part VII – Determination of water content- dry density relation using light compaction |
| IS 2720 | Part VIII – Determination of water content – dry density relation using heavy compaction. |
| IS 2720 | Part IV – Grain size analysis. |
| IS 1498 | Classification and identifications of soil for general Engineering purposes. |

3. **SUB GRADE PERPARATION**

The surface of natural siol exposed at the bottom of excavated pit shall be throughly compacted by rolling or other means as directed by Engineer-in-Charge to obtain 90% of Max. laboratory dry density for the siol as per Is 2720 part VII.

4. **TANK PAD CONSTRUCTION**

The tank pad shall be either of sand fill or Murum fill construction as specified in construction drawings.

4.1 **SAND FILL**

Sand for filling shall be clean and well graded conforming to IS 383 with grading Zone II or III> It shall not contain any vegetable and organic materials. Sand shall be obyained from a source approved by Engineer – in – Charge.

4.2 **SAND FILL**

Sand for filling shall be clean and well graded conformings to Is : 383 with grading zone II or III. It shall not cotain any vegetable and organic materials. Sand shall be obtained from a source approved by Engineer – in – Charge. Sand shall contain an average 15% of cohesive fines such as clay (grain size less than 0.074) in natural state or artificially mixed with it. If artificially mixed, the mixture shall be subjected to through mixing to obtain a uniform mix.

4.3 **MURRUM FILL**

It shall of coarse and granual murrum containing not more than $20^0$ Cohesive fines such as only. Size than o.o74mm. The murrum shall be of 20 mm and covered size and shall be taken from approved qualities.

4.4 Sand murrum shall be spread in nit conceding 15cm in loose increase over than area each of these shall be uniform on density. Quility of materials and moisture content before compaction. The moisture content shall be within (2) two percent of obtimum moisture content (OMC) on side OMC as per IS : 2720.

4.5 Compaction of each layers shall be done Mechanical means as per the directions of Engineer-in – Charge shall be worke manually. Each layer should be uniformly compacted to obtain $90^0$, of standard perfication in the material fails to achive the required density, the layer should be renwered. With necessary alteration in the composition So that the required compaction is obtained.

4.6 Further layer shall be placed only after the layer already laid has been compacted to the required density.

4.7 The finished surface must be dressed to required grade and stops Excess material must removed from Compaction site.

4.8 **PAYMENT**

Payment for sand/Murrum filling shall be made on the basis of volume of fill, after placement and Compaction. The rate qouted should inclde cost of material royalties, transportation, handing compacting, watering, testing at various stages, dressing removal of surplus material and other work incidental to this.

5. **CRUSHED ROCK RING**

5.1 A crushed rock ring shall provided below the tank shall as per details given in consrtuction drawings. The stone aigrettes for the ring wall shall be 50 mm and down grade size and shall be of hard black trap, granite or such other approved materials, sand used shall be medium to course grade as per IS 383 and shall be clean and free organic/clayey materials.

5.2 **LAYING**

The stone aggregate shall be laid in laid layers of 150mm thickness and such shall be compacted to obtain a hard core ring wall to the satisfaction of Engineer – in – charge. The surface shall be checked from time to time during spreaing and copmaction to ensure a finished surface true to levels and grade as per drawings. Use of fine aggregate such as sand or finer stone aggregates may be required to fill voids and pockets, to obtain a uniform compacted hard core. Over the final compacted layer of stone aggregate sand shall be evenly spread and copmacted by tamping rolling.

5.3 **PAYMENT**

The rate shall inclde the supply of all materials, feels, labour including cutting a trench, supporting the sand suitably, during such a cutting, placing, th e hard core and copmacting the same to the satisfaction of Engineering- in – Charge. The payment shall be made on the cubic metre basis, with the finished cross section of the hard core.

6.0 **ANTI CORROSIVE LAYER**

6.1 Anti corrosive layer shall of succeded coarse sand mixed with 80,100 bitumen or equivalent 8 to 10 inches by volume.

6.2 Bitumen shall be heated to a temperatur $175^0$ C to $190^0$ C with 3 kerosene if required and sand shall be throughly moved with in in a mixing drum to give uniform mixture and shall be laid over the compacted surface of paid in line, grade and levels as shown on the drawings, as shown on the drawings, as directed by the Engineer- in – charge Bitumem shall not be heated bryoned the temperature limits….above.

6.3 The layer shall be temped to from hard mass of uniform compacted thickness as per the schedule of items and drawings.

**6.4 PAYMENT**

The payment shall be made on Squre Meter basis of the area of layer laid on top Of Tank pads. The quoted rate shall include cost of Materials. Transportation. Mixing, Laying, Tamping finishing etc. all complete.

7. **PERMIX CARPET FOR TANKPADS**

7.1 **MATERIALS**

7.1.1 **SAND**

# CONCRETE PAVEMENTS

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## 1. MATERIALS

### 1.1 WATER

Water used for cement concrete, mortar, plaster grout, curing etc. shall be clear and free from injurious amounts of oils, acids, alkalis, organic matters or other harmful substances. Only natural water suitable for drinking shall be used. It shall conform to IS:456.

### 1.2 AGGREGATE FOR CONCRETE

The aggregate for concrete shall comply in all respect with IS:383. This should be furnished in at least two separate sizes with separation at 20mm when combined material graded from 5 to 38mm is specified and 25mm Is sieve when combined material graded from 20 to 50mm is specified. This shall be obtained from a source approved by Engineer-in – charge and shall be chemically inert, strong, hard, durable and of limited porosity. This shall be of the gauge specified in the schedule of rates and approximately cubical in shape. It shall be free from soft or decayed pieces, dirt, clay, leaves or any organic matter. The aggregate shall not have any injurious effect when mixed with cement nor shall it corrode the reinforcement, nor otherwise impair the strength and durability of the concrete. The size of coarse aggregate mentioned in this specification denotes maximum size aggregate and the same shall be graded downwards as per IS:383.

### 1.3 SAND FOR CONCRETE AND MORTAR

Fine aggregate shall preferably be natural sands. In case of crushed sand the very find natural sand amount passing IS: NO: 383. Sand shall consist of clean, hard, strong, sharp, durable uncoated particles free from any mix of clay, dust, vegetable matter, mica, iron pyrites, shells, soft or flakey and elongated particles, alkali organic matter, salts, Loam and other impurities which may be considered by the Engineer-in-charge as harmful. Sulphate content should not exceed 5''. The source or sand shall be approved by the Engineer – in – charge. Sand obtained from river bed subject to tidal effect will not be allowed in works. All sand shall be washed before being brought to site.

### 1.4 STORAGE OF AGGREGATES

The subcontractor shall at all times maintain at the site of work such quantities of aggregate as are considered by the Engineer-in-charge to sufficient to ensure continuity of work.

Earth type and grade of aggregate shall be stored separately. The ground on which the aggregate are stored shall be firm and have sufficient slope to ensure adequate drainage of rain water.

Any aggregate delivered to site wet shall be placed in storage for at least 24 hours to ensure adequate drainage before it is used for concreting.

Sand heaps shall be covered with bricks or such other materials to prevent blowing off and to assist in good house keeping.

## 1.5 CEMENT

1.5.1 The cement used shall be ordinary Portland cement, conforming to IS:8112 unless otherwise specified.

1.5.2 The cement used to the contractor to the contractor shall be stored in suitable weather tight building and in such a manner as to permit easy access for proper inspection. All cement stored at site by the contractor shall be arranged in batches and used in the same orders as received from owner. Contractor shall maintain a cement register in which all entries shall be completed day to day showing quantities received, date of receipt and daily cement consumption.

### 1.5.3 REJECTION OF CEMENT

The Engineer-in-charge may reject cement which has deteriorated after issue to the contractor owing to inadequate protection against moisture or other causes or in other case where the cement is not to his satisfaction.

### 1.5.4 ADMIXTURE

No admixture shall be normally permitted for concrete or mortar. Water proofing compound to be used in concrete, plaster, damp proof course etc, where specified, shall be either CICO or approved equivalent make. It shall be mixed as per manufactures specifications and as approved and directed by the Engineer-in-charge.

### 1.5.5 JOINT SEALING IN PAVEMENTS AROUND FOUNDATIONS.

Joint sealing in pavements and around equipment structural columns shall be of approved compound conforming to IS : 1834 type “B” (Shalitex or approved equivalent).

## 2 GRADE AND PROPORATIONING

2.1 The grade indicated in drawings and schedules shall conform to IS:456, the strength being indicated below.

Grade Min Crushing Strength of 15 cm. Cube in Kg. Sq. Cm. At 28 days.

| Test | Prel.test | Work cube |
|---|---|---|

| | | |
|---|---|---|
| M-10 | 135 | 100 |
| M-15 | 200 | 150 |
| M-20 | 260 | 200 |
| M-25 | 3200 | 250 |
| M-30 | 380 | 300 |

2.2 The water cement ratio, aggregates and grading for each shall be predetermined From the results of cube tests of trail mixes. The mix proportions determined thus shall be followed at site and shall in no way relive the contractor of his responsibility as regards the prescribed strength of mix. The mix proportions, however, shall be revised if the results of the cube tests during the construction show consistently lower or higher strength than the prescribed one. No claim to alter the rates of concrete work will be entertained, due to such changes in mix designs, as the concrete work will be entertained. Due to the concrete in mix designs, as the contractor will be responsible to produce compacted by vibrations should not be more than 25mm & that for manual compaction not more than 50mm.

2.3 All concrete shall be controlled concrete conforming to IS:456. For mud-mat and filling purpose, ordinary concrete 1:4:8 mix proportion may be used as indicated in drawings.

## 3 EQUIPMENTS

All equipments like weighing devices, measuring boxes, mixers, sub grade templates, hand tampers, vibrating screeds, internal vibrations, longitudinal floats, bridges, belts, push brooms, straight edges, tools etc. shall be on the worksite in first class working condition and shall have been inspected by the Engineer-in-charge before paving operations are permitted to start. Through out the construction period class working conditions to ensure the proper execution of the work.

## 4 PREPARATION OF SUB GRADE

4.1 The sub grade of sub base for laying of the concrete slabs shall comply with following requirements.

4.1.1 That no soft spots are present in the sub grade or sub base.

4.1.2 That the uniformly compacted subgrade or sub base extends at least 300mm on either side of the width to be concreted.

4.1.3 That the subgrade is properly drained.

4.1.4 That the minimum modulus of subgrade reaction obtained with a plate bearing test shall be 5.54 $kg/cm^3$

4.2 Sub grade shall be prepared to the lines and grades shown on the drawings.

4.3 No concrete shall be placed around manholes or other structure until they have been briught to required grade and alignment.

4.4 The subgrade shall be in most condition at time of concrete placement.

## 5 FORMS

5.1 All side forms shall be of mild steel unless use of wooden sections are specially permitted. The steel forms shall be MS Channel section and their depth shall be equal to thickness of the pavement. The sections shall have a length of at least 3.00 m expect on curves, where shorter sections may be used.

These forms should be provided with ample bracing and supports to prevent the springing of the forms under the concrete pressure or thrust of machinery operation near by.

5.2 The forms should be in sufficient number and they should not be removed until concrete is hardended sufficiently.

5.3 In case wooded forms are permitted, these shall have minimum base width of 100mm for 200mm slabs and 150mm for more than 200mm thickness.

## 6 REINFORCEMENT

6.1 All reinforcement work shall conform to IS :456. Reinforcement steel shall be free from dirt scale or other foregin matter and rust. The number, size, from and position of all the reinforcement shall, unlerss otherwise directed or authorised by Engineer-in-charge, be strictly as per drawings. The placing or reinforcement shall be such that when properly placed into the work, extreme longitudinal bars will be located not less than 50mm nor more than 100mm from the edges of the slabs. Except for dummy joints, the length of reinforcement will keep clear or transverse joints by not less than 50mm nor more than 100mm as measured from the centre of the joint to the ends of longitudinal bars.

6.2 While overlapping the bars in either direction the overlap shall be atleast equal to spacing between bars in the respective direction.

6.3 To prevent displacement before or during concreting, the bars, shall be secured to one another with 16 SWG black annealed binding wire. Wooden planks soft labour to move shall be supported independent of reinforcement and the cage shall never be permitted to sag or get displaced during concreting Concrete spacer blocks shall be used to ensure r\correct cover of concrete over bars as shown in drawings.

6.4 Dowels if used as load transferring device shall be checked for exact position before concreting. Dowels shall be parallel to the surface and perpendicular to the joint and shall not place any restraint on the movement of joint.

## 7 MIXING

7.1 Mixing should be carried out in mechanical mixers. Drum of the mixer shall Rotate at a perpheral speed of 60mm per minute. Hand mixing can however be permitted by Engineer-in-Charge in special cases. Water cement ration shll be rigidly controlled during mixing. Mixers shall be fitted with automatic devices to discharge measured quantity to water directly into the mixing pan. The water shall be introduced into the drum within first 15 seconds of mixing, but not until all the cement and aggregate constituting the batch are throughly mixed. Mixing shall continue until the concrete is uniform in colour and for not less than 2 minutes after all the materials and water are in the drum. The entire content of the drum shall be discharged before any materials are placed therein for the succeeding batch.

7.2 Correcting for Building-In volume batching suitable allowance shall be made for the bulking of fine aggregates due to presence of water. For this pupose the bulking shall be determined as directed by Engineer-in-Charge.

## 8 PLACING

8.1 The place where concrete is to be poured should be clean and free from all loose dirt, wooden pices, dust, standing water etc.

8.2 Walking on reinforcement layers is permissible, walkways of wooden planks or similar material can be placed with removable supports, and should be independent of the reinforcement. The reinforcement position should not be disturbed not should it sag during carriage and placement or concrete.

8.4 Concrete should not be dropped from a height of over 1.5 m

8.5 To ensure bond and water tightness between old concrete surface and fresh concrete to be placed, the surface should be cleaned and, roughened by ‘Initial geen cut’ by wire brushing or chipping. The initial green may be done by wire brush after 6 hours of placing concrete in order to facilitate the work. Chipping can be done only after 48 hours. A layers of cement slurry with 1 :1 mix (1cement : 1 sand) shold be poured to obtain a uniform coating on old concrete. Immediately thereafter the fresh concrete should be poured.

8.6 Concrete shall be mixed in quantities required for immediate use and shall be besposited on the sub-grade in single operation to the required depth and width of the pavement Spreding shall be as uniform as possible to avoid rehandling of Concrete, where however, a certain amount of redistribution is necessary it shall be done with shovels and not with rakes. Concrete shall be vibrated with internal vibrators, Concrete shall placed continuously until complection of the part of the work between continuosly until complection of the part of the work between construction joints or as directed by Engineer-in-charge.

8.7 **PLACING IN INCLEMENT WETHER**

All precautions shall be taken for concreting to weather in accordance with the relvent clauses of IS :456. Due protection shall be provided to prevent cement being blown away white proportioning and mixing during windy weather. No concreting shall be carried out in continuos heavy rains, Necessary/arrangements to cover the freshly poured concrete shall provided, to protect it form the direct rays of the sun and from drying winds.

8.8 All concreting placement should be co-ordinated with placement of conduits, inserts, embedded parts etc., executed either by same agency or separtely.

8.9 Concrete in standing water shall be executed strictly as per IS : 456. This shall be paid as a separate item where applicable.

8.10 The concrete shall be laid in panels not exceeding 3 Mx3M as shown in layout drgs. Or as directed by Engineer-in-charge.

9 **COMPACTION & FINISHING**

9.1 **COMPACTION**

The surface of the pavement shall be compacted either by means of power driven finishing machine or by a vibrating hand screed for areas where width of the slab is very small as the corner of street junctions etc. hand consolidation and finishing shall be done as follows :

9.1.1 Concrete soon as placed be struck off uniformly and screeded to the crown and section shown on the plans and to such level above the base that when compacted and finished the pavement shall conform to the grade and cross section indicated by the plans. The entire surface shall then be tamped until a close knit dense surface is obtained.

9.1.2 The tamper shall rest on the side forms and shall be drawn ahead with a swing motion in combination with a series of lifts and drops alternating with lateral shift, the aim of this operation being compactionand screeding to the approximate level required. Subsequent tamping should advance 75mm at a time in the directed in which the work is proceeding and final stages the tamping should be closer about 12mm at a time until a level and in final stages the tamping should be closer about 12mm at a time until a level dense surface is obtained.

9.13 If so directed by Engineer-in-Charge hand operated vibrating tampre consisting of Normal type of hand tamper attached to a pneumatic or electric vibrating unit shall be used for compaction.

9.14 Segregated particles of coarse aggregate which collect in front of the tamper shall be thrown outside the forms or throughly mixed by hand with a mass of concrete already on the base.

9.15 Compaction by tamping shall be carried on till the mortar in the mix just works upto the surface. The surface shall be examined after compaction correction if needed, shall be made by adding or removing concrete followed by further compaction finishing.

9.2 **FLOATING**

As soon as particable, after concrete has been struck off and compacted, if shall be further smoothened and compacted by means of longitudinal float 1200mm long and 75mm wide operated from a foot bridge.

9.3 **STRAIGHT EDGING**

After floating is completed and excess water remove water but while concrete is still plastic the slab surface shall be tested for truness with a straight edges and rectified if necessary.

9.4 **BELTING**

Just before the concrete becomes non-plastic, the surface shall be belted with a two ply canvas belt not less than 200m wide and at least 1.0m longer than the width of the slab, Hand belts shall have suitable handles to permit controlled uniform manipulation. The belt shall be operated with short strokes transverse to the carriage way centreline and a rapid advance parallel to the center line.

9.5 **BROOMING**

After belting and soon as surplus water has risen to the surface the pavement shall be given a broom finish to produce corrugations of uniform appearance of not more than 1/16 inch in depth.

9.6 **EDGING**

Before the concrete has its initial set the edges shall be carefully finished with an edges of the radius required and pavement edges shall be left smmoth and true to line.

10 **CURING**

10.1 **INITIAL CURING**

Immediately, after the complection of the finishing operations, the surface of pavement shall be entirely covered with wetted burlap, cotton or jute mats.

10.2 **FINAL CURING**

Upon the removal of the mats, the slab shall be throughly wetted and covered by the following method.Curing with wet earth-A system of transverse and longitudinal dykes of clay about 50mm shall be laid over the slab. The dykes shall be blanketed with sandy soil free from stones to prevent drying up. The rest of the slab shall be covered with sufficient sandy soil so as to produce the blanket of earth not less than 37mm depth after wetting. This earth shall be kept throughly wet till the concrete as attained strength but not less than 14 days.

11 **JOINTS**

11.1 Whereever called for on the drawings expansion joints, dummy joints and longitudinal joints shall be provied as per detailed indicated in the drawing and as directed by Engineer-in-Charge.

11.2 Sealin of Jonts.

11.2.1 After the temperary seal or other intruded materials of all expansion and Contraction paint which shall be allowd to dry before the sealing compound is applid.

11.2.2 The edges of the joints shall be throughly cleaned and primed with a thin bituminouspaint which shall be allowed to dry before the sealing compound is applied.

11.2.3 The primer shall be applied with a brush. The composition of primer shall be as follows :

| Name of the material | percent of weight |
|---|---|
| 1. 200-penetration Bitumen | 66) Blended Blended |
| 2. Light creosote oil | 13) Hot cold |
| 3. Solvent Naptha | 20) |

The bitumen shall be melted and fluxed with oil, When cold, solvent, Naptha shall Be added. Bituminous emulsion shall not be used as primer. Care shall be taken to ensure that the sealing compound is not heated above $200^0$ C and the temperature does not exceed $180^0$ C for long periods.

11.2.4 Sealing compound shall be poured into the joint opening in such a manner that the material will not spilled on the exposed surface of the exposed surface of the concrete. When required to prevent pick up under traficc, the exposed surface of the exposed surface of the sealing compound shall be dusted with hydrated lime.

12 **OPENING TO TRAFFIC**

12.1 Traffic shall not be allowed for a period of 28 days after laying of concrete.

12.2 Before opening the roads to traffic all joints shall be filled and trimmed or topped as required.

## 13 METHOD AND BASIS FOR PAYMENT

13.1 Payment for concreting in pavements shall be made on cubic meter basis of the actual finished work done. The rate shall be inclusive of all labour, materials, curing, cost of leaving pockets, if necessary making recesses drain including casting and testing of cubes, all complete. The rate for concreteing shall include the cost of shuttering but exclude only the cost of reinforcement and joint sealing. E making grooves at construction/expansion joint for joint scaling compound, compaction of sub-grade, if required,

13.2 Payment for MS reinforcement, deformed or twisted bars shall made on the basis of weight. The weight shall be derived from the sizes and corresponding weights given in hand book of Indian Standards Institution. Standard hook lenths, chairs, spacer bars and authorised laps only will be inclded in the weight calculations. Binding wire will not be weighed nor otherwise measuerd. Measurement for weight-shall not include cutting, bending, placing, binding with subcontractor's own binding wire and providing necessary cover bloks of concrete etc. all complete including cost of wastage and cutting allowance and rolling margin.

13.3 Payment for joint sealing shall be made on running meter basis of joints. The rate shall inclde cleaning joints and sealing with approved compound all material labour etc complete as per drawing.

## 14 PAYMENT FOR JOINTS

Payment for expansion joints, longitudinal joint, dummy joints, shall be done on running meter basis.

# ANTI TERMITE TREATMENT

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1.0.0 SCOPE

The scope of work is to set up a chemical barrier against attack by subterrannean termites while the building is under construction.

2.0.0 **EXCAVATION**

2.1.0 **GENERAL**

All work shall in general be executed as specified in IS :6313 part 11 and per approved specification of the agency having special know-how for the job.

All necessary work to ensure uniform distribution and proper penetration of treating solution shall be done according to the instruction of the engineer.

Soil treatment shall not be done when it is raining or when the soil is wet with rain or subsoil water. Once forme, the treatment soil barrier shall not be disturbed.

2.2.0 **CHEMICAL AND RATE APPLICATION**

Any of the following chemical (conforming to relevant Indian Standards) in water emulsion shall be applied by prressure pumps, unioformly over the area treated.

| Chemicals | Concentration by Weight. Percentage |
|---|---|
| Dieldrim(IS :1052-1962) : | 0.5 |
| Heptachlor | 0.5 |
| Aldrim (IS :1306-1958) : | 0.5 |
| Chlodane (IS :2863-1964) : | 1.0 |

2.3.0 **METHOD OF TREATMENT**

2.3.1 **Treatment of column pits. Wall Trenches and Basement Excavations.**

Foundations, basements etc., may either be fully evenloped by the chemical barrier or the treatment may start 500mm below ground level. The bottom surface and sides of excavation (upto a height of about 300mm) for column pits, walls trenches and basements shall be treated with chemical at the rate of 5 liters / $m^2$ of surface area. Backfills around columns. Walls etc. Shall be treated at the rate of 15 liters / $m^2$ of the vertical surface. Chemical treatment shall be done in stages following thecompaction of earth in layers. The treatment shall be carried out after the ramming operation is done by rodding the earth at 150mm centers close to the walls surface and sprying the chemicals in the specified dose.

2.3.2 **Treatment of Top Surface of Plinth Filling**

Holes 50mm to 75mm deep at 150mm centers both ways shall be made crow-bars on the surface of compacted plinth fill. Chemical emulsion at the rate of 5liters/$m^2$ of surface shall be applied prior to laying soiling or sub-grade. Special care shall be taken to maintain continuity of the Chemical barrier at the junction of vertical and horizontal surface.

2.3.3 **Treatment of soil surrounding pipes and conduits**

Special care shall be taken at the points where pipes and conduits enter the buildung and the soil be treated for a distance of 150mm and a depth of 75mm at the point where they enter the building.

2.3.4 **Treatment of Expansion Joints**

These shall recive special attention and shall be treated in a manner approved by the Engineer.

3.0.0 **ACCEPTANCE CRITERIA**

The Contractor shall given a 10 years service guarantee in writing supplemented by a seperate and unilateral guarantee fron the specialised agency for the job to keep the building free of termitee for the specified period at no extra cost to the Owner.

4.0.0 **RATES**

Rates shall be lump sum rate per $m^2$ of plinth area for the complete treatment.

5.0.0 **METHOD OF MEASUREMENT**

Treatment to building shall be measured in $m^2$ of the building for the buildings where treatment has made and accepted.

No separate measurement shall be done for treatment to foundation walls of trenches, DPC at plinth level, top surface of plinth filling, treatment around pipes, etc.

6.0.0 **I.S.CODE**

Relevant code applicable for this Specification.

IS :6313 (Part II) : Code of Practice for Anti-Termite Measures in Buildings.

# FIRE PROOFING OF STEEL STRUCURES WITH R.C.C

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1.0 SCOPE

2.0 MATERIALS/ APPLICATION

3.0 FIREROOFING BY IN-SITU CONCRETE

4.0 MEASUREMENT

1.0 **SCOPE**

The specification covers materials and methods of application for fireprrofing of steel structures and equipment supports.

2.0 **MATERIALS/APPLICATION**

Fire proofing shall be provided by in- situ-concreting. Steel sutface to be fire proofed shall not be painted and shall be cleared of all loose dirt, rust, mill scale, soot and concrete by mechnical wire brushing or sand blasting. Oil and grease deposit shall be removed with detergents and steel surface made clean and dry.

3.0 **FIREPROOFING BY IN-SITU-CONCRETE**

3.1 Fireproofing shall be done as indicated in enclosed drg. No 4-38144-00049.

3.2 oncrete for fireproofing shall be of M15 grade with 6mm and down aggregates. Mixing and placing shall be done as per BHEL specified for plain laid reinforced concrete.

3.3 Thickness of fireproofing concrete shall be as drawings no. 4-38144-00049 enclosed.

3.4 Centering and shutting shall be approved quility, properly designed to give smooth and even surface. Any defects honeeycomb etc. shall be made good at contractor's cost. All other specifications regarding from work shall be in accordance with BHEL 's specification for plain and reinforced concrete.

3.5 Concrete shall be poured into well made forms properly oiled and made to correct dimensions to give 50mm minimum coverage Concrete shall be vibrated as necessary to ensure smooth free from voids and irregularities.

3.6 Reinforcement materials and placement shall be as per enclosed drg no. 4-38144-00049.

3.7 Concrete shall be cured by constant wetting for fifteen days

4.0 **MEASUREMENT**

4.1 Concrete will be paid for on volume basis. For encasing of 'I' section outer dimensions of encased section will be taken for measurement and not deduction will be taken for measurement and not deduction will be made for steel sections encased. For laced columns the difference in volume taking outer dimensions of encased and unencased sections will be considered. No deduction will be made for batten plates, lacing angles etc.

4.2.1 Reinforcement inthe form of ungalvanised wiremesh will be paid for on area basis. Overlaps will also be measure.

4.2.2 Formwork will be measured on area basis of the outer surface area of encased section.

# COATING AND WRAPPING OF UNDERGROUND PIPES

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1. OBJECTS AND SCOPE
2. REGULATIONS
3. LIMIT OF UTILIZATION
4. MATERIAL AND PROCEDURE OF WORK
5. REPAIR OF PIPE

## 1. OBJECT AND SCOPE

The object of the specification is to described the method of protecting the underground by the peocess of coating and warpping. The job shall be generally performed in the following operation :-

i) Cleaning the external pipe surface
ii) Priming with synthetic primer
iii) First coat of coal tar enamel
iv) First layer of inner warpping with glass fibre
v) Final coat ($2^{nd}$ coat ) of coal tar enamel
vi) Outer warp of coal tar impregnate glass fibre
vii) White wash

In addition, this specification also covers an defines the material specifications, method of cleaning, priming, procedures of coating & Wrapping testing, repairing, handling and stroring etc,required for the satisfactory complection of the job.

## 2. REGULATIONS

2.1 All materials used shall conform to the quility and testing requirement indicated in AWWA-C-203-86 or BS 4164-1987 or ASTM Standards and or directed by Engineer-in-charge.

2.2 All appurtenances and equipment to be used for cleaning, priming, coating an warpping and testing shall be approved by the Engineer-in-Charge.

## 3. LIMIT OF UTILISATION

The underground pipe line protected by coating an warpping as described in this specification should be able to carry a liquid at a temperature upto $60^0$ C.

## 4. MATERIAL AND PROCEDURE OF WORK

4.1 Preparation and cleaning of Piping

The pipe line shall be throughly cleaned of all rust, grease, dirt, mill scales, weld scales, weld burns etc. by means of cleaning machine. This cleaning operation shall be immediately followed by priming with the airless spray priming machine.

Altenatively, if permitted by the Engineer – in – charge, the pipeline shall be adequate scrubbed manually with stiff wire brushes and scrapped where necessary. The primer coating should immediately follows the cleaning of pipes. The primer coating may also be done manually if permitted by the Engineer – in – charge.

The cleaning an priming operation may be carried out in the contractor's workshop or on site. The entire pipe length shall be cleaned but the end of the pipes shall be left without coating and warping for a distance of 20mm for joints, which shall coated and warpped manually on site after laying, welding an testing the pipes.

## 4.2 PRIMING

### 4.2.1 MATERIALS, COAL TAR PRIMER

The Primer shall be a type B ( fast drying, synthetic) certified meet AWWA C-203-86 or British Standard BS – 4164, Section 3. The primer shall consist of chlorinated rubber, synthetic plasticciser and solvents suitably blended to produce a liquid coating which may be applied by brushing or sprying and which will produce effective bond between the metal and subsequently coating of coal tar enamel. Primer should not contain benzol or other toxic and/or highly voltatile solvents, added pigments or inert fillers or other substances and shall shown no tendency to settle out in containers. The main charcteristics of the primer shall be as follows :

| | |
|---|---|
| - Drying time to touch at normal humidity @ $30^0$ C (70 %) | Approx 5-15 mts. |
| - Flash point, BS 2000, part 170 | $23^0$ C (minimum) |
| - Flash time 4mm flow cup (ISO) at $23^0$ C, BS 3900, part A6 | 35-60 sec |
| - Volatile matter (105-$110^0$ C), max. by mass. BS, Appendix A | 75% loss |
| - Coverage | 8-12 M2 / lit / coat |

### 4.2.2 PRIMING OPERATION (COLD APPLICATION)

The prime shall be applied on the pipes in uniform thin film (Single coat) leaving no drips or runs. The entire surface of the pipe should be primed without any patch left out. Any holidays or unprimed places shall be reprimed immediately. Any flooded areas or primer applied on improperly cleaned pipes shall be cut down to surface of pipe and reprimed at Contractor's cost. The primer shall be cold applied to a clean dry surface, immediately after cleaning operation.

- The surface shall be dry at the time of appling primer coat. Primer shall not be applied during rain or fog or on wet surface.

- Primer which comes foul with foreign substances or thickended through evaporation of solvent shall not be permitted.

- Freshly primed pipe shall be placed on clean squre cut skids and shall not be allowed to come in contact with the ground or with any other foregin matter. It shall remain on skids until lifted or cradled for the coating & warpping operation.
- All primed pipes which have excessive coat of dust or primer accumulated over them before the primer is dry or where primer has become dead shall be reprimed. Drying time shall be minimum 24 hrs. The application of coal tar coating shall be taken up after primer coat has dried up completely and normally within 24hrs after priming with applied Contractos's cost. The Engineer-in-charge shall approve the primer coat befor the next coat is applied.

- The primer shall be kept in tightly sealed containers when not in use to prevent evaporation.

- The primer shall be applied as received from the manufacturer and should not be thined under any circumstances.

## 4.3 COATING AN WRAPPING

### 4.3.1 COAL TAR ENAMEL

Enamel shall be composed of a specially processed coal tar pitch combined with an inert mineral filler.

Noasphalt of either petroleum or nature base shall be acceptable as part of the ingredients. The enamel shall have the following physical charecteristics coforming to AWWA C 203/86 or 4164-1987.

| | | |
|---|---|---|
| Softening point (Ring and ball ) | Min | Max |
| ASTMZ-36 | $105^0$C | $115^0$C |
| Filler (Ash) ASTM-2415 by wt. | 25% | 35% |
| Fineness filten, through 200 mesh ASTMD 546 by wt. | | |
| Specific gravity at $25^0$C ASTM X 71 | 1.4 | 1.6 |
| Penetration,AWWA C 203-86, Sec 2 :8 :1 | | |
| @ $77^0$F ($25^0$C)-100 gm. Wt . 5 Sec. | 5 | 10 |
| @ $115^0$F ($46^0$C)-50 gm. Wt . 5 Sec. | 12 | 20 |
| High Temperature Test (SAG) | | |
| @ $62^0$F ($71^0$C) AWWA C-203-86 Sec.2.8.9 | | 1/16'' (1.6mm) |
| Low Temperature test @ - $10^0$ F, (-$25^0$C) | | |

| | | |
|---|---|---|
| (Cracking) AWWA C-203-86 Sec.2.8.10 | | None |
| -Impact test @ $77^0$ F, ($25^0$C) Direct impact 650gm ball,8ft drop AWWA C 203-86, Sec.2.8.12)Indirect impact. | | 16 in 2 (10,323mm2) 6in2(3841mm2) |
| -Peel test, AWWAC- 203-86, Sec.2.8.11 | | No pealing |
| -Spark test 15 KV low Amperage | | None |
| -Water absorpion, 35 weeks | | 0.3% |
| - Application temperatures | $225^0$ C | $245^0$ C |

4.3.2 **GLASS FIBRE MAT FOR LANNER WRAPPING**

The Fiberglass mat for inner warpping shall be thin, flexible, uniform mat, composed of chemical resistant borosilicate glass fibre or hydrolitic class 3-m conforming to DIN-12-111 mono-filaments distributed in random open poyous structure, bonded together with a thermosetting phenolic type resin which shall be compatible with the coal tar enamel. The innerwrap glass fibre tissue shall be longitudinally reinforced by continuos flamet glass yard- embedded in mat & shall have nominal thickness of 0.5 mm ($0.02^0$) and shall Conform to AWWA C 203-86, Appendix section A.@.

- No disbonding of individual glass fibre shall occur during or following the embedding process.

- The glass fibre mat shall not cause bubbling under the condition of application.

- The glass fibre mat shall be sufficiently porous so that it can embedded in the hot coal tar enamel as it is applied to the exterior of the pipe.

- The glass fibre mat(reinforced glass warp) shall also conform to AWWA C 203-86 section A2 and the following Charecteristics.

| | |
|---|---|
| - Weight (minimum) | 41gms/m2 |
| Nominal thickness | 0.5mm$\pm$ / - 0,1 mm |
| Tensile (average, breaking Strength) | |
| Longitudinal direction | 2277 N/M OF width (mIn) |
| Transverse direction | 700N/M of width. |

| | |
|---|---|
| Porosity | The glass fibre mat shall have a porosity of not more than1.90mm water gauge measures at pressure difference across the sample at an air velocity of 1.02 M / sec. |
| Temp. Resistance | The glass fibre tissue shall be unaffected Unaffected under load in hot enamle at $53^0$F ($288^0$C ) for minute. |
| Moisture absorption by Wt. At relative humidity of $95^0$ at $125^0$($50^0$C) for 24 hrs | 5%(max) |

4.3.2 **OUTER WARP COAL TAR IMPREGNATED GLASS FIBRE**

The outer warp shall be non-woven, thick reinforced glass fobre mat uniformly impregnated with coal tar enamel and shall conform to AWWA C-203-86 Section 2.10.3 with following characteristics :

| | |
|---|---|
| Glass tissue Base | :83 gm/m2 (min) |
| Weight (finished material) | :586-732 gm/m2 (12-15 lbs/100 ft2) |
| Thickness | : 0.76 mm (30 mills) |
| Tensile strength (Average Breaking Strenth) | |
| Longitudinal Direction | : 6130 N / M of width (min) |
| Transverse Direction | : 4730 N / M of width (min) |
| Pliability (1 » dia Mandrel $25^0$C, 2sec) | : No cracking |
| Weight loss on heating at $82^0$ C For 2 hours | : 2% (max) |
| Moisture absorption percentage Weight at a relative humidity of A relvent humidity of 95% an $50^0$ C For 24 hours. | |

The finishing reinforced glass fibre mat outer warp have a smooth, uniform surface free of visible defects. When unrolled at a temperature from $0^0$C to $50^0$C , the outer warp shall not crack or stick to such an extent as to cause breaking or tearing. The outer a 3'' diameter core in widths and lengths as specified at the time of purchase. The rolls shall be packed to exclude dust and

dirt during shipping and handling and shall have card board separators and end shield adequate to prevent roll damage when stacked. The sides of the rolls shall be clean, smooth and square cut and shall have no telescoping.

4.3.3 The white wash used as a final coat shall be manufactured in accordance with white wash formulas as specified in AWWA C- 203-86, Section 2.11. coal tar enamel. The fibrous glass mat shall be of suitable uniform width for smooth spiral application. The over lap of the fibrousmat shall not be less than ½ inch (12mm).

A second coat of hot coal tar enamel shall then be applied of such a thickness that finished thickness of two layers of enamel inner and outer warps shall be a minimum of 4.0mm.

4.4.2 **BY MANUAL APPLICATION**

The already primed pipe is placed in a fixed position. The coal tar enamel heated to $225^0$ - $245^0$ C is then applied by means of sling as follows.

A canvass strip (alternatively a tinplate strip) about 450mm wide and 1.5m long held under the pipe by two men. Molten enamel is poured on the sling at each end of the pipe and some on top of pipe. The men holding this sling move it up and down and walk slowly forward whilst fresh enamel is poured on the pipe an they manipulate the sling so than an even coating is obtained all around. This work shall not be any formation of 'Whiskers' and holes in the coating must be made good.

The glass fibre mat warping may be applied with hand with the approval of the Engineer-in-charge.

4.5 **APPLICATION OF SECOND (OUTER) LAYER OF COAL TAR ENAMEL COATING & GLASS FIBRE WRAPPING**

Immediately after application of the $2^{nd}$ layer of coal tar enamel, outer wrap Of coal tar impregnated glass fibre shall be applied in a tigth uniform spiral and shall be spirally wound round the pipe with a minimum of 15mm overlap on each spiral.

The thickness of final coat of enamel shall be so adjusted that total finished thickness of double coating & wrapping in dividing outer warp is maintained minimum 4.0 mm. The coatinng and erapping must be free of pin holes, bubbles on holidays. The engineer- in- charge shall cu samples from the coating from time to time to determine the thickness and bond of coating.

4.6 **PRIMER, COATING AN WRAPPING APPLICATION FOR FIELD JOINTS OF PIPES AFTER LAYING AT SITE.**

4.7 Primer shall be applied with brushes after cleaning the pipe throughly (joints portion etc.) as per specification.

Originally offered to comply with these specications will be borne by the contractor.

In addition to above, the contractor shall submit manufacture's certificates, in original for each batch of materials used on the job.

The contractor shall furnish the inspector reasonable facilities and space without charge for the inspection, testing and obtaining of such information as he desire regarding the characteristics of materials used and the manner in which the work is progressing.

The Fie ld Bond Test Procedure as per AWWA C 203-86 sectionn 2.8.11 or BS 4164 Appendix L shall be applied to each pipe initially till the Engineer-in-charge relaxes it later to a random of one in ten pipes.

The pipe shall be throughly inspected for any holiday, pinholes, torn, abrained or mutilated spots.

The contractor shall furnish and operate at his own cost, a high voltage electronic holiday detector of type acceptable to Engineer – in – charge. The detector will have to be calibrated by the contractor at his own cost before use and the calibration shall be witnessed and approved by the Engineer-in-charge.

4.7 **TESTING AND REPAIRS**

4.8.1 All the finished insulation shall meet with the requirements spark tests to be applied with Holiday detector. All pinholes, voids, holidays, air bubbles, cracks and outer breaks, shall be carefully marked. Repiars may be made immediately following the coating and wrapping operation or may be deferred but in any case shall be repaired and re-inspected prior to installtion. Repairs to coal tar enamel coating shall be made by removing the damaged coating back to the pipe surface, hot coal tar enamel shall then be pored over his area and a piece of outer wrap of similar size shall then be embedded and bonded to the enamel. All coating repairs shall be made with the wrap smoothly applied and without wrinkles or buckles. Repairs must successfilly pass a test by the electronic holiday detectior.

4.8.2 The thickness of coating and wrapping shall be checked with suitable instrument by the contractor at his own cost. If the thickness is found insufficient, the contrctor shall have to modify the same to the satisfaction of the Engineer-in-charge without any extra cost.

4.9 **HANDLING AND SUPPORTING COATED PIPES**

4.9.1 Contractor shall develop the method of stock piling and loading out coated pipes

and shall recive approval from Engineer-in-charge prior to handling of coated pipes.

4.9.2 The coated pipes shall be carefully handled so as not to damage them in any way. No wire ropes or chains shall be used to lift the coated pipe. Canvas or rubber belts of minimum 300mm width and sufficient strength shall be used. The use of tongs, bane pinch bars, chain slings, protruding rivets, pipe hooks without proper

Padding or any other handling equipment that may injure the coating shall not be permitted.

4.9.3 If the pipes are coated in a shop, one pipe should not be placed above another during transist in the wagon or truck. The pipe shall be carried on suitable paddle skis mounted on the wagon or a truck to ensure that the coating will not be damaged in any way.

4.9.4 Pipes shall be stored in the field under covered protection during rains. Pipe shall be kept on clean squre cut padded wooden skids protected with fibre glass mat felt or straw until ready to be lowered in the trench.

4.9.5 The contractor handling and transporting the pipe shall conform to standards as set out in AWWA C 203 – 86 section 4.1 'Transporting and Handling Enameled Pipe'.

4.10 **ADJACENT PIPE – LINES, STRUCTURES ETC.**

If any damage is caused to the coating and wrapping of adjacent pipe or any other existing structure during excavation of subsequent work or during coating and wrapping if field joints the contractor shall carry out necessary repairs at his own cost in a manner as directed by the Engineer-in-charge,

5.0 **REPAIR OF PIPE**

Any damage to the pipe, such as dent, gauges, flattering damage caused by contractor to bevels shall be cut out, the pipes bevelled and if necessary, rewelded with prior approval of Engineer-in –charge. All such rewelding shall conform to the applicable provisions of codes. The cost of work, plus the cost of pipe lost due to repair will be to the account of contractor.

6.0 **RATE**

6.1 Rate shall be for coating wrapping laying, laying, testing and commissioning of the pipeline and shall be inclusive of cost of all materials, labour, equipments etc., reqd for the work including cost of pipes (pipe will be issued by BHEL at issue rate specified else where ), primer, coater enamel, impregnated glass fibre, white wash, jointing he pipes, testing and commissioning.

6.2 Rate shall be inclusive of all tests to be carried out on raw materials and also for

finished pipelne.

6.3 Excavation of trenches and backfilling for laying of pipes will be paid for separately.

## 7.0 MEASUREMENT

7.1 The work will be paid for in Meters of finished pipeline.
7.2 Excavation of soil and backfilling will be measured in Cubic M.

# PILING PART – I PREAMBLE

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## 1.0 GENERAL

This part technical Specifications Covers the installation and testing of Piles forming foundations to buildings and structures.

## 1.2 GENERAL REQUIREMENTS

The construction and testing of the Piles and shall conform to the recommendations of the following :

i) Current edition of India Standard IS : 2911- code of practice for design and construction of pile foundation.

a) Part I – Concrete Piles
b) Part II – Timber Piles
c) Part III – Under-reamed Piles
d) Part IV – Load Test on piles

ii) BHEL Standard Specifications enclosed herewith : (Part IV to VI)

a) PEDC/STD.SPEC/0040(d) Material for reinforced concrete Piles.

b) PEDC / STD.SPEC /0040(e) Testing of Concrete Piles ‘

c) PEDC/STD.SPEC/0040(f) Design Consrtuction and Installation of R.C.C Bored Cast-in-Situ Piles

iii) Ceneral Specifications for Design, installation and Testing of Piles (enclosed-PartII)

iv) Specification requirements for bored cast in situ uniform dia / bored / for this Project (Enclosed Part III)

In the event of any conflict between various Specifications the order of precedence will be from (iv) to (i) above.

# PILING PART II – I GENERAL SPECIFICATIONS

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## PART II – I GENERAL SPECIFICATIONS

1.0 **SUBMISSIONS WITH THE TENDER**

The contractor shall submit with his tender the following information in relation to his proposals:

A) Proposed specialist Firm to undertake pilling-outline data including.

i) Name and Address of firm.
ii) Summary or firms experience with piling system.
iii) Key personal controlling the piling work.

B) **PLANT PROPOSED**

Number, Type and size of main Plant items to be employed on the work Including

i) Cranage
ii) Piling Equipment
iii) Concreting Equipment

c) **QUALITY CHECKS**

Outline proposals for installation and testing of trial piles and tests on work piles.

2.0 **INITIAL PILE TESTING**

2.1 Test shall be conducted of Test Piles and work Piles as per specifications.

2.2 At least there weeks before installation of trial piles the Contractor shall submit in triplicate for the approval of the Engineer – in – charge, final of the test piling installation. There details include location, procedure for installation and testing together with list of associated equipment to be provided for construction and testing of the same.

2.3 The report on Pile testing shall be submitted within 10 days of completion of the testing of each trial Pile.

2.4 Following complection of testing of trial pile and less than Three Weeks before working Pile installation is scheduled to commence the contractor shall submit, in triplicate, for the approval of the Engineer- in – charge, report discussing the over all results of the on trial piles.

3.0 **TECHNICAL SUPERVISION**

The contractor's site staff shall include a senior qualified and experienced engineer in attendance full time on site during piling work to be responsible for over all Technical control of the work. This person shall be fully conversant with the procedures for installation and testing of piles.

4.0 **PILING**

4.1 **GENERAL**

The Contractor shall be responsible for the quqlity as well as the number of Pile cast per day. Work should be done as per specification as well targets fixed. The Contractor's site representative shall give full time attention to the pilling work in progress.

4.2 **PROGRAMME**

The Contractor shall inform the Engineer-in-charge each day of programme of pilling for the following day and shall give adequate notice of his intention to work out side normal hours and week ends.

4.3 **SETTING OUT**

Setting out shall be carried out from the main grid lines of the proposed structure immediately before installation of the Piles, the Piles position shall be marked with suitable identificable pins or markets. All layouts shall be checked with theodelite from original grid lines only and not from the Co – Ordinates of nearby Piles.

4.4 **RECORDING OF DAY TO DAY WORK**

Each pile being east shall be recorded in a format as is given in rspective specifications. There should be four copies of each record in different colours for easy differentiation. Two are to be submitted to engineer in charge. Out of the remaining, one to he submitted along with RA Bills and should be for the Contractor's records.

(The original shall be attached along with the RA Bill 2$^{nd}$ and 3rd copies to the Engineer – in – charge and the 4th one for the Contractor. The format shall be submitted to the Engineer- in- charge immediately after complection of concreting of the particular Pile. Any unexpected boring conditions reported in accordance with the particular obligation as specified in the format shall briefly be noted in the records.

4.5 **FINISHING OF PILE HEAD**

Following excavation subsequently for pile cap construction the contractor shall carefully remove excess concrete above specified cut off level without damaging the remainder of the Pile inclding the Projecting reinforcement. Any cracked or defective concrete occuring below specified cut off level shall be cut away and made good with new concrete properrly bonded to the old, at contractos's cost.

4.6 **VERTICALITY**

The maximum permitted deviation of the finished Pile from the vertical shall be as given in respective standard specifications.

4.7 **FORCIBLE CORRECTION**

Forcible corrections to concrete Piles shall not be made.

4.8 **NOISE DISTURBANCE**

The contractor shall carry out the work in such a manner and at such times as to minimum noise and disturbance.

4.9 **DAMAGE TO ADJACENT STRYCTURES**

If during the execution of the work damage is, or is likely to be, caused to mains services or adjacent structures the contractor shall submit to the Engineer – in – charge his proposal for repair and avoidance of such damage.

4.10 **DAMAGES TO PILES**

The contractor shall ensure that damage does not occur to completed Plies.

# PILING PART III-SPECIFIC REQUIREMENTS

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**PART III – SPECIFIC REQUIREMENTS**

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2.0 PILE TYPE

3.0 SAFE LOAD CARRYING CAPACITY

4.0 MATERIALS

5.0 INSTALLATION

6.0 CONSTRUCTION

7.0 DEFECTIVE PILES

8.0 PILE TESTING

9.0 CRITERIA FOR ASSESSMENT OF SAFE LOADS

10.0 MEASUREMENT

1.0 **GENERAL REQUIREMENTS**

All work shall carried out in accordance with specifications enclosed herewith and the Contractor shall ensure minimun requirements as laid down hereunder.

2.0 **PILE TYPE**

The piles shall be 500mm dia. bored cast-in situ piles approximately 24m long from pile cutoff. The pile shall be terminated after embedding in weathered rock strata. The socketing length of pile will be about 2m on weathered rock (having N>100).

**3.0 SAFE LOAD CARRYING CAPACITY:**

The piled are designed for the following minimum safe load capacities.
-safe vertical load capacity = 95T
-safe lateral load carrying capacity = 3T
-pull out capacity = 25T

4.0 MATERIALS:

4.1 Materials shall confirm to BHEL specification no PEDC/STD/001 enclosed and forming a part of this bid document.

4.2 Concrete:

The concrete shall be of M-35 grade with minimum strength of 35N/mm2 at 28 days. The other concrete specification shall be as per relevant clauses of standard specification for construction & installation of bored cast-in-situ piles BHEL specification No EDC/STD/003.

4.3 Cement:

Ordinary portland cement shall be used. However, the cement content shall not be less than 400kg/m3 maximum water/cement ratio of 5.0. the allowable slump shall be as per IS:2911 part1/sec1. The engineer-in-charge may also allow marginal adjustmentental ratio to obtain concrete of good workability.

4.4 Reinforcement:

4.4.1 Reinforcement

The approx. reinforcement requirement is as follows:
a) Longitudinal reinforcement
4 No- 25mm and 4 No- 12mm extending 7000mm below the cut-off level and
8 No- 12mm extending from cut off level to full length of pile conforming to IS:1786 or IS:1139.

b) Links

Stirrups shall be 8mm. conforming to IS: 1788 or IS: 1139. Pitch shall be 175mm. stirrups shall be tack welded with main reinforcement to maintain its shape and spacing.

c) Clear cover to main reinforcement shall be 50mm.

## 5.0 INSTALLATION:

**5.1** Installation of piles shall be carried out in accordance with pile layout drawings which shall be available to the contractor at the time of execution of work.

5.2 Cutoff level of the piles shall correspond to those given in the working drawings. For broad guidance, however, this may be assumed as 2 to 3m below the NGL.

5.3 To ensure dense and sound concrete up to the cut of level, concreting shall extend up to 1000mm, above the cut off level.

5.4 In case the reinforcement cage is made up of more than one segment, the same shall be assembled by welding only before lowering as per IS: 456 by providing necessary laps.

5.5 The vertical reinforcement shall project 50times its diameter above he cutoff level.

## 6.0 CONSTRUCTION:

6.1 Bored cast-in-situ piles

6.1.1 The construction of piles shall be in accordance with the provision of bhel standard specification no PEDC/STD.SPEC/003.

6.1.2 The borehole sides shall be stabilized using direct and circulation technique. The concretion shall be done by termite observing all necessary precautions and producers as per IS: 2911 part-1 section 2 provisions. The final clearing of the borehole byres mud circulation must be accomplished just prior to commencement of concretion by tremie. The quality of drilling and used shall be checked as per latest IS: 2911 part-1 section 2 provisions and shall be replaced if it does conform to the same.

6.1.3 The concreting shall be proceed immediately after completion of the drilling and cleaning process of the borehole.

6.1.4 The concrete shall be placed by a tremie of suitable diameter. All precaution for obtaining clear and sound pile shaft be strictly observed.

6.1.5 For treime concreted piles, a sample of drilling fluid shall be taken from the base of borehole by means of an approved sampling device in the first few piles and at suitable intervals of piles thereafter. Concrete placing shall not proceed if density of fluid exceeds 1250kg/m3. The sand content in the fluid shall not exceed seven percent.

6.1.6 To ensure dense and sound concrete up to cutoff level concreting shall be extended for length of 1000mm above the cut off level. However, no extra payment shall be made for this and quoted rate shall be inclusive of this.

**7.0 DEFECTIVE PILES:**

Defective piles shall be removed or left in place and replace by additional piled as directed by the engineer-in-charge at no additional cost.

**8.0 PILE TESTING:**

**8.1** Type of loading test

8.1.1 Initial loading test

a) prior to commencement of the job piling, initial vertical and lateral tests shall be carried out on separate test piles cast for the purpose. The number of tests in each category shall be as given n schedule of quantities.

b) the contractor shall be allowed to proceed with the job piping only after successful completion of the various initial piles load tests to the satisfaction of the engineer-in-charge.

8.1.2 Routine load tests

The number of tests in each category shall be as given in schedule of quantities. The piles for the various tests shall be randomly selected by engineer-in-charge.

8.2 Pile load test

8.2.1 For various tests, the test set up shall be as “specification for testing of concrete piles (BHEL Standard Specification No PEDC/STD/005).

8.2.2 All testing shall be done by the cyclic/direct loading test in minimums eight stages as per the relevant clause of “specification for testing of concrete piles” BHEL Standard PEDC/STD/005.

8.2.3 Each stage of loading for various tests should be maintained till the rate of movement of piles isles than 0.02mm/hr. however, this rate is not permitted to be extrapolated for 24rs. And settlements shall be observed every hr. during this period.

8.2.4 Maximum test loads for various tests shall be as follows:

a) Initial vertical pile load tests-load corresponding to a total settlement of 10% of pile dia. Or twice the pile vertical load capacity which ever occur earlier.

b) Initial lateral pile load tests-load corresponding to 12mm total deflection.

c) Initial pull out test.

Thrice the estimate safe uplift load on respective pile or until the load displacement curve shows clear beak (downward trend) whichever occurs earlier.

d) Routine vertical load test- 2.5x95T or load corresponding to 12mm total settlement.

e) Routine lateral load test- 3T or load corresponding to total deflection of 5mm

## 9.0 CRITERIA FOR ASSESSMENT OF SAFE LOADS:

9.1 Safe vertical load

It shall be the latest of the following:
-2/3 of final load at which the total settlement attains a value of 12mm.
-50% of the total at which load at which the total settlement equate 10% of the pile diameter.

The criteria for the safe load form routine load test shall also be the same.

9.2 Safe lateral load
Safe lateral load shall be the latest of the following:
-50% of the final load at which the pile deflection attains a values of 12mm
-Final load at which the total pile deflection corresponds to 5mm.
The criteria for the safe load form routine load test shall also be the same.

9.3 Safe up lift load
Safe up lift load on pile shall be the latest of the following:

a) Two-third of the load at which the total displacement attains a value of 12mm.
b) Half of the load at which the total displacement curve shows a clear break. (downward trend)

A full record of pile load tests results shall be submitted to the engineer-in-charge immediately on completion of each test. The record shall also include the plots of load-settlement and time-settlement (for various stage of loads) characteristics of pile and also the interpretation of the pile load test curve as per criteria for safe loads as mentioned in clause 9.0of “Specification Requirements”. Further it should also include driving record of tested piles. Any special observations shall be duly explained by the contractor.

## 10.0 RATE:

1. Rate to be quoted for piles shall be inclusive of all equipments, lab our and materials(excluding reinforcement) including boring, betonies slurry, concrete , chipping of excess concrete over cut off length, disposal of surplus earth , used slurry and debris beyond 7 KM distance, shifting of plant and equipment from pile to another etc, complete.

2. Rate for providing reinforcement to be quoted separately.

## 11.0 MEASURMENT OF PILES

The piles shall be measured and paid for the actual pile length from pile tip to cut-off level, given in the working drawings or as indicated by the engineer-in-charge. No extra payment shall be made for empty up to cut-off-level of 3m below N.G.L or for concrete cast above cut-off-level (ref.clause 6.1.6)
If actual cut-off-length as per construction drawing is more than 3m form N.G.L,

payment for boring beyond 3m will be made.
Reinforcement will be measured as per actuals and paid for by weight as a separate item

# PILING PART-IV – MATERIAL FOR REINFORCED CONCRETE PILES

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## SPECIFICATION OF MATERIALS FOR REINFORCEMENT CONCRETE PILES

**CONTENTS :**

1. GENERAL

2. MATERIALS FOR CONCRETE

3. ADMIXTURES

4. REINFORCEMENT

## GENERAL

### 1.1 SCOPE :

1.1.1 This specification establishes the material specification of reinforced Cement Concrete to be used in Pile foundations. Any special requirements as shown or noted on the drawings shall govern over the provisions of these specifications.

1.1.2 For specific work requirements concerning design and construction or otherwise modifying or supplementing the provision of this specification, refer to the specific requirements. In case of confict between requirements. In case of conflict between specific requirements and provisionof this specifications, former shall govern.

### 1.2 DEFINITIONS

2.1 Reference to Indian Standard Codes shall always mean reference to the latest issue of the relvent standards including all its amendments upto date.

### 1.3 CODES :

All design and conctruction shall be perfomed in accordance with the Indian Standard Code of Practice for plain and Reinforced Concrete IS : 456.

### 2 MATERIALS FOR CONCRETE :

### 2.1 GENERAL :

All materials which may be used in the Plain or Reinforced Cement Concrete work shall be of Standard quility manufactured by renowned concerns conforming to IS or equivalent and shall have Is certification mark as for as possible unless otherwise approved by the Engineer-in-charge. The contractor shall get all materials approved by Engineer-in-charge prior to its procurement and before actual use. The Engineer-in –charge shall have the right to determine whether all or any of the materials offered or delivered for use in the works are acceptable. Any material brought to site and conforming to specification and instruction of Engineer-in-charge shall be rejected and the contractor shall instruction of Engineer-in-charge shall be rejected and the contractor shall have to remove the same immediately from site at his own expenses.

### 2.2 CEMENT :

2.2.1 The cement used shall be Ordinary Prortland Cementconforming to IS :8112 or Blast furnance slag cement conforming to IS : 455 or Portland pozzolona cement conforming to IS : 1489 or as specified and/or directed by the Engineer-in-charge.

2.2.2 **TESTS AFTER DELIVERY :**

Each consignment of cement may, after delivery on the site and of the discretion of the Engineer-in-charge, be subjected to any or all of tests and analysis required by the relvent indian Standard Specificatons Favilities for testing shall be provided by contractor of his own cost.

2.2.3 **STORAGE ON THE SITE :**

The Cement shall be stored in a suitable weather-light building and in such a manner as to permit easy access for proper inspection to prevent deterioration. Cement of different types and brands shall be kept in separate storage.

All accepted cement stored on the site shall be arranged in batches, and used in the same order as received from the manufacturer. The contractor shall maintain a cement register in which all entires shall be completed day to day showing the quantities received, date of receipt, source of despatch, type of cement, etc. and also the daily cement consumption on site. The register shall be accessible to the Engineer-in-charge for his verification.

2.2.4 **REJECTION OF CEMENT :**

The Engineer-in-charge may reject any cement as a result of any tests therof, not-withstanding the manufacture's certificate. He may also reject cement which has deteriorated owing to indequate projection from moisture or due to instruction of foreign matter or other causes. Any cement which is considedred defective by the engineer-in-charge shall not be used, and shall be promptly removed from the site of the work by the contractor at his own expense.

2.3 **AGGREGATES FOR CONCRETE :**

2.3.1 **GENERAL :**

Corse and Fine Aggregates for concrete shall conform in all respects to IS : 383, 'Specification for Coarse and Fine Aggregates from Natural Sources for Concrete'. Aggregate, shall be obtained from a sorce known to produce those satisfactory for concrete. Aggregates shall consist of naturally occuring sand and gravel or stone, crushed or uncrushed, or a combination theof. They shall be chemically insert, hard, strong, dense, durable, clean and free from veins, adderent coatings and shall be of limited porosity.

Flaky and elongated pieces shall not be used. Whereever required by the Engineer-in-charge the aggregates shall be washed by the contracor before use in the work.

The source of aggregate shall be approved by the Engineer-in-charge and shall not be changed during the course of the job without this approval. Rejected aggregates shall be removed from the work site by the contractor of his own expense.

2.3.2 **DELETERIOUS MATERIALS :**

Aggregate shall not contain any harmful materials, such as iron pyrites, coal, mica, shale or similar laminated materials, clay, alkali, soft fragments, sea shells, organic impurities etc. in such quantities as to affect the strength or durability of the concrete in addition to the above, for reinforced concrete, any materials which might cause corrosion of the reinforcement, and aggregates which are chemically reactive with alkalie of cement shall not be used.

The maximum quantities of deleterious materials in the aggregates, as determined in accordance with IS.2386 (part-II). Methods of Test for Aggregates for concrete, shall not exceed the limits given in Table –I of IS 383.

The sum of the percentages of all deleterious materials shall not exceed five. Deleterious materials also include materials passing 75 micron IS sieve.

2.3.3 **COARSE AGGREGATES**

Coarse aggregate is aggregate most of which is retained on 4.75mm sieve.

These may be obtained from crushed or uncrushed gravel or stone as per Cl. 2.3.1 and may be supplied as single sized or graded aggregates given in table II of IS :383.

The Engineer-in-charge may allow all-in-Aggregatesto be used provided they satisfy, the requirements of clause 4.4 and Table – IV of IS :383.

2.3.4 **FINE AGGREGATES**

Fine aggregate is aggregate most of which passes 4.75mm IS : Sieve but not more than 10% pass through 150 micronn IS : Sieve. These shall comply with the requirements of grading Zone II of IS :383. Fine aggregate conforming to grading Zone shall not be normally used in reinforced concrete unless tests have been made by the contractor to ascertain the suitability of the proposed mix pooportions and approved by the Engineer-in-charge.

Fine aggregates shall consist of natural sand resulting from natural disintegration of rock which has been deposited by streams or glacial agencies, or curshed stone sand or crushed gravel sand.

2.3.5 **SAMPLING AND TESTING**

In case of doubt the Engineer-in-charge may require the contractor to carry out tests, at the contractor’s expense in accordance with

IS :516- Method of Tests for Strenths of Concrete and

IS :2386-Methods of tests Aggregates for Concrete.

2.3.6 **STORAGE OF AGGREGATES**

The contractor shall at all times maintain at the site of work such quantities of aggregate as considered by the Engineer-in-charge to be sufficient to ensure continuity of work.

Each type and grade of aggregate shall be stored separately on hard firm ground having sufficient slope to provide adequate drainage to rain water.

Any aggregate delivered to site in awet condition or becoming wet at site due to rain shall be kept in storage for at least 24hrs. To obtain adequate drainage, before it is used for concreting, or the water content of mix must be suitably adjusted as directed by Engineer-in-charge.

2.4 **WATER**

Water used for concrete shall be clear and free from injurious amounts of Oil, Alkali, Organic matters or other harmful substances in amounts that may impair the strength or durbility of the structure. Potable water shall generally be considered satisfactory for mixing and curing concrete.

The Engineer-in-charge may required the contractor to prove at latter's expense, that the concrete mixed with water proposed to be used should not have a compressive strength, lower than 90% of the strength of concrete mixed with distilled water.

The Engineer-in-charge may required the contractror to get the wtater tested from an approved laboratory at his own expense and in case the water contains any sugar or an excess acid, alkali, any injurious salts etc. the Engineer-in-charge may refuse to permit its use.

3. **ADMIXTURES.**

3.1 Admixtures such as CICO grade I or puddlo or equivalent may be used in concrete only with the approval of Engineer-in-charge.

4. **REINFORCEMENT**

4.1 Mild steel Bars

4.1.1 The reinforcement shall normally be mild steel in the form of round bars, conforming to IS : 432 Grade I unless specified otherwise.

4.2 Hard Drawn Steel Wire fabric.

4.2.1 When specified on the drawings, hard drawn steel wire fabric shall be used conforming to IS : 1566 - It shall be of an approved type and of weights and dimensions shown on the drawing.

4.3 High yield Deformed Steel Reinforcement conforming to IS :1786

4.3.1 Cold twisted high yeild deformed steel bars, shall conform to IS :1139.

4.4 Other Bars & Sections

4.4.1 Any other type of reinforcement bars specified on the drawings shall conform to its respective Indian standard Specification. Medium Tensile Steel Bars when specified on the

4.5 **WELDING**

4.5.1 Field welding of reinforcing bars not be permitted without the written consent of the Engineer-in-charge. Where welding is permitted it must be at staggered locations. Tests shall be made to prove that the joints are of the full strength of bars connected. Welding of reinforcement shall be done in accordance with the recommendation of IS : 2751.

4.6 **STORAGE**

4.6.1 The Steel reinforcement shall be stored in such a way as to avoid distoration and to prevent distoration and corrosion.

4.7 **OTHER SPECIFICATION**

4.7.1 General construction details and workmanship relative to reinforcement including bar bends, lap splices and installation shall be in accordance with IS : 2502 – Code of practice for Bonding and Fixing of bars for concrete reinforcement, as well as the detaining of reinforcement given in IS : 456.

4.7.2 Hot bending of bars shall not be allowed.

4.7.3 The number sizes, shape and position of all the reinforcement shall, unless otherwise directed or authorised by the Engineer-in-Charge, be strictly in accordance with the drawings. The reinforcement shall be adequately secured and held in position by metal chairs and spacers. Ties at inter-sections shall be made with 16 SWG soft block annealed binding wire.

4.7.4 The contractor must obtain the approval of the Engineer-in-charge for the reinforcement placed, before any concrete is placed in the forms. The reinforcement at this time shall be free from loose rust or scale of other coatings that will destroy or reduce bond.

4.7.5 Concrte spacer blocks of the same strength as parent concrete, I shall be used to ensure correct cover to the reinforcement. This clear cover shall be as shown on the drawings or as per instructions of the Engineer – in-charge.

4.7.6 All the reinforcing bars shall be so tied as to from a rigid cage to prevent displacement before or during concreting.

# PILING PART-V
# TESTING OF CONCRETE PILES

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2. VERTICAL LOADING TESTS
3. LATERAL LOADING TEST
4. PULL OUT CAPACITY OF PILES
5. COMBINED VERTICAL AND LATERAL LOADING
6. SPECIAL TYPE OF LOADING

APPENDIX 1 – PILE LOADING TEST RECORD

## 1. GENERAL

### 1.1 Scope

1.1.1 This specification covers the requirements and methods of testing of a single pile for evaluating its safe capacity in :

a) Vertical Loading (compression )

b) Lateral loading

c) Pull out.

d) Combined vertical and lateral loading.

e) Special type of loading such as vibratory loadings.

1.1.2 These specifications shall be applicable for all types of piles in general excepting sheet piles.

1.1.3 For specific work requirements or otherwise modifying or supplementing the provisions of this specification, refer to specific requirements. In case of conflict between requirements set forth in the specific requirements and the provisions of this specification, the specific requirements and the provisions of this specification, the specific requirements shall govern.

### 1.2 Definitions

1.2.1 Reference to Indian Standard codes shall always mean reference to the latest issue of the relevant standards, including all the amendments up to date.

### 1.3 Codes

1.3.1 All testing shall be performed in accordance with the following codes and the provisions of these specifications:

IS: 2911 – (part-IV) – Codes of practice for design and Construction of Pile Foundations – Load test on piles.

### 1.4 Requirements

1.4.1 The load test shall be required to provide data regarding the load – deformation characteristics of the pile up to failure or otherwise specified and the safe design capacity.

1.4.2 Full details of the equipment proposed to be used and the test set up shall be submitted to the Engineer-in-Charge with detailed sketches for approval. Approval of the Engineer-in-Charge shall be also be obtained after the test set up is complete, prior to commencement of loading.

1.4.3 All measuring devices shall be tested satisfactory performance and accuracy at an approved institution and certificate to that effect obtained and submitted to the Engineer –in-charge, prior to use.

1.4.4 The test pile shall be constructed using the same equipment and technique as for the job piles.

1.4.5 A minimum time period of one week shall be allowed between the time of installation and testing in case of a precast pile and less than four weeks from the time of vesting in case of a cast-in situ pile.

1.4.6 Recodes

A full record giving all details of the test in the Proforma in appendix-1 shall be submitted in TRIPLICATE to the Engineer-in-Charge immediately on COMPLETION of each test. The record shall also include the plot of load- time settlement characteristics of the piles.

## 2 VERTICAL LOADING TEST:

2.1 Equipment and test Set-up

### 2.1.1 Test pile

2.1.1.1 The test pile shall be decided by the Engineer-in-Charge. It may be one of the working piles or separate test pile.

2.1.1.2 The head of the test pile shall be brought to the proper level and provided with a pile cap with a moral and plane surface and with adequate space for proper seating of a jack and dial gauges.

2.1.1.3 Test pile surface shall be prepared for testing purposes on the expiry of one week after casting the pile.

### 2.1.2 Loading Systems

2.1.2.1 Loading shall be applied by the reaction method consisting of an hydraulic jack reacting centrally against a loaded platform. Supports of the platforms shall be adequately designed. Special anchor piles or any other suitable type of anchorage system may also be used. However, use of the uplift supply of neigh boring piles for providing the reaction shall normally not be permitted.

2.1.2.2 The loading system shall be adequate to ensure that the test can be carried up to the specified limit. The reaction to be made available for the test shall be at least 25% greater than the maximum jacking force required.

**2.1.3 Measuring System**

**2.1.3.1 Loading on piles**

The load applied on the pile shall be recorded on a calibrated pressure gauge mounted on the jack.

**2.1.3.2 Settlement of pile**

a) Settlement of pile shall be recorded by dial gauges suspended from datum bars.

b) The datum bars shall have rigid supports preferably of concrete pillars or steel section, embedded well into the ground. The supports shall be locked more then three times the piles diameter, subject to a minimum of 1.5 M, clear away from the pile face and also sufficiently away from the supports of the loaded plat from to avoid any disturbance on these accounts. Movements near the supports of the datum bar shall be avoided while the test is in progress.

**2.2 Method of conducting Test**

The test shall be carried out by the direct method of loading in successive increments or by the cyclic loading method as specified and as directed by the engineer-in-charge.

**2.2.1 Direct Method of Loading in Successive Increments**

The test shall be carried out as per the procedure outlined.

a) The load shall be applied to the pile top in increments of about one fifth the rated capacity of the pile or as specified. Settlement readings shall be taken before and after the application of cash new load increment and at 2, 4, 8,15,30,60 minutes and at every two hours until application of the next load increment.

b) Each stage of loading shall be maintained till the rate of movement of the pile top is not more than, 0.1 mm in first 30minutes, 0.2 mm per hours or until two labours have elapsed, whichever is later.

c) (I) Yield of soil-pile system occurs causing progressive settlement of the pile exceeding a value of one tenth of the pile diameter.

(II) The loading on the pile top equals twice the rated capacity or as specified in the case of a separate test pile and 1.5 times the rated capacity of the pile in case of a working pile.

d) Where yielding of the soil does not occur, the full test load shall be maintained on the pile head for 24 hours or more if necessary and settlement reading shall be taken at 6hours interval during the period.

e) Unloading shall be carried out in the same steps as loading. A minimum period of ½ hour shall be allowed to elapse between two successive stages of load decrement. The final rebound shall be recorded 6 hours after the entire test load has been removed.

f) If so directed by the Engineer-in- charge, loading and unloading cycles shall be carried out for all load stages within the assumed working load.

g) Assessment of Safe Load:

The safe of the pile shall be the least of following values:

i) 2/3 of final load at which the total displacement attains a value of 12mm. Unless otherwise required, in given case on the basis of nature and type structure in which case, the safe load should be corresponding to the stated total displacement permissible.

ii) 50 percent of final load at which the total settlement equate the 10% of pile diameter in case of bored piles and 7.5 percent of bulb diameter in case of under – reamed piles.

**2.2.2 Cycle Loading Test**

The test shall be carried out as per the procedure outlined by IS: 2911 – (part – IV) and as described below:

a. The load shall be supplied to the pile top in increments of about one fifth the estimated safe capacity of the pile or as specified. Settlement readings shall be taken before and the application of each new load increment and at 2, 4, 8,15,30,60 minutes and at every two hours until application of the next load increment.

b. Alternate loading and unloading shall be carried out at each stage and the total and net settlements recorded as specified. If so directed by the Engineer-in-charge, more then one cycle of loading and unloading shall be carried out at any or all of the stages.

c. Each stage of loading or unloading shall be maintained till the rate of movement of the pile top is not more then 0.2 mm per hour provided that the minimum period is two hours for loading and one hour for unloading. The following lod stages shall however be maintained for longer periods as given below:

i) At 1. 5 times assumed safe Capacity (for routine test only) - 24 hours.

ii) At load of twice assumed safe capacity ( for initial test only ) - 24 hours

This loading shall be continued till one of the following occurs:

i) Yield of the soil pile system occurs causing progressive settlement exceeding one tenth of the pile diameter.

ii) The loading on the pile top equals twice the estimated safe load in case of a separate test pile and 1.5 times the rated capacity of the pile in case of working pile.

d) Assessment of Safe Load :

The safe capacity of the pile shall be the least of the following:

i) Two thirds of the final load at which the total settlement attains a value of 6 mm.

ii) Two thirds of the final load at which the total settlement attains a value of 6 mm.

iii) Half of the final load at which the total settlement equals one tenth of the pile diameter.

## 3. LATERAL LOADING TEST:

### 3.1. Equipment and test set-up

#### 3.1.1 Test Pile

The test pile shall be decided by the Engineer-in-Charge. It may be one of the working piles or a separate test pile.

The test pile shall be cut off at the proper level and provided with a cap with vertical plane sides having an adequate area for proper seating of the jack and dial gauges.

#### 3.1.2 Loading System

Loading shall be applied by an hydraulic jack of adequate capacity, abutting the pile horizontally and reacting against a suitable system. The reaction may be provided by the wall of the excavated-pit when the test is being conducted below ground level or by a neighbouring pile in which case thrust pieces shall be inserted on either end of the jack to make up the gap.

**3.1.3 Measuring System**

3.1.3.1 Lateral load applied on the pile shall be measured by a calibrated pressure gauge mounted on the jack, having a least count of 500 Kg.

3.1.3.2 Deflection of the pile hand shall be measured by dial gauges, fixed to datum bars and having a least count of 0.01 mm. The datum bars shall be provided with rigid supports as described in Clause 2.1.3.2 (b) above.

**3.2 Method of Conducting Test :**

The test shall be carried out in accordance with the provisions of IS: 2911– (part-I) and as detailed below:

3.2.1 Loading shall be applied in increments of 500 kgs. or as specified.

3.2.2 Each stage shall be maintained for a period till the rate of movement of the pile head is not more then 0.1 mm / 30 min. or 1 hr. whichever is greater.

3.2.3 Loading shall be continued till one of the following occurs:

a) Deflection of the pile head exceeds 12 mm.

b) The applied load on the pile is twice the assumed lateral load capacity of the pile in case of a separate test pile and 1 ⅓ Times the rates capacity in the cast of a working pile.

**3.2.4 Assessments of Safe Load :**

The safe load shall be the smaller of the following:

i) Half the final load for which the total deflection is 12 mm.

ii) Loading corresponding to 5 mm total defection.

NOTE: The deflection is at the cut off level of the pile.

**4. PULL OUT CAPACITY OF PILES**

**4.1 Equipment and test Set up**

**4.1.1 Test pile**

The test pile shall be decided by the Engineer-in-Charge. The test shall be conducted on a separate pile installed separate pile installed specifically for this purpose.

4.1.1.2 The test pile shall be built upto the proper length and the proper length and the head provided with suitable arrangements for anchoring the load applying system.

**4.1.2 Loading System**

4.1.2.1 Load shall be applied using an approved reaction system uplift force on the pile may be applied directly to the test pile or through a lever system. The reaction may be provided by neighbouring piles or blocks may be constructed for the purposes. A hydraulic jack shall be used for load application.

**4.1.3 Measuring System**

4.1.3.1 Load applied by jack shall be measured by a calibrated pressure gauge with a least count of 1000 kgs.

4.1.3.2 Movement of the pile shall be measured by dial gauges, fixed to datum bar and having a least count of 0.01 mm. A minimum of two dial gauges, placed diametrically opposite shall be used. Datum bars shall be provided with rigid supports as described in 2.1.3.2 (b) above.

**4.2 Method of Conducting Test**

The test shall be conducted as outlined below:

4.2.1 Loading shall be applied to the pile top increments of one fifth the rated capacity of pile.

4.2.2 Each stage shall be maintained for a period till the rate of movement of the pile head is not more then 0.1 mm / 30 min. or one hour, whichever is greater.

4.2.3 Loading shall be continued till one of the following occurs:

a) Yield of soil pile system occurs causing progressive movement of the pile exceeding 12 mm.

b) The loading on the pile top equals twice the estimated safe load or as specified.

**4.3 Assessment of Safe Load**

The safe capacity of the pile shall be the smaller of the following:

a) Two-thirds of the load at which the total displacement is 12 mm or the load corresponding to a specified permissible up lift, and

b) Half of the load at which the load-displacement curve show as a clear break (downward trend).

## 5. COMBINED VERTICAL AND LATERAL LOADING :

5.1 Equipment and Test Set-up

5.1.1 The equipment and test set up shall be same described in Clause 3.. In addition a platform shall be constructed on the pile top, and loaded to 1.0 times the pile capacity in vertical loading.

The pile shall be first subjected to the full vertical load. The lateral load shall commence after all settlements due to the vertical load have ceased and while the full vertical load is in position.

5.1.2 The loading system, measuring system and recording of results shall be the same as described in Clause – 3.

### 5.2 Method of Conducting Test and Assessment of Safe Load

This shall be in accordance with the provision of Clause 3.2 above.

## 6. SPECIAL TYPE OF LOADING

This shall include evaluating the pile response to vibratory loads, both horizontal and vertical in nature. The test set up and method of conducting the test shall be covered under specific requirements.

APPENDIX-1

FILE NO……DATE OF ……WT. OF HAMMER……

TYPE……..DRIVING ……AVR. DROP OF HAMMER……

DIAMETER (CM)……..CASTING……..TOTAL NO. OF BOWS……..

LENGTH BELOW COMMENCEMENT OF TEST… SUM OF TEMPORARY

G.L.(M)…….. ……COMPRESSION IN CMS……

LOCATION …… COMPLETION OF TEST……. GROUND LEVEL ……

TYPE OF TEST: DIRECT/CYCLE LOADING

| DATE | TIME | TOTAL TIME | LOAD ON | LOAD OFF | TOTAL LOAD | SETTLEMENT (DEFLECTION) GAUGE I | II | AVRSETTLEMENT (DEFLECTION) SOUND TOTAL | NETT | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| | HR.MINS | TONNES | TONNES | MM | MM | MM | MM | M | | |

# PILING PART-VI
# CONSTRUCTION AND INSTALLATION OF RCC BORED CAST IN-SITU PILES

| REV. NO. | PRAPARED | APPROVED | DATE |
|---|---|---|---|
| 00 | Marina | P Mishra | |
| | | | |

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# PART-VI
# CONSTRUCTION AND INSTALLATION OF RCC BORED CAST IN-SITU PILES

## CONTENTS

1. SCOPE
2. CODES
3. MATERIALS
4. DESIGN CONSIDERATIONS
5. EQUIPMENT AND ACCESSORIES
6. PILING INSTALLATION
7. DEFECTIVE PILES
8. REFECTIVE OF DATA

## 1. SCOPE

1.1 This standard specification covers the construction and installation of load bearing reinforced concrete bored cast-in – situ piles.

1.2 For specific work requirements concerning construction or otherwise modifying or supplementing the provision of this specification, reference may be made to "Specific Requirements" and the provisions of this specification, the "Specific Requirements" shall govern.

## 2.0 CODES

2.1 IS: 2911 (part I Sec.2) – Indian Standard Code of practice for Design and Construction of pile Foundations: Part I concrete piles, Section 2 – Bored Cast – in Situ piles, shall be referred in conjunction with these specifications during the entire design, construction and installation work.

2.2 Reference to any code shall always mean reference to the latest revised edition of the code including all its amendments up to date, unless otherwise specified. In the event of any conflict between the requirements of this specification and those of the referred codes, the former shall govern.

## 3.0 MATERIALS

3.1 All materials, vizcement, steel, aggregates, water, etc. which are to be used in the Construction work, shall conform to BHEL Standard Specification for Reinforced Concrete pile NO.PEDC/STD.SPEC/040-d.

### 3.2 Concrete

3.2.1 Methods of the manufacture of cement concrete shall in general, be in accordance with IS: 2911 (part – I/Sec.2) and as per following clauses.

3.2.2 The grade of concrete shall be M35 a min. cement content of 400 kg/$m^3$.

3.2.3 Slump of Concrete

Slump of concrete shall range between 100 to 180 mm depending on the manner of concreting. The table below gives the general guidance:

| PILING | SLUMP ( in MM) | | TYPICAL CONDITION OF USE |
|---|---|---|---|
| | MIN | MAX | |
| A | 100 | 180 | Poured into water- free unlined bore having Widely spaced reinforcement. Where Reinforcement is not spaced widely enough, cut off level of pile is within the casing and diameter of pile is less then or equal this to 600mm, higher order of slump within this range may be used. |
| B | 150 | 180 | Where concrete is to be placed under water or drilling mud, by tremie or by placer. |

## 4. DESIGN CONSIDERATIONS

### 4.1 Structural Design

The piles shall have necessary structural strength to transmit the loads imposed on it, to soil. Relevant parts of IS : 2911 (part 1/Sec.2 ) and specific requirements shall be considered to apply for assessing the structural capacity of piles.

### 4.2 Reinforcement

4.2.1 The minimum longitudinal reinforcement shall be 0.4% of the cross-sectional area of the pile.

4.2.2 Clear cover to the main reinforcement shall be 50 mm. This shall be increased to 75 mm. In case of aggressive soils and ground water conditions.

4.2.3 The vertical reinforcement shall project 50 times its diameter above the cut off level.

4.2.4 The minimum clear distance between the two adjacent main reinforcement bars should normally be 100 mm for the full depth of case. The bars shall be so placing as not to impede the placing of concrete.

4.2.5 The lateral ties in the reinforcing cage shall be preferably spaced not closer then 150 mm centre to centre and shall be tack welded to the main reinforcement.

4.2.6 The minimum diameter of the lateral ties shall be 6 mm.

## 5. EQUIPMENT AND ACCESSORIES

5.1 The equipment and accessories for installation of bored cast-in – situ piles shall be selected giving due consideration to the subsoil conditions and the manner of operations etc. these shall be of standard type and shall have approval of the Engineer- in –Charge.

5.2 The capacity of the rig shall be adequate so as to reach the desired depth.

5.3 Provision shall be kept for chiselling within the borehole in case of any underground obstruction/ hard strata. However, chiselling shall be carried out only with the approval of Engineer – in –Charge.

5.4 In case pile list required to be socketted in medium or good quality rock strata, the equipment mobilized shall have adequate capability to do so up to the required socket length. For the purposes of classification of rock for the determination of the socket ting and payment pilot drill holes shall be carried out in the areas to pile.

5.5 Pilot drill holes shall be Nx or Bx size as per specification requirements. Rock drilling shall be carried out using double tube core barrel. Drilling and storing of rock cores shall conform to relevant IS Codes. Rock quality shall be classified as under depending upon the RQD.

| RQD (%) | ROCK QUALITY |
|---|---|
| 25 | Poor |
| 25 to75 | Medium |
| 75 | Good |

## 6. PILING INSTALLATION

### 6.1 Control of Alignment

6.1.1 The piles shall be installed as accurately as possible as per the designs and drawings. The permissible positional deviations shall be governed by IS : 2911 (part I/Sec.2). in case of piles deviating beyond such permissible limits, the piles shall be replaced or supplemented by additional piles, as directed by Engineer – in – Charge.

### 6.2 Boring

6.2.1 the boring shall be done by one of the following methods:
(a) direct mud circulation
(b) Reverse mud circulation.
The actual method of construction to be followed shall be as per specific Requirements as furnished in customer's specification.

6.2.2 In case the strata being bored through is reasonably stiff or dense and the length of the pile is less then 10 m use of bail bentonite method may be permitted.

6.2.3 In very soft soil a permanent liner shall be installed to ensure stability of borehole. A line shall be used to protect the green concrete where a high hydrostatic pressure exists in the subsoil or where an underground flow of hydrostatic pressure exists in the subsoil or where an underground flow of water exists and which is likely to damage the concrete on withdrawal of casing.

6.2.4 Use of temporary liner in lieu of bentonite to stabilise sides of boreholes shall not be permitted.

6.2.5 Properties of bentonite used and quality control shall be as per IS : 2911 (part I/Sec.2).

**6.3 Concreting of piles**

**6.3.1 Reinforcement**

6.3.1.1 The reinforcement shall be made into cages sufficiently rigid to withstand handling without damage. In case the reinforcement case is made up of more then one segment, the same shall be assembled by providing necessary laps or, preferably, by welding.

6.3.1.2 Sirrups to the main bars shall be tack welded.

6.3.1.3 Care shall be taken to ensure that the reinforcement bars do not move together before the cage is lowered down the hole.

6.3.1.4 Proper cover and central placement of the reinforcement shall be ensure by use of suitable concrete spacers or rollers, case specifically for the purpose.

**6.3.2 Concreting**

6.3.2.1 Concreting shall not be commenced until the Engineer-in-charge satisfies himself that at final borehole depth the soil is not weaker then that taken as the basis for pile design. If necessary, SPT or similar test shall be conducted to ensure the above.

6.3.2.2 Borehole bottom shall be thoroughly cleaned to make it free from sludge or any foreign matter before lowering the reinforcement cage . the full length of reinforcement cage shall be in position before start of concreting.

6.3.2.3 Concreting shall be done by tremie method. The operation of tremie concreting shall be governed by IS :2911(part I/Sec.2).

6.3.2.4 The concrete placing shall not proceed if density of fluid near about the bottom of borehole exceeds 1250 Kg/$m^3$. Determination of the density of the drilling mud from the base of the borehold shall be carried out by taking samples of fluid

by suitable slurry sample approved by the Engineer-in-charge, in first few piles and at a suitable interval of piles there after and the results recorded. Control of Concreting operations.

6.3.2.5 Care shall be exercised to preserve correct cover and alignment of reinforcements and avoid any damage to it throughout the complete operation of placing the concrete.

6.3.2.6 The top of pile shall be brought up above the cutt of level by min 1.0 m or upto the ground whichever is more as to permit removal of all laitance and weak concrete before capping and to ensure good and sound concrete at the cut-off level for proper embedment into the pile cap. Any defective concrete in the head of the completed pile shall be cut-away and made good with new concrete.

## 7.0 DEFECTIVE PILES

7.1 Defective piles shall be removed or left in place, as judged convenient by the Engineer-in-charge, without affecting the performance of adjacent piles or capping above and additional piles shall be provided to replace them.

## 8.0 RECORDING OF DATA

8.1 A competent supervisor shall be present to record the necessary information during the installation of piles. The data to be recorded shall include:

a) The dimensions of the piles, including the reinforcement detail and the mark of the pile.

b) The type of boring employed.

c) The type of soil in which pile is constructed.

d) The depth bored.

e) The depth of water table.

f) When drilling mud is used, the specific gravity of the fresh supply and contaminated mud in the borehole before concreting is taken up, in case of first few piles and subsequently at suitable interval of piles.

g) The time taken for concreting.

h) The cut off level/working level, and

i) The consumption of cement

j) Any other important observations.

8.2 Typical data sheets of recording piling data shall be as given in Appendix D of IS:2911 ( part I/Sec.2 ).

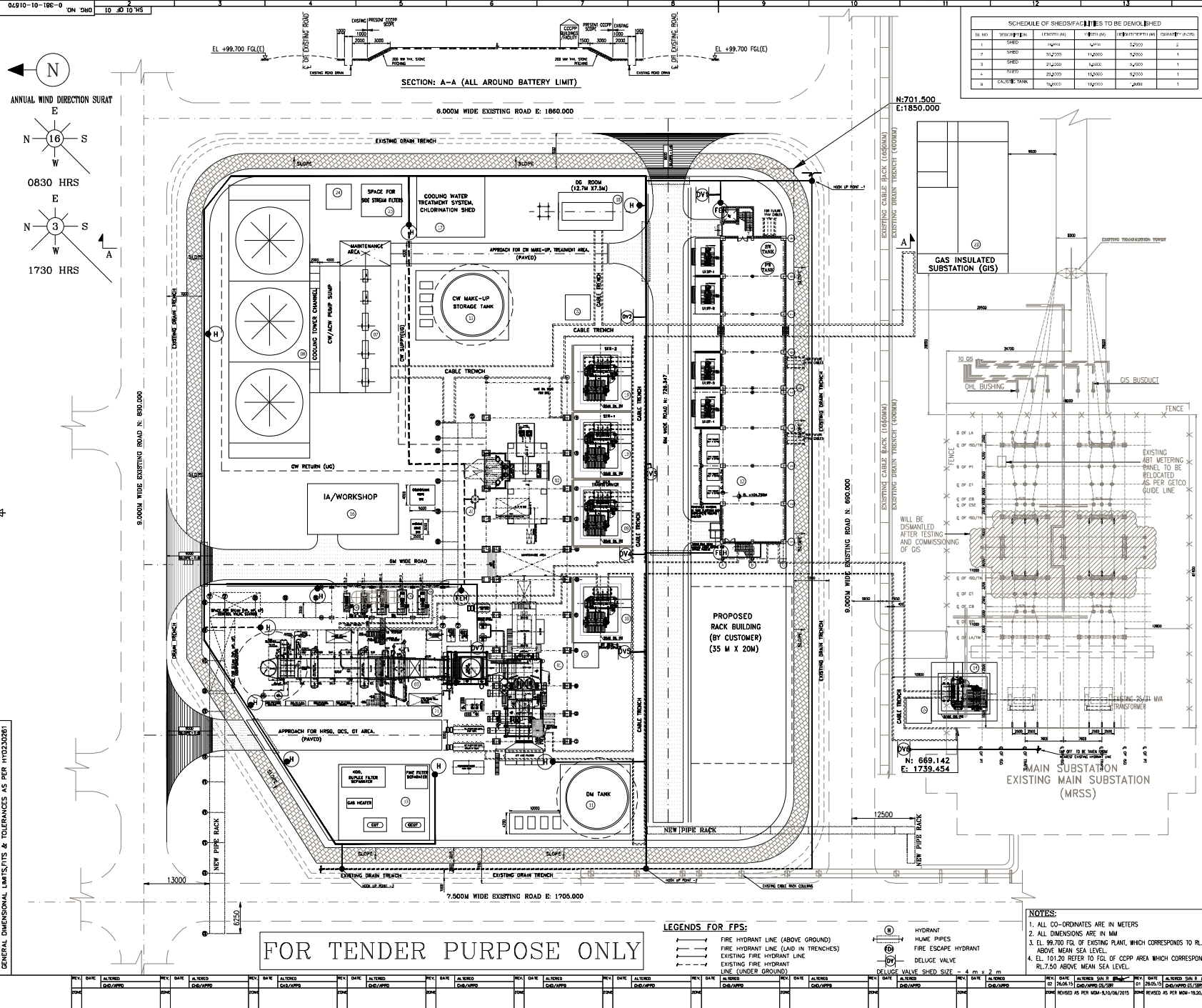
8.3 Any deviation from the designed location, alignment of load carrying capacity of any pile shall be noted and promptly reported to the Engineer-in-charge.

FIRST ANGLE PROJECTION

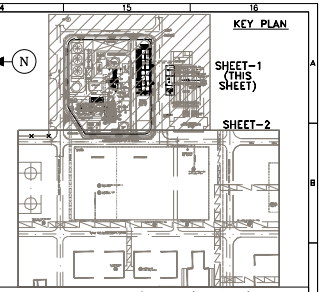
(ALL DIMENSIONS ARE IN mm)

DRG. NO. 0-381-01-01570

SH. 01 OF 01




| SCHEDULE OF SHEDS/FACILITIES TO BE DEMOLISHED | | | | | |
|---|---|---|---|---|---|
| SL NO | DESCRIPTION | LENGTH (M) | WIDTH (M) | HEIGHT/DEPTH (M) | QUANTITY (NOS) |
| 1 | SHED | 24.000 | 14.000 | 5.7000 | 2 |
| 2 | SHED | 30.2000 | 11.2000 | 5.7000 | 1 |
| 3 | SHED | 21.2000 | 11.2000 | 5.7000 | 1 |
| 4 | TURBO | 20.2000 | 16.2000 | 5.7000 | 1 |
| 5 | CAUSTIC TANK | 16.0000 | 16.0000 | 4.0000 | 1 |




LIST OF EQUIPMENTS/BUILDINGS (PRELIMINARY)

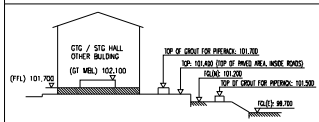
| S. NO. | DESCRIPTION | QTY. | SIZE (M X M) |
|---|---|---|---|
| 1 | GTG SHED | 01 | 32 X 14 |
| 2 | STG SHED | 01 | 32 X 16 |
| 3 | HRSG AREA | 1 | - |
| 4 | DEAERATOR AREA | 1 | 22 X 6 |
| 5 | HP BFP | 3 | 4.92 X 1.95 |
| 6 | LP BFP | 2 | 3.66 X 1.3 |
| 7 | CW, ACW PUMPS AREA | 01 | 25 X 10 |
| 8 | COOLING TOWER AREA | 1 | 48 X 16 |
| 9 | ST GENERATOR TRANSFORMER | 01 | 13 X 11.9 |
| 10 | GT GENERATOR TRANSFORMER | 1 | 13 X 11.9 |
| 11 | DM WATER TANK AREA | 01 | 14 X 14 |
| 12 | CABLE CELLAR /SWITCH GEAR/CONTROL ROOM | 1 | 60 X 12(W) X 15(H) |
| 13 | FUEL GAS CONDITIONING AREA | 01 | 15 X 18 |
| 14 | NEW GEN. TRANSFORMER FOR EXISTING GTG-3 | 1 | 13 X 11.55 |
| 15 | CW MAKE-UP STORAGE TANK | 01 | 19 X 14 |
| 16 | IA/ WORKSHOP | 01 | 18 X 10 |
| 17 | COOLING WATER TREATMENT SYSTEM | 01 | 13.5 X 12 |
| 18 | DG ROOM | 01 | 12.7 X 7.5 |
| 19 | SAT | 02 | 13 X 11.9 |
| 20 | SIDE STREAM FILTERS AREA | 01 | 8 X 6.5 |
| 21 | HRSG BLOW DOWN PIT | 01 | 2 X 2 |
| 22 | BLOWDOWN PIT (OILY WASTE) | 03 | 5 X 5 |
| 23 | GAS INSULATED SUBSTATION (GIS) - INDOOR | 01 | 30 X 18 |
| 24 | SSF BACK WASH PIT /CT DRAIN PIT | 01 | 5 X 5 |
| 25 | NEW MB UNIT FOR CCCPP | 01 | 17 X 12 |
| 26 | ATMOSPHERIC FLASH TANK | 01 | 1.5 (DIA) X 3.6 (H) |

THE DIMENSIONS INDICATED ABOVE ARE PRELIMINARY, TO BE FINALISED AFTER RECEIPT OF PROJECT SPECIFIC EQUIPMENT DESIGN/DATA.

REFERENCE DRAWINGS,

A) CUSTOMER

A1. KEY PLAN SHOWING TERMINAL POINTS : 00-5111168-G-002 REV-C




REFERENCE LEVELS OF FLOORS/FOUNDATIONS

LEGEND:

FFL: Finished Floor Level

TOP: Top Of Paving

FGL(N): Finished Ground Level (NEW CCCPP AREA)

FGL(E): Finished Ground Level (FGL OF EXISTING PLANT)

MBL: Machine Base Level

– NEW PIPE RACK

– ROADS INSIDE CCCPP

– SLOPED AREA (WITH STONE PITCHING)

LEGENDS FOR FPS:

- FIRE HYDRANT LINE (ABOVE GROUND)
- FIRE HYDRANT LINE (LAID IN TRENCHES)
- EXISTING FIRE HYDRANT LINE
- EXISTING FIRE HYDRANT
- LINE (UNDER GROUND)
- DELUGE VALVE SHED SIZE – 4 m x 2 m
- H HYDRANT
- HUME PIPES
- FEH FIRE ESCAPE HYDRANT
- DV DELUGE VALVE

NOTES:

1. ALL CO-ORDINATES ARE IN METERS
2. ALL DIMENSIONS ARE IN MM
3. EL. 99.700 FGL OF EXISTING PLANT, WHICH CORRESPONDS TO RL.6.00 ABOVE MEAN SEA LEVEL.
4. EL. 101.20 REFER TO FGL OF CCPP AREA WHICH CORRESPONDS TO RL.7.50 ABOVE MEAN SEA LEVEL.

FOR TENDER PURPOSE ONLY

GENERAL DIMENSIONAL LIMITS,FITS & TOLERANCES AS PER HYD230261

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COMPUTER FILE NAME: 3810101570_S01_R07.DWG

SIGN. AND DATE (INIT./DRG. NO.)

REVISION NO

| REV. | DATE | ALTERED CHD/APPD |
|---|---|---|
| 02 | 26.06.15 | ALTERED SIN R CHD/APPD GS/SRR |
| 01 | 26.05.15 | ALTERED SIN R CHD/APPD GS/SRR |

ZONE 02: REVISED AS PER MOM-9,10/06/2015

ZONE 01: REVISED AS PER MOM-19,20/05/15

PROJECT: 1X51 MW COMBINED CYCLE COGENERATION CAPITIVE POWER PLANT

CLIENT: ONGC — OIL AND NATURAL GAS CORPORATION LTD. AT HAZIRA PLANT, GUJARAT.

CONSULTANT: FICHTNER Consulting Engineers (India) Private Limited, Bangalore.

EPC CONTRACTOR: BHARAT HEAVY ELECTRICALS LTD HYDERABAD

BHARAT HEAVY ELECTRICALS LTD. HYDERABAD

| | NAME | SIGN | DATE |
|---|---|---|---|
| DRN. | SIN R | | 27.04.15 |
| CHD. | GS | | 27.04.15 |
| APPD. | VISS S | | 27.04.15 |

SCALE: 1:250

TITLE: PLOT PLAN (POWER BLOCK AREA)

CARD CODE: N.A.

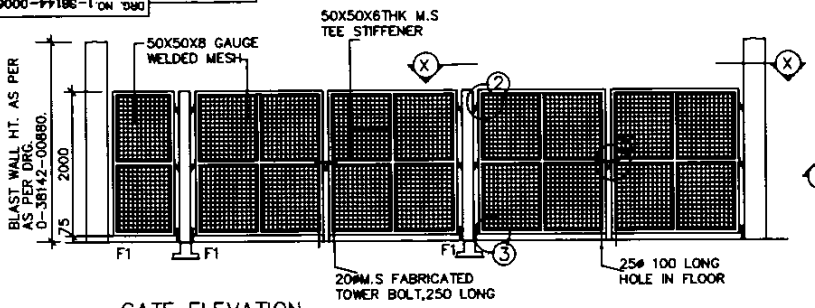
DRAWING NO. 0-381-01-01570

REV. 02

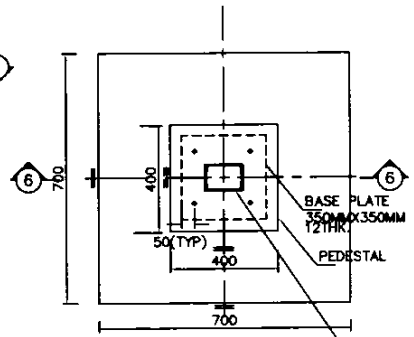
SHT. No. 01 NO. OF SHT. 02

FIRST ANGLE PROJECTION

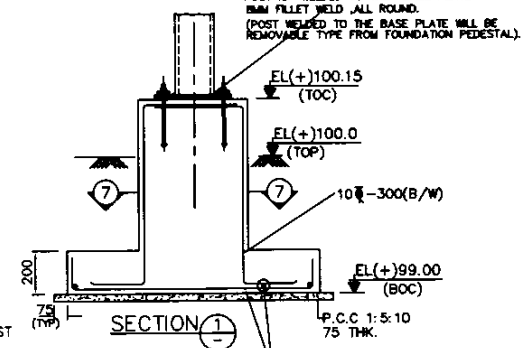
(ALL DIMENSIONS ARE IN mm)



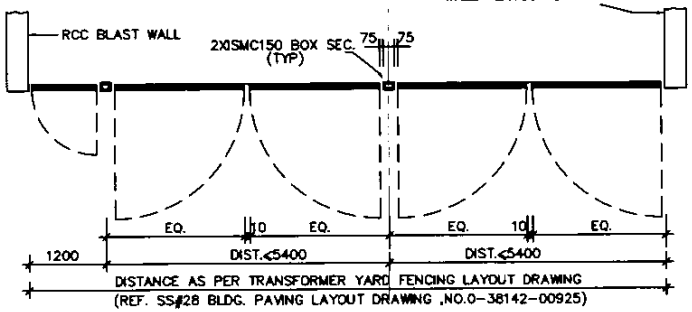

GATE ELEVATION



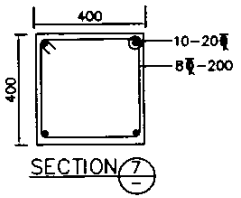

FOUNDATION PLAN(F1)




SECTION (1)




GATE PLAN

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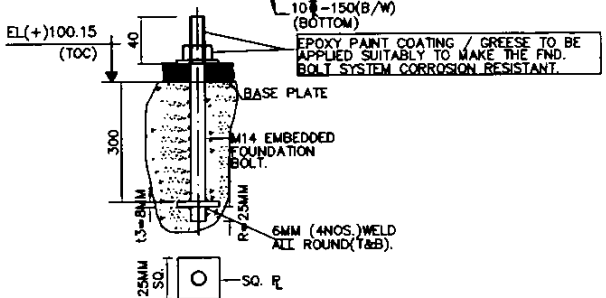
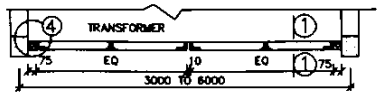
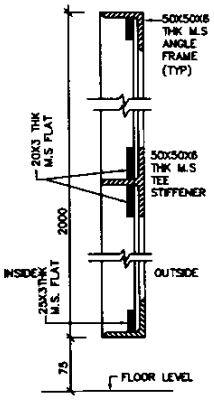


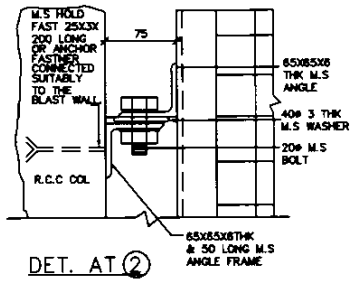

FOUNDATION BOLT (EMBEDDED).



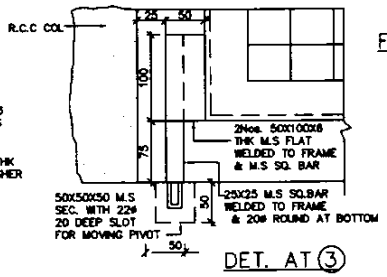

PLAN(TOP VIEW/X-X)




DET 1-1




DET. AT (2)

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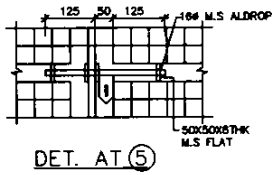


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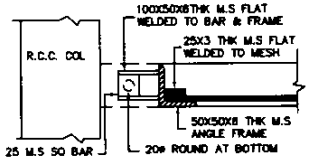


DET. AT (4)

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES AND LEVELS & CO-ORDINATES ARE IN METRES, UNO.
2. EL(+)100.150 CORRESPONDS TO FINISHED FLOOR LEVEL OF EXISTING GTG BUILDING UNIT-1 WHICH CORRESPONDS TO SITE RL(+)238.970M.
3. NO DIMENSIONS FROM THIS DRAWING TO BE SCALED OFF AND ONLY FIGURED DIMENSIONS SHALL BE FOLLOWED.

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GENERAL DIMENSIONAL LIMITS,FITS & TOLERANCES AS PER HY0230261

BHARAT HEAVY ELECTRICALS LTD. HYDERABAD

| | NAME | SIGN. | DATE |
|---|---|---|---|
| DRN. | S.SARKAR | | 8.12.05 |
| CHD. | S.SARKAR | | 8.12.05 |
| APPD. | K.T.SAILESH | | 8.12.05 |

SCALE N.T.S.

TITLE TYPICAL REMOVABLE TYPE TRANSFORMER GATE & FENCING DETAIL.

DRAWING NO. 1-38144-00062 REV. 00

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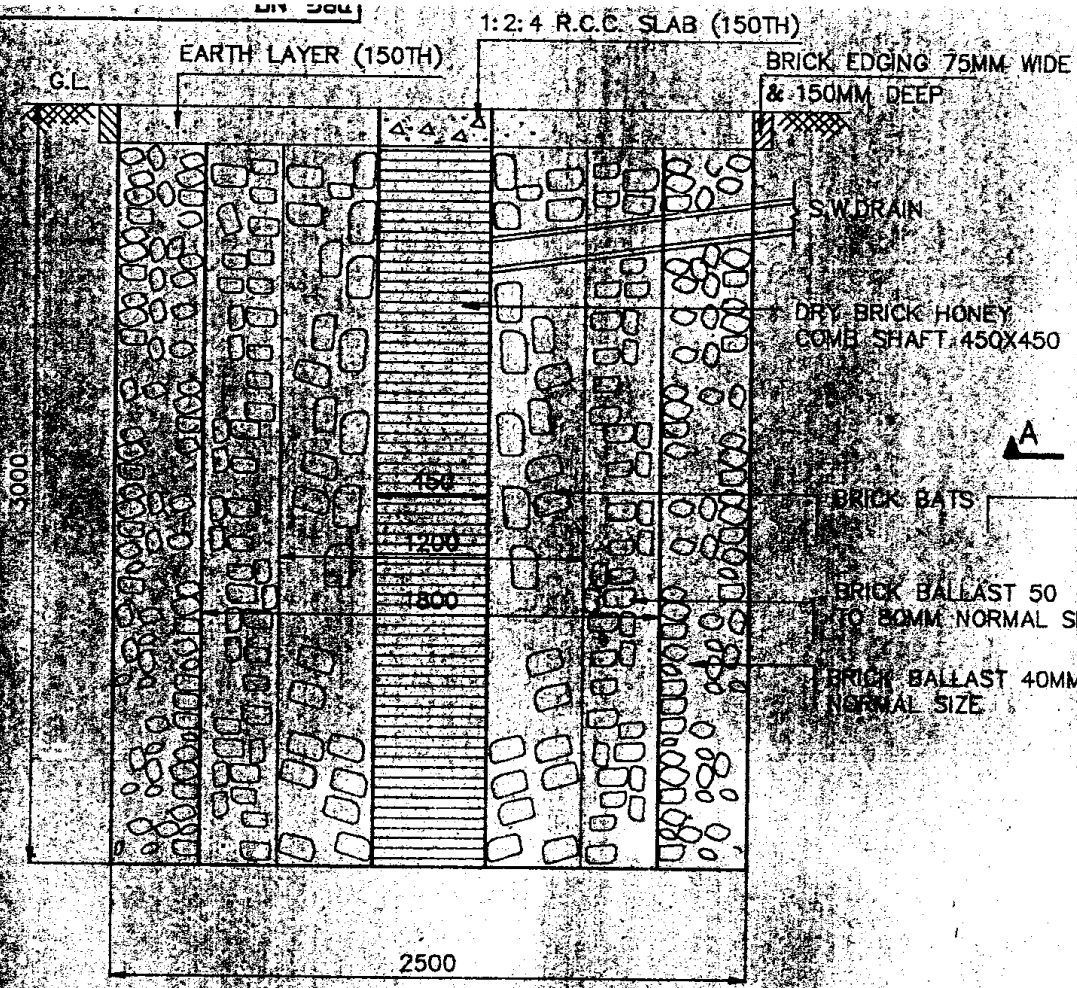
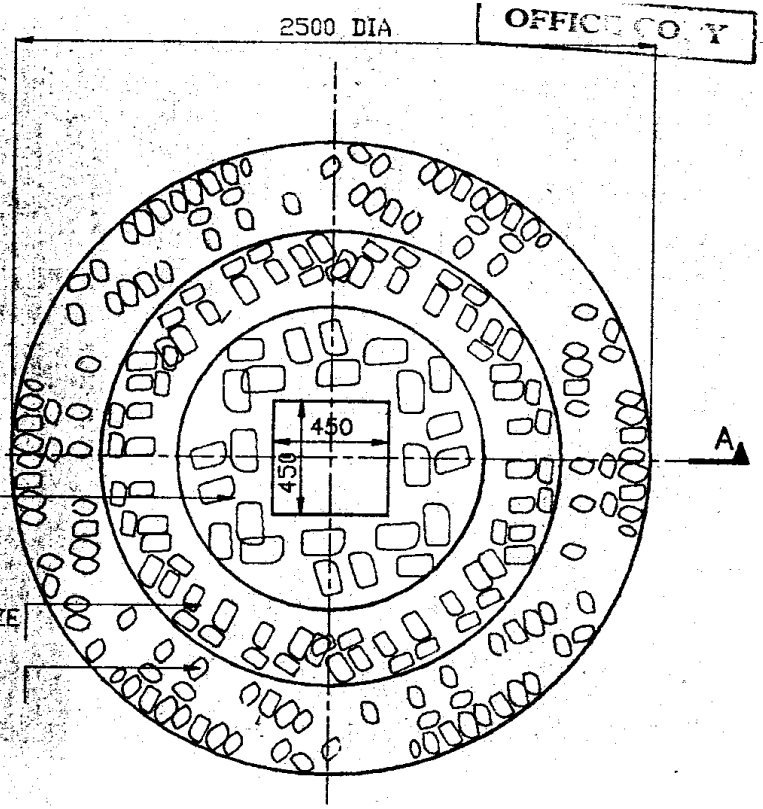
OFFICE COPY




SECTION A-A




PLAN

o/c

TYPE OF PRODUCT OR NAME OF CUSTOMER/PROJECT: STANDARD

BHARAT HEAVY ELECTRICALS LTD. HYDERABAD

| | NAME | SIGN. | DATE | NO. OF VAR |
|---|---|---|---|---|
| DRN. | L.W.C. | | | |
| CHD. | M.R.RAM | | 23/10/87 | |
| APPD. | P. SAHA | | 23/10/87 | |

| REV. | DATE | ALTERED/CHECKED |
|---|---|---|
| | | |

DEPT. PED
CODE 459
SCALE 1:20
WEIGHT (KG)
REF. TO ASSY DRG.
ITEM NO.
NO. OF ITEMS

TITLE: SOAK PIT DETAILS

CARD CODE

DRAWING NO. 3-38144-00003 REV. 00

SHEET NO. 1 NO OF SHEETS 1

(53)

(2)

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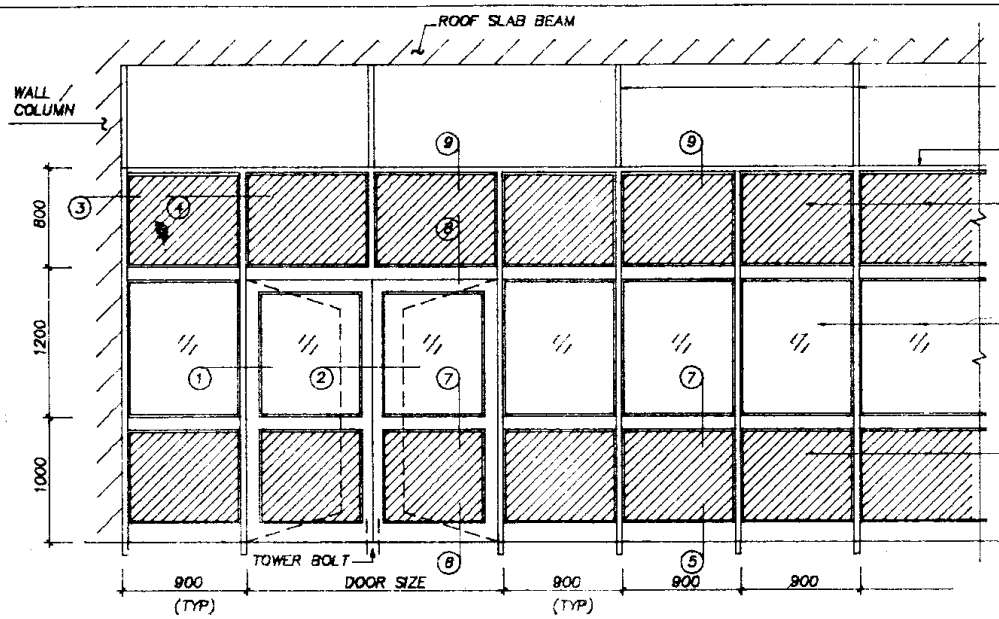
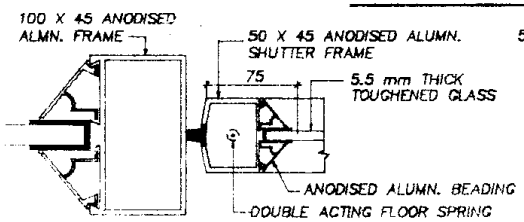
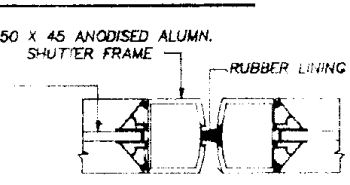



TYPICAL ELEVATION OF PARTITION




DETAIL AT (1)

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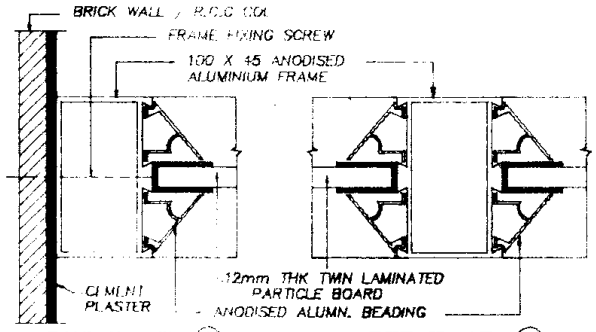


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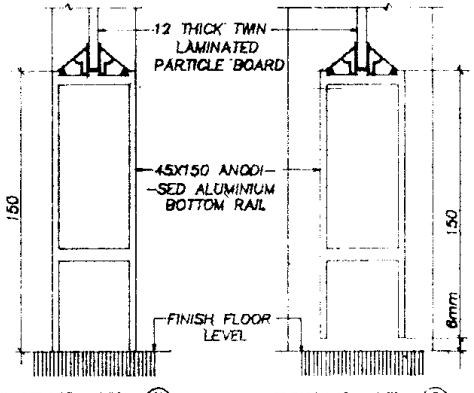
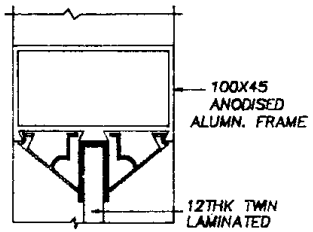


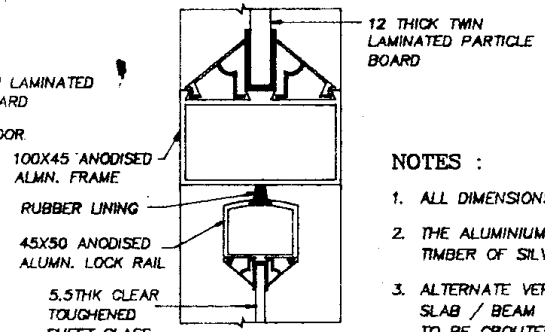

DETAIL AT (4)

DETAIL AT (5)

DETAIL AT (6)




DETAIL AT (9)

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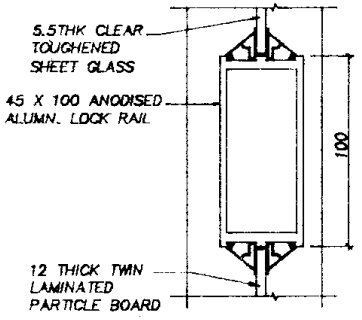



DETAIL AT (7)

NOTES :

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. THE ALUMINIUM HOLLOW SECTIONS SHOULD BE FILLED WITH TIMBER OF SILVER OAK.
3. ALTERNATE VERTICALS ARE TO BE TAKEN UP TO THE ROOF SLAB / BEAM AND FIXED WITH CLEATS. ALL VERTICALS ARE TO BE GROUTED 25mm INTO THE FLOOR FINISH , AT THE BOTTOM. HOWEVER , FOR MEASUREMENT , ONLY AREA OF PARTITION ABOVE FLOOR FINISH & BELOW FALSE CEILING WILL BE CONSIDERED.
4. THE MAXIMUM SPACING OF VERTICALS SHALL BE 900 MM.
5. TWIN LAMINATED PHENOL BONDED PARTICLE BOARD SHALL BE OF 'NOVAPAN' MAKE OR APPROVED EQUIVALENT.
6. TWIN LAMINATED PHENOL BONDED PARTICLE BOARD SHALL BE OF APPROVED SHADE.
7. FOR LAYOUT OF PARTION REF. DRG. NO. 1-38142-00532.
8. ALL ALUMINIUM HOLLOW SECTIONS ARE TO BE 3 MM THK.
9. DOORS SHALL BE PROVIDED WITH DOUBLE ACTING HEAVY DUTY FLOOR SPRINGS, APPROVED TYPE OF HANDLES, DOOR STOPS, 450 LONG TOWER BOLTS AT THE TOP AND 300 LONG TOWER BOLT AT THE BOTTOM FOR EACH SHUTTER. A MORTICE LOCK, GODREJ MAKE OR APPROVED EQUIVALENT SHALL BE PROVIDED FOR EACH DOOR

| ARCHITECTURAL | NO | DATE | REVISION | DRN | CHD | APP |
|---|---|---|---|---|---|---|
| | 0 | 22-4-96 | ISSUED AS STANDARD | M.R.J | | |

PROJECT ENGINEERING
BHEL HYDERABAD

DETAILS OF ALUMINIUM PARTITIONS

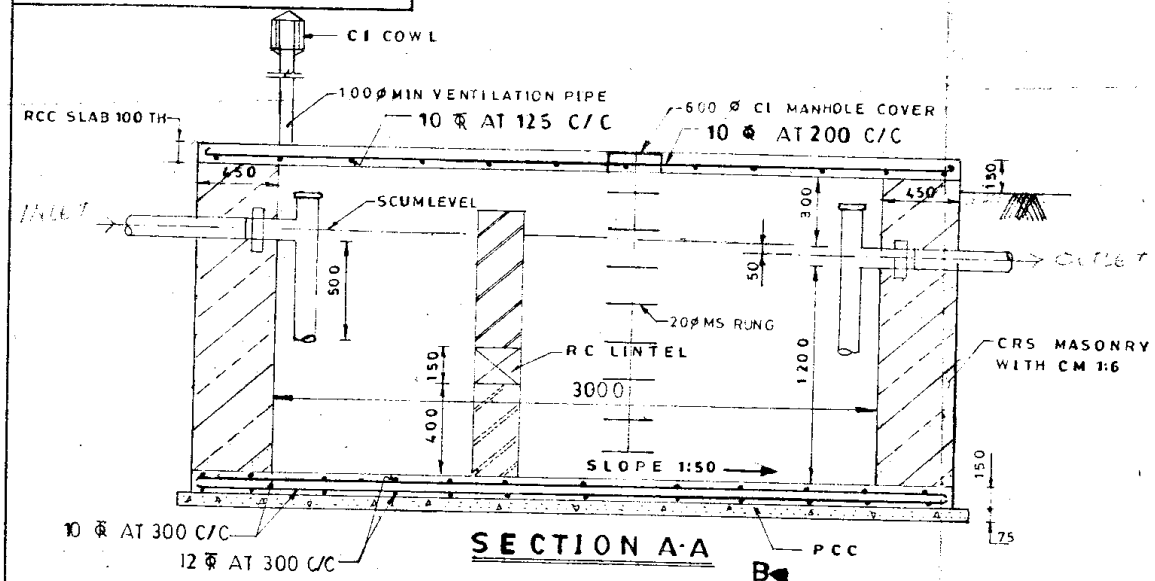
DRG. NO 3-38144-00068

RE 0

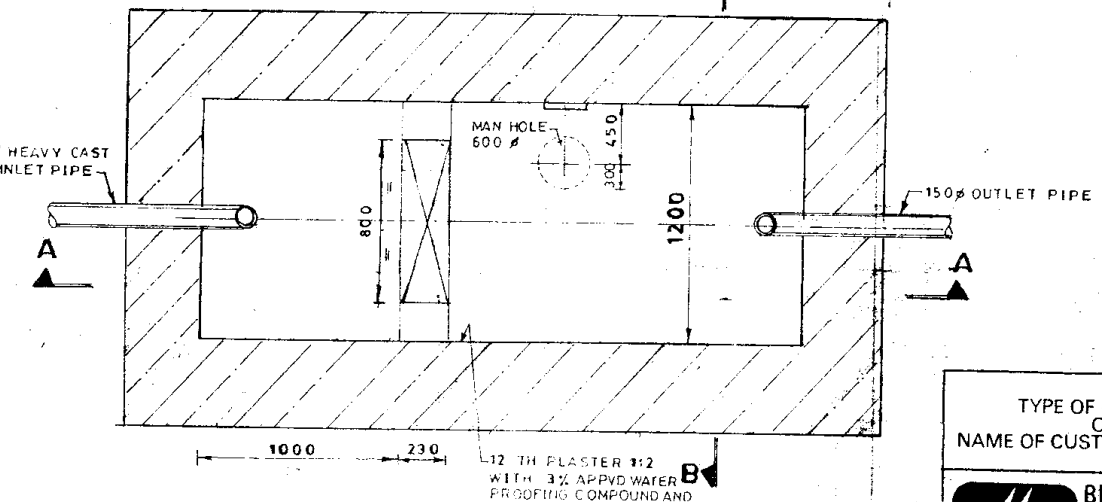
(ALL DIMENSIONS ARE IN mm)

OFFICE COPY

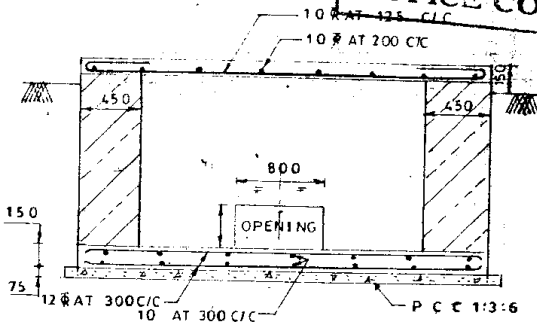
DRG NO 3-38144-00009



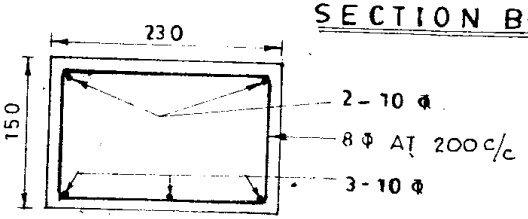

SECTION A-A




PLAN




SECTION B-B




LINTEL BEAM DETAIL

**NOTES**

1 ALL DIMENSIONS ARE IN MM **UOS.**

| STD. | DRAWING NO. | IT NO | MATL. CODE | A/C | UNIT WT. | GS | ZONE |
|---|---|---|---|---|---|---|---|
| | | VAR. | MATL. SPCN. | UNIT | QTY. | | |

28 → CARD TYPE -1

TYPE OF PRODUCT OR NAME OF CUSTOMER/PROJECT: **STANDARD**

BHARAT HEAVY ELECTRICALS LTD.
HYDERABAD

| | NAME | SIGN. | DATE |
|---|---|---|---|
| DRN. | G.S.S | | 26/6/92 |
| CHD. | S.SARKAR | | 9/7/92 |
| APPD. | K.T.SAILESH | | 9/7/92 |

NO. OF VAR.

| DEPT. | GRADE OF TOL. DIM. C/M/F | SCALE | WEIGHT (Kg) | REF. TO ASSY. DRG. | ITEM NO. | NO. OF ITEMS |
|---|---|---|---|---|---|---|
| PED | | N.T.S | | | | |
| CODE 450 | | | | | | |

TITLE: **SEPTIC TANK (25 USERS)**

CARD CODE

DRAWING NO. **3-38144-00009** REV. **00**

SHEET [redacted] NO. OF SHEETS

| REV. | DATE | ALTERED / CHECKED | ZONE |
|---|---|---|---|
| | | | |

ID 151, REV NO 2

SIZE A2

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INVENTORY NO | SIGN & DATE | REF. DRG NO

OFFICE COPY

| ARCHITECTURAL | NO | DATE | REVISIONS | DRN | CHD | APPD |
|---|---|---|---|---|---|---|
| | 0 | 05/02/93 | ISSUED AS STANDARD | | | |

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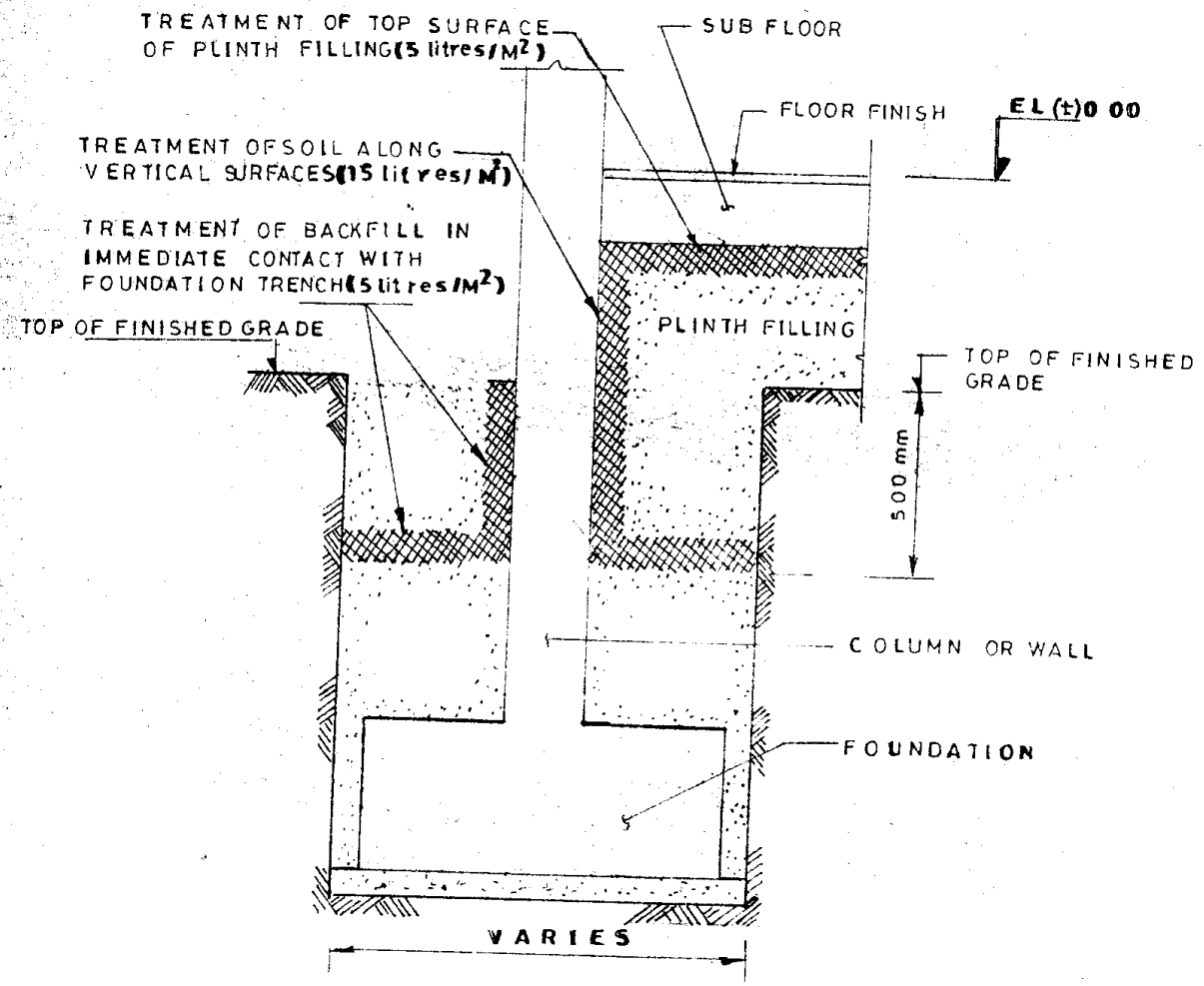
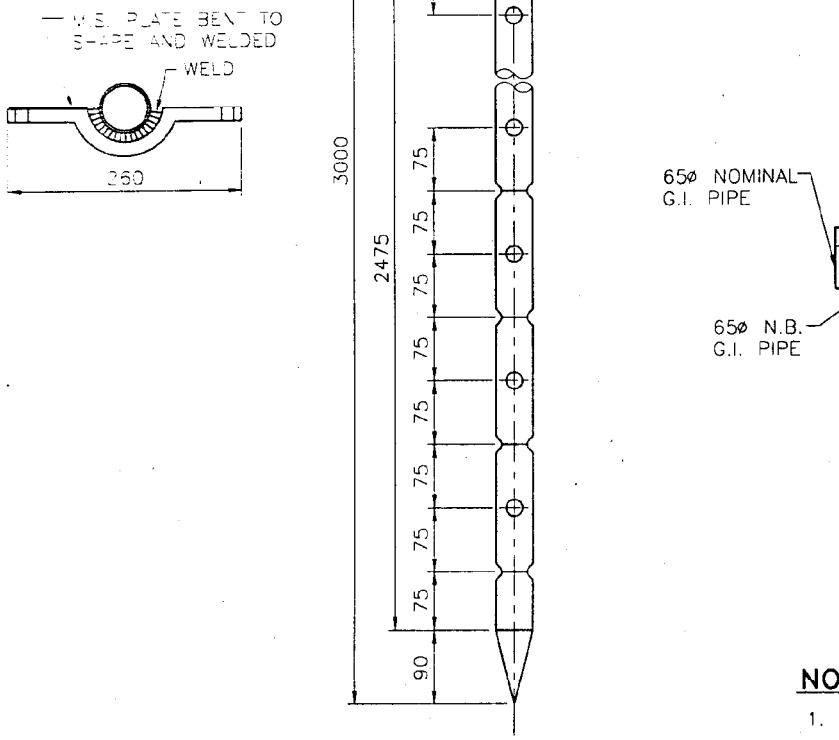



A TYPICAL SECTION

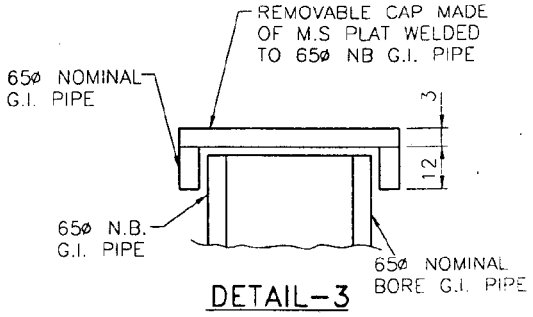
| PROJECT ENGINEERING BHEL HYDERABAD | ANTI-TERMITE TREATMENT | DRAWING NO: 4-38144-00004 | REV 0 |
|---|---|---|---|

# 1.2 PIPE ELECTRODE










DETAIL-3

**NOTE:-**

1. PIPE ASSEMBLY SHALL BE HOT DIP GALVANISED AFTER FABRICATION
3. AS PER IS:3043 (LATEST REVISION)

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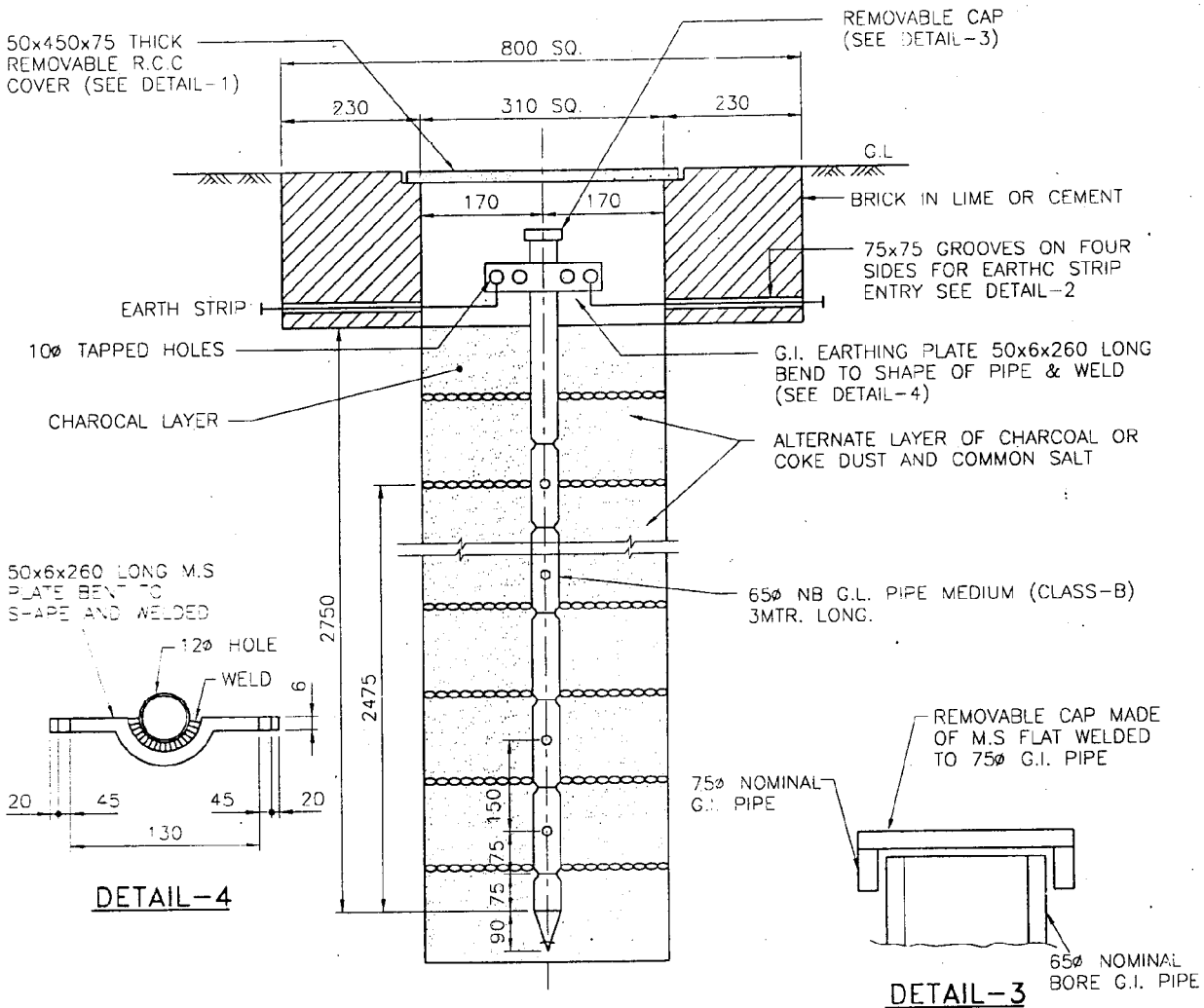
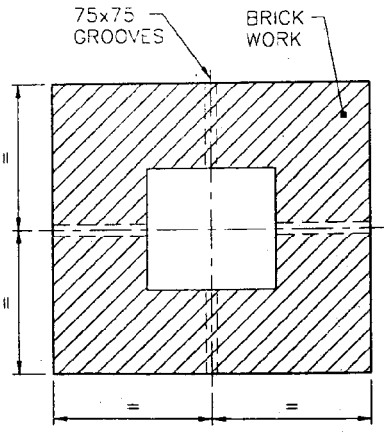
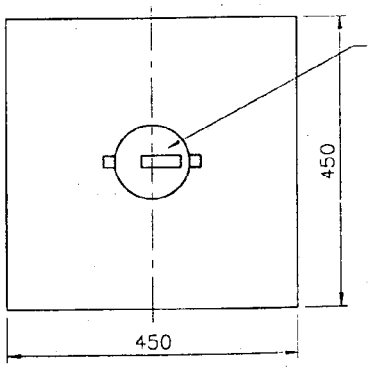
Ref. Doc

# 1.1 EARTH ELECTRODE IN TEST PIT




DETAIL-2




DETAIL-1

## NOTE:-

1. PIPE ASSEMBLY SHALL BE HOT DIP GALVANISED AFTER FABRICATION
2. CONDUCTOR SIZES & MATERIAL ARE AS PER ANNEXURE-A OF THIS SPECIFICATION.
3. AS PER IS:3043 (LATEST REVISION)

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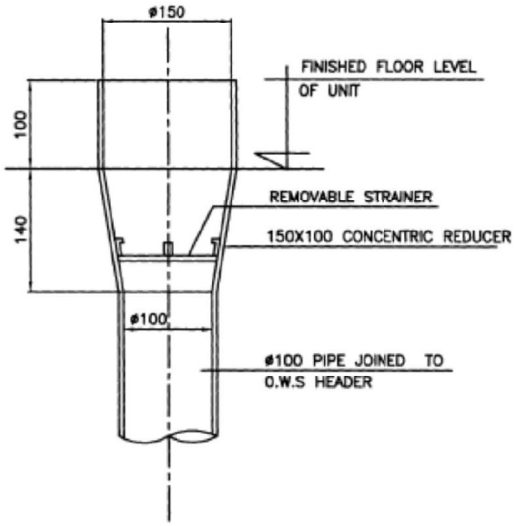
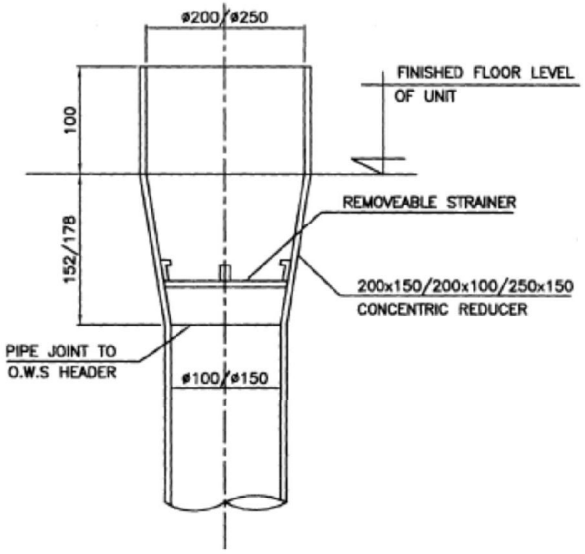
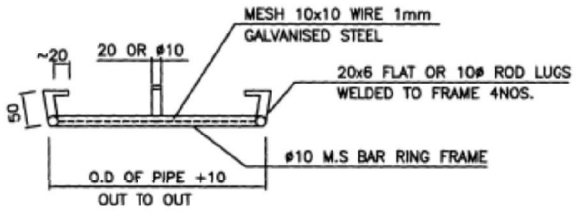



STANDARD EQUIPMENT
DRAIN FUNNEL

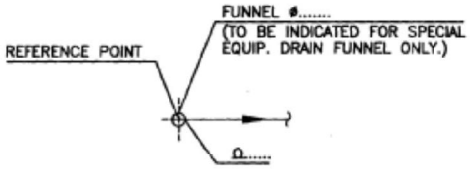



SPECIAL EQUIPMENT
DRAIN FUNNEL




DETAILS OF STRAINER

ISOMETRIC VEIW OF STRAINER




REPRESENTATION ON UNIT AREA DRG

NOTES:–

1. ALL DIMENSIONS ARE IN MM.

STD DWG FOR OWS FUNNELS