HARYANA POWER GENERATION CORPORATION LIMITED

# RGTPP HISAR (2X600 MW)

## PART –B

## SECTION – VI

## TECHNICAL SPECIFICATION

## FOR

## FLUE GAS DESULPHURISATION (FGD) SYSTEM PACKAGE

**BIDDING DOCUMENT NO.: 31/CE/PLG/RGTPP/FGD-250**

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# PART – B (DETAILED TECHNICAL SPECIFICATION)

# SUB-SECTION-I-M (MECHANICAL SYSTEM)

# SUB-SECTION-I-M1

# FLUE GAS DESULPHURISATION SYSTEM

## FLUE GAS DESULPHURIZATION (FGD) SYSTEM

**1.00.00 GENERAL**

The design/specifications/sizing of various plants/systems/equipment offered for Flue Gas Desulphurisation (FGD) System shall comply with the requirements detailed hereinafter:

1.01.00 **System Description**

The Flue Gas Desulphurisation (FGD) System shall be based on Wet Limestone Forced Oxidation process. The FGD system shall be installed downstream of the Induced Draft (ID) fans (Employer's scope).The flue gas is drawn from air preheater outlets of the balanced draft, pulverised coal fired Steam Generator and guided through adequately sized duct work into the specified number of independent gas streams of each Electrostatic Precipators. The flue gas after the Electrostatic Precipitators is led to the suction of the ID fans. The flue gas temperature may approach the economiser outlet temperature of about 300°C in case the regenerative airpreheaters fails to operate. The Contractor shall take this aspect into account while designing the Flue Gas Desulphurisation (FGD) System.

1.02.00 **Service Conditions**

The Steam Generators provided are designed to burn pulverised coal having properties as indicated in Sub-section-II-A (Project Information), Part-A, Section-VI. Also HFO/HPS/LSHS and LDO shall be used during startup and at low loads for warm up and flame stabilization as specified in respective Project Information Chapter. The design of Steam Generator does not call for any oil support for flame stabilization beyond 40 % BMCR load when firing any coal. Further, the frequency and duration for startup and low loads operation may be quite long during the first year of unit commissioning and operation. The Steam Generator has been designed for cyclic/two shift operation. Expected numbers of Steam Generator start-ups during 25 years of design life are as follows:

| | **Type of Starts** | **Number of Starts** |
|---|---|---|
| | | |
| a. | Hot start (after 8 hours of unit shut down) | 4000 |
| | | |
| b. | Warm start (after 36 hours of unit shut down) | 1000 |
| | | |
| c. | Cold start (after 72 hours of unit shut down) | 150 |

The Contractor, shall take into account the entire characteristics of expected combination of fuels to be fired and the expected numbers of Steam Generator start-

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| | ups while designing the FGD system. |
| 1.03.00 | **Design Criteria** |
| 1.03.01 | The Flue Gas Desulphurisation (FGD) System shall be designed to meet all the conditions specified above. Representative coal and ash analysis for the expected coal and oil are given in Sub-section-II-A (Project Information), Part-A, Section-VI for each project. The FGD system and all the associated auxiliaries shall be designed to comply with the requirements stipulated under 'Guarantee Point' and 'Design Point' conditions indicated in Sub-Section-V, Part-A, Section-VI of the Technical Specification for the respective projects. The values indicated for FGD sizing shall be considered as minimum design criteria. These shall be modified to more conservative values if Contractor experience warrants the same. However, no credit shall be given to the Contractor for this during evaluation of the bids. Utilization of these values in no way relieves the Contractor of his responsibility to meet all the guarantee requirements. The Contractor shall also furnish along with his offer the detailed calculations and data along with his Bid to establish as to how the Bidder will meet the efficiency requirements both at design and guarantee point as specified in FGD sizing criteria. |
| 1.03.02 | The FGD system shall be installed downstream of the ID fans and shall be based on wet Limestone Forced Oxidation Process. The FGD system shall be designed to achieve the required $SO_2$ capture without the use of oxalic acid or any other additives. The FGD System shall be designed so as to be in operation whenever the Steam Generator is in operation.<br><br>However, provision shall be made by the Contractor for facilitating operation of unit with emergency FGD bypass. This shall also facilitate the online maintenance of absorber system and associated equipment's. The arrangement of the flue gas system shall allow complete isolation of the absorber from the gas side, with the unit in operation. For this purpose, Motorized Guillotine type gates shall be provided by the Contractor at (i) hot gas inlet to Booster Fans, (ii) Outlet of Booster Fans. Further, Quick opening Bi-plane motorized/pneumatic damper along with 2x100% seal air fans shall be provided in the by-pass duct by the Contractor. The same shall also be taken into account while designing the control & logics for the FGD System. |
| 1.03.03 | The wet absorber system shall be designed to maintain the required $SO_2$ removal. |
| 1.03.04 | In order to be compatible to all possible modes of operation, the design of the FGD plant shall enable short start-up times, compatible with load changes in the Steam Generator and shall ensure reliable mode of continuous operation. |
| 1.03.05 | The flue gas desulphurization plant (FGD) shall be designed to be operated with limestone as specified in Sub-Section-V, Part-A, Section-VI of the Technical Specification. |

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| 1.03.06 | The FGD and the ancillary facilities shall be suitable for unlimited operation with all transients and at any load point between the minimum and maximum load point of the Steam Generator. Further, the FGD plant shall be suitable for an unlimited operation at any pollutant concentrations between minimum and maximum without exceeding the emission values of $SO_2$ emission of less than 200 mg/$Nm^3$ (6% $O_2$ dry). |
| 1.03.07 | In case of failure of the SG and ancillary equipment, the FGD plant shall be brought automatically to the off-load operation without restriction by the current load case by suitable measures. |
| 1.03.08 | In case of a power failure all items of equipment (e.g. minimum one agitator in absorber and limestone slurry tank, Process water pump & lube oil system of Booster Fan & Ball Mill) which may cause irreversible damage to the FGD System shall be connected to the emergency power supply system to be provided by the Contractor. Bidder shall furnish a list of all such Auxiliaries in their bid proposal. |
| 1.03.09 | In case of shutdown and outage periods, draining and flushing of limestone slurry and gypsum slurry pipe work, tanks and all other items being in contact with limestone slurry or gypsum slurry shall be possible without restriction and without necessity of extensive or unusual preparation and activity. Draining and flushing which are required even during short time outages or an emergency shutdown shall be started automatically and by remote control from the Control Room. |
| 1.03.10 | AII items or equipment which are subject to wear, abrasion or failure (e.g. nozzles, pumps, pipe work, etc.) shall be designed and installed for easy replacement, repair and maintenance. |
| 1.03.11 | The design and the construction shall be performed so as to avoid stress corrosion cracking, galvanic or other types of corrosion. Especially when using two different alloys, appropriate measures shall be taken to avoid corrosion. This is subject to approval by the Employer. |
| 1.03.12 | All items of equipment including flue gas ducts, expansion joints, etc. shall be designed considering thermal and mechanical strength as a function of the maximum temperature which might occur in case of a failure of any upstream equipment. |
| 1.03.13 | Waste water which might be generated during flushing and cleaning procedures of the equipment (e.g. lime slurry bins, pipes, trucks, etc.) shall be collected in sump and shall possibly be reused in the wet absorber. |
| 1.03.14 | In case distance from Limestone Grinding system/ Gypsum Dewatering and Absorber is more than 500M, Bidder shall provide the flushing system at intermittent locations for the lime stone slurry pipeline which shall contain tank and pumps. Intermittent location distance of flushing system shall be based on their proven practice. |
| 1.04.00 | **Justification of Proposed Design** |

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| 1.04.01 | All the design procedures, systems, and components proposed shall have already been adequately developed and have demonstrated good reliability under similar or more arduous conditions elsewhere. |
| 1.04.02 | The Bidder shall submit with the offer, comprehensive information on how the L/G ratio, mass balance, spray nozzle cone angle, spray nozzle arrangement, limestone consumption etc. of the proposed design has been arrived at. The Contractor shall also submit alongwith the offer, a detailed write up on the proposed design features with recent design modifications, if any, and their specific advantages over the previous designs. |
| 1.05.00 | **Statutory Approval**<br><br>The engineering, design, supply and installation of FGD system and the associated auxiliaries shall comply with the applicable safety code and regulation of the locality where the system is being installed. |
| 1.06.00 | **Location & Layout Requirements** |
| 1.06.01 | The Contractor shall offer the best design to accommodate the Flue Gas Desulphurisation (FGD) System and Lime stone & Gypsum handling & storage system within the confines of the space available. The location of FGD System and associated facilities shall be decided by the Bidder after visiting the Project site. |
| 1.07.00 | **Capital Overhaul of FGD System**<br><br>Employer envisages to carryout the capital overhaul of units once in three (3) years. The design and materials for various equipments/auxiliaries etc. shall be selected by the Contractor keeping in view the above requirement of the Employer, such that no major repairs/replacements, requiring shutdown of the unit, are needed in between the capital overhauls. |
| 1.08.00 | **Maintenance** |
| 1.08.01 | The Contractor shall provide adequate handling facilities & approach as for carrying out on-line and off-line maintenance of the FGD system and its auxiliaries. In order to carry out on-line maintenance, it shall be possible to readily disassemble, repair and reassemble the equipment supplied in the shortest period. |
| 1.09.00 | **Noise level**<br><br>The equivalent weighted average of sound level measured at a distance of 1.5 m above floor level in each elevation and one meter horizontally from the base of any equipment furnished and installed under these specifications, expressed in decibel to a reference of 0.0002 microbar, shall not exceed 85 dB(A). However for Ball Mill and Crusher, the noise levels as per following shall also be acceptable: |

a) Ball Mill < 90 dBA
b) Crusher < 90 dBA

**2.00.00 EQUIPMENT AND SYSTEMS SPECIFICATIONS**

Specified hereafter are the minimum acceptable functional requirements of the Employer, and all components, equipment and systems for the Flue Gas Desulphurisation System shall be designed to cater to these requirements. Compliance to various stipulations of the Technical Specifications, functional requirements of Employer and utilization of various parameters and their values in the specification by the Contractor shall in no way relieve the Contractor of his responsibilities to meet all guarantee requirements or of providing completely safe and reliable operating equipment/systems.

The complete FGD system and the associated auxiliaries shall be designed by the standard industrial practices. The FGD system shall be designed to achieve the required $SO_2$ capture without the use of oxalic acid or any other additives. Only field proven materials for similar application shall be used for the system. The complete installation of liners shall be made under the supervision of the liner supplier as per their guidelines. In the execution of the welds contractor must ensure that welding material has same corrosion resistance as the actual plate surface.

Alloy to carbon steel welds must either be hidden behind a covering strip of alloy material, or be executed by a special welding procedure ensuring the same quality at the weld surface as the alloy lining. All welding which shall be in the contact with process fluids shall be executed under the supervision of the designer/manufacturer.

**3.00.00 FLUE GAS SYSTEM**

3.01.00 The entire flue gas system, flue gas ducts, absorber etc. shall be designed to meet the following conditions:

| | | |
|---|---|---|
| 1. | Design internal pressure at 67% yield strength (mm wc) | +660 and -150 mmwc or maximum conceivable head of Booster fan (if provided), whichever is higher |
| 2. | Design Inlet Gas Temperature (deg.C) | 150 |
| 3. | Short temp excursion temperature of inlet gas (for approx. fifteen (15) | 300 |

| | | |
|---|---|---|
| | minutes at a time) (deg. C) | |
| 4. | Inlet Dust Burden in Gas (mg/Nm3) | 200 |
| 5. | Maximum flue gas velocity through the Absorber (M/sec) | Not more than 4 m/s at Design Point Conditions |
| 6. | Recirculation Slurry pH | Not less than 5.5 under all operating conditions |

**3.02.00 Design**

3.02.01 The flue gas ducts shall be sized and designed to meet all the criteria as specified in Cl. No 16.00.00 this subsection.

3.02.02 All ducts with operating temperature above $60^0$C shall be insulated in accordance with cl. No. 17.00.00 of this sub section.

3.02.03 The duct layout shall ensure that there is no accumulation of acid mist on the duct floor.

3.02.04 The duct to Absorber inlet shall be made of Carbon steel of minimum 7mm thickness. The duct from Absorber outlet to the new wet flue chimney shall be made of Carbon steel of minimum 7mm thickness cladded with 2 mm (minimum) thickness Alloy C276 / Alloy 59 / Titanium Gr-II.

3.02.05 In addition to the base offer as described above, the bidder may also submit an alternate offer for a different material / lining of duct from Absorber outlet to stack, if the bidder has previous experience of the same. The bidder should have supplied a similar design of duct in previous installations for similar application. Bidder shall indicate the applicable price implication for such an alternate offer in the relevant Bid Proposal sheet. The Bidder shall also furnish details of the previous installations of such system and bring out all the technical features of the system proposed. Bidder to note that application of lining material in the ducts shall be carried out under the supervision of designer/manufacturer. Bidder to note that application of lining material in the duct shall be carried out under supervision of Designer/Manufacturer.

3.02.06 Wherever required, expansion joints of proven design shall be provided in the ducts to take care of differential expansion in the system. The material chosen for expansion joints shall suitable for the duty conditions and the corrosive atmosphere of the FGD system and shall be field proven for similar applications. The expansion joints shall be guaranteed for faultless material and workmanship, for a minimum guaranteed life of not less than 20000 hrs. of operation. During Guarantee period any defects noticed in the expansion-joints due to faulty material and workmanship

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| | shall be rectified by the Contractor free of cost. |
| 3.02.07 | The chimney shall be designed to meet the criteria as specified in clause 2.00.00 of Salient Design Data Subsection-V Part A of the technical specification. |
| **3.03.00** | **Gates & Dampers** |
| 3.03.01 | The arrangement of the flue gas system shall allow complete isolation of the absorber from the gas side, with the unit in operation. Guillotine gate type damper shall be provided by the Contractor before the suction and discharge of each Booster fan. |
| 3.03.02 | All gates/dampers shall be designed to withstand the operating flue gas temperature without distortion. |
| 3.03.03 | There shall not be any backlash, play, etc. with linkage mechanism, actuator and final control element. |
| 3.03.04 | Thermal expansion of ducting shall not produce stress in louvers, linkage arrangement etc. |
| 3.03.05 | Outlet dampers of seal air fans shall be pneumatically operated, suitable for remote manual operation**.** |
| 3.03.06 | All pneumatically operated interlocked dampers actuators shall be provided with solenoid valves. |
| 3.03.07 | A quick acting biplane damper shall be provided by the Contractor in the bypass duct (flue gas duct connecting the existing chimney) for quick opening to allow bypass to come into operation in case of emergency. The damper shall be capable of quick opening during emergency conditions within a time of 10-20 secs. Bidder should indicate the required opening time for bypass damper for emergency operating condition. |
| 3.03.08 | All the gates shall be designed for tight shut off. The Guillotine gate type dampers mentioned at Clause No. 3.03.01 above shall have a guaranteed gas tightness efficiency (on flow) of not less than 99.95% along the duct as well as from the duct to atmosphere or from atmosphere to the duct, depending on the pressure in both the damper open and damper closed condition without the use of seal air fans of the damper and 100% leak tight with seal air fans under operation. The motor operated Guillotine gates shall also be provided with a 2X100% complete seal air system. The bypass damper shall have a guaranteed gas tightness efficiency (on flow) of not less than 99.5% and 100% leak tight with seal air fans under operation. The gas tightness shall be demonstrated at shop for minimum one type of damper of each type and size. |

3.03.09 The dampers shall be pneumatically operated and controlled from the control room. Provision shall be made for giving signal automatic bypass controls of the absorber in case of failure of the absorber spray system. The dampers shall have provision for manual operation, through a hand wheel. The force required for manual operation of the gate shall not exceed 35 kg (max.) at the rim of the hand wheel.

3.03.10 The isolating gates shall be provided with locking devices to permit locking in fully closed position.

3.03.11 Pressurization Fans:

a) All gates shall be provided with 2x100% pressurization fans to achieve 100% sealing efficiency.

b) The location and scheme for pressurization system shall be subject to Employer's approval.

3.03.12 All gates shall be designed to withstand the operating air and flue gas temperature without distortion.

3.03.13 All guillotine gates shall be located in horizontal duct to avoid fly ash build up when in closed position and shall be of top entry type.

**4.00.00 BOOSTER FAN:**

4.01.00 The Booster Fans shall be located downstream of the ID Fans (Induced Draft Fans) in the inlet duct to Absorber and shall be capable of handling the pressure drop in the FGD system, ducting and wet stack considering the exit loss from wet stack over the entire load range with any one or both Booster fans in operation in conjunction with one or both ID fan in operation while firing the specified range of fuels.

Booster Fans shall be sized such that they satisfy the criteria stipulated below.

4.01.01

| S.N. | Description | Booster Fan |
|---|---|---|
| 1 | Type of fans | Constant speed, axial type. |
| 2 | No. of fans per unit | Two |

| | | | |
|---|---|---|---|
| | 3 | Fan sizing criteria with all the following conditions occurring together : | Booster Fan to be sized for one (1) Booster Fan stream in operation taking into account following factors occurring together: |
| | (i) | Flue Gas Flow through fan | 642.8 $m^3$/sec |
| | (ii) | Power supply frequency | 47.5 Hz |
| | (iii) | Pressure at Terminal Point before Booster Fan suction | 0 mmWc |
| | (iv) | Gas temperature (degree Celsius) | 150 |
| 4.01.02 | The fans shall also fulfill following sizing criteria in addition to those mentioned at clause 4.01.01 above | | Each fan to be sized with following conditions occurring together. |
| | (i) | No. of fans in operation | 2 |
| | (ii) | Flue gas flow through each fan | 467.6 $m^3$/sec |
| | (iii) | Margin over flow | 20% |
| | (iv) | Margin over pressure requirement | Bidder shall consider the margin over pressure requirement as 44% over the calculated head value excluding the static head. Margin on Static head shall be taken as 10%. For bubbling type Absorber, Bidder shall consider choking/blockage of 10% sparger tubes while calculating the head requirements of fan. |

| | | | |
|---|---|---|---|
| | (v) | Power supply frequency | 50 Hz |
| | (vi) | Pressure at Booster Fan suction | 0 mmWc |
| | (viii) | Gas temperature (degree Celsius) | 150 |
| | (viii) | Flue gas control | Blade pitch control |

**Note to 4.01.01 & 4.01.02**: Booster fan shall have a minimum stall margin of 10% over the Design duty points.

4.02.01 Both fans shall operate with highest possible efficiency which shall be nearly equal at the Guarantee point flow and test block points.

4.03.00 Fan components along with servo/blade pitch control mechanism shall be designed to withstand and continuously operate with the maximum air or flue gas temperature that these fans will be required to handle. Fan component shall also be designed to withstand the excursions in flue gas temperature up to 300 degree Celsius, which may persist for about 30 minute duration. Such temperature excursion will not inhibit the safe and smooth operation of fans or cause any damage or increased maintenance.

4.04.00 The construction of Booster fans shall also comply with following requirements

| **DESCRIPTION** | **Booster Fans** |
|---|---|
| Type of fan blades | stream lined, aerofoil shaped section |
| Blade material | Nodular Cast Iron or High Wear Resistant Steel with or without Hard coating as per the proven practice of the fan manufacturer |
| Fan rotational speed | 745 rpm (max.) |
| Air/Flue gas flow | blade pitch control |
| Fan critical speed | not less than 125% of fan maximum operating speed |
| Fan component design* | to withstand torsional stresses three (3) times the normal full load motor torque at all speeds |

| | |
|---|---|
| **DESCRIPTION** | **Booster Fans** |
| Fan casing material thickness | Abrasion and wear resistant, high BHN steel having minimum 8.0mm thickness or 12mm mild steel with liner of thickness 10mm (min.) Alternatively, 22 mm thickness casing of mild steel is also acceptable. |
| Fan Housing design | for shut off head of fan |

*Note :

(a) Contractor shall submit detailed calculations, for Employer's approval, to confirm compliance with above requirements for all fan components, specifically for fan shafts, impeller hubs and impeller as a whole. Areas of high stress concentration and residual stresses, like welded attachments shall be avoided on the fan rotor/shafts. Combined static, dynamic as well as residual stresses shall be demonstrated to be within allowable limits. These fan components shall last the life of the plant with such combined stresses present in them.

(b) Although employer envisages to install highly efficient electrostatic precipitator to control particulate emission, however. Bidder shall select the Booster fan components such as blades, hubs, casing etc. to encounter the high dust burden of the order of 250 mg/$Nm^3$. The minimum wear life of Booster fan components shall not be less than 25000 hours of operation from the date of commissioning.

4.05.00 **Fan Bearings**

(a) Bearing shall be provided with oil bath to prevent damage in case of complete loss of plant auxiliary power when the fans must coast down without power.

(b) Size oil reservoir in bearings housing for maintaining lubrication for extended periods in case of oil circulation system is out of service.

(c) Cooling air circulation to be provided across main bearing

(d) Adequte numbers of duplex Pt-RTD (100 ohm at 0 degree Celsius) and temperature indicator shall be provided for each bearing. Local as well as remote monitoring features shall be provided.

(e) For mounting of vibration pads/pickups, flat surfaces shall be provided both in X and Y directions, by the Contractor on the bearing housing.

4.06.00 **Fan balancing**

(a) The fans shall be statically and dynamically balanced before shipment.

(b) Balancing of each fan shall be checked and adjusted at site, if necessary.

(c) Natural frequency of all fan components shall be established by vibration testing to ensure that no part of the wheel is adversely excited by any force generated at operating speeds.

(d) The fan blade shall be subjected to natural frequency test. The other components of fan wheels need not be subjected to natural frequency test if supplier can prove that these component are very rigid and have very high natural frequency compared to the operating frequency of respective fans giving justification.

4.07.00 Booster fans shall meet following operational requirements.

| | Description | Booster Fans |
|---|---|---|
| (a) | Mode of operation | i) two fans in parallel.<br>ii) one fan (one stream in operation) |
| (b) | Fan control system | i) capable of operating in automatic mode for all regimes of operation in a steady and stable manner<br>ii) The final control element shall not have any backlash, plays etc., and shall operate in the range of 20% to 80% depending upon generating loads upto Boiler MCR |
| (c) | Vibration | For mounting of vibration pads/pickups (in the contractor's scope) flat surfaces shall be provided, both in X & Y directions, by the Contractor on the bearing housing in such a way, so that welding/screwing of the pads shall be possible. |
| (d) | Bearing metal temperature monitoring | Shall be possible from remote as well as locally, using atleast 2 nos. of duplex platinum RTD's (100 ohms at 0 deg. C) per bearing |

4.08.00 The fans shall be suitable for parallel operation and sharing the load capacity over the entire range of operation without hunting. Pulsation shall be avoided by suitable design of fans and

4.09.00 **Fan Casing :**

(a) The fan casing shall be split to provide easy removal of the fan hub/impeller for replacement and repairs.

(b) The sections shall have gasket joints to ensure airtight sealing.

(c) Access doors shall be provided in each suction chamber casing and diffuser.

4.10.00 **Drain Connection:**

Drain connections shall be provided at bottom most point of the fan housing to the nearest trench.

4.11.00 The complete installation of the fans shall be under the supervision of the fan manufacturer.

**5.00.00 ABSORBER**

The unit shall be provided with an independent/dedicated absorber.

5.01.00 The contractor may offer either a spray type absorber, with single or multiple levels of spray, or an absorber with gas bubbling through the slurry, as per Bidders/Collaborator's proven practice. Only proven system in successful operation in previous installations supplied by the contractor shall be offered.

**A Spray System**

(i) The contractor shall provide spray system and minimum spray levels required to meet the stipulated guarantee and design requirement. The spray system (including slurry recirculation pump & nozzles) shall be sized to achieve a desired L/G ratio required to meet the guarantees $SO_2$ removal efficiency, with redundancies specified under this clause.

(ii) In case the contractor offers an absorber with multiple levels of spray nozzles, each spray level shall be provided with independent 2x100% pumps. Alternatively, the contractor may offer a spare spray level with each spray level served by an independent 100% capacity pump. In case the contractor offers a single level of spray, one number of standby pump of the same capacity & head as the working slurry recirculation pumps shall be provided. The contractor shall provide

spray system / spray levels only as per his proven practice, which should be in successful operation elsewhere.

(iii) The slurry recirculation pumps shall have a minimum margin of 10% on flow and 10% on frictional head, over the actual requirement for meeting the guarantee and design point conditions. All slurry recirculation pumps including motors shall be of the same size and type.

(iv) The slurry recirculation pumps shall have motor driven knife gate valve at pump suction and discharge side.
In order to optimise power consumption of FGD system at part load operation, Bidder to provide atleast one slurry recirculation pump preferably lower level with Variable Frequency Drive (VFD).

(v) The slurry recirculation pumps shall be wear-resistant and equipped with flushing devices to prevent sedimentation and shall be designed and installed in a manner to allow easy replacements, repair and maintenance. The slurry recirculation pumps shall be equipped with oil level indication, coupling guard and collecting equipment for leakage, made of resistant material. Single mechanical seals with automatic flushing with a connection for additional manual flushing shall be provided.

(iv) The slurry pumps shall also comply with the requirements stipulated in Clause 8.00.00 of this sub-section.

(v) Sufficient redundancy, as per the proven practice of the contractor, shall be provided in the spray nozzles. Minimum 10% spare nozzles shall be provided at each level.

**B Bubbling Type Absorber**

In case the bidder offers an absorber with gas bubbling through the slurry, the complete gas distribution system to the slurry shall be in bidder's scope. No recirculating pump and spray header and nozzles shall be required in such case. However, 3 x 50% Gas Cooling Pumps instead of Slurry Recirculation shall be provided. The spray headers & piping which are in contact with hot flue gas shall be made of Alloy 59 or C276 and nozzles shall be made of Silicon Carbide or ceramic or equivalent having a minimum guaranteed life of 20,000 hrs. Cooling Pump discharge piping and valves outside the flue gas path shall be in line with the requirements specified for slurry recirculation pumps. The Cooling Pumps shall be installed in a shed with roof sheeting.

The sparger and gas riser tubes shall be made proven material which shall have a minimum life of 5 years.

Minimum 10% redundancy, shall be provided in the Sparger Tubes.

**5.02.00 Absorber Recirculation Tank**

Sufficient number of agitators, as per the proven practice of the contractor, shall be provided for thorough mixing of the re-circulating slurry. In case the Contractor's Absorber includes side entry agitators, the contractor shall offer and demonstrate mixing arrangement such that n-1 number of agitators are sufficient to avoid the slurry settlement in the absorber tank in case of one agitator under breakdown (n-total no. of working agitators). In case vertical agitators in Absorber are offered, one complete mechanical assembly of agitator shall be supplied as warehouse spare for each Absorber.

**5.03.00 Absorber Oxidation Systems**

5.03.01 The contractor may offer either a grid type oxidation system or a sparge jet oxidation system or lance type or air rotary sparge system or jet air sparger system for oxidation of sulfite sludge to sulfates, or any other proven system as per the practice of the FGD vendor.

5.03.02 The oxygen required for oxidation shall be supplied by 2x100% oxidation air blowers for each absorber. The compressor/blower shall be sized to supply at least 2.5 times the stoichiometric air requirement for spray tower process & at least 4.0 times the stoichiometric air requirement for Bubbling Type process or the actual requirement, whichever is higher, under the following condition, all occurring simultaneously. The natural oxidation of sulfite by residual oxygen in flue gas shall not be considered for this purpose.

| **Load** | **Design point Flow** |
|---|---|
| Flow | Minimum 2.5 times for spray tower process & 4.0 for Bubbling Type process the stoichiometric requirement |
| Head | For spray tower process actual requirement considering choking/ blockage of minimum 10% of the oxidation nozzles / sprayers or minimum 8500 mmwc whichever is higher.<br>Note: For unit sizes 250 MW & below, minimum 10% of the oxidation nozzles / sprayers or minimum 6500 mmwc whichever is higher.<br><br>For Bubbling Type process actual requirement considering choking/ blockage of minimum 10% of the oxidation nozzles / sprayers or minimum 3500 mmwc whichever is higher. |

| | |
|---|---|
| | Margin on Head 10% under above conditions. |
| | Ambient Conditions 45°C / 60% RH. |
| 5.03.03 | Oxidation nozzles / spargers shall have a minimum redundancy of 10% or as per the contractor's proven practice whichever is maximum. |
| 5.03.04 | The oxidation system shall be complete with a quenching system to cool down heated oxidation air in order to prevent any scaling or buildup that could occur at the sparger tips due to localized evaporation of recycled slurry. |
| **5.04.00** | **Gypsum Bleed Pump** |
| | Each absorber shall be provided with 2x100% Gypsum Bleed Pumps for supply of gypsum slurry to Gypsum Dewatering system. Each Gypsum bleed pump shall be sized to bleed-off the gypsum slurry from the absorber with slurry solid concentration not exceeding 30%, under the following conditions, all occurring simultaneously: |
| | Load Design point |
| | Flow 100% of gypsum produced at Design point condition |
| | Head As per system requirement |
| | Margins Flow -- 15%<br>Head – 20% |
| | The pumps shall be designed to meet the stipulations of Clause No.8.00.00 of this Sub-Section. |
| | Provision shall also be provide in the Gypsum Bleed Pumping system by provision of tap off, valves etc. for pumping the gypsum bleed to alternate source. |
| **5.05.00** | **Emergency Spray System** |
| | An emergency cooling system for automatic spray of quenching water for a sufficient time (minimum 15 min) at the inlet to the absorber, in case the gas temperature exceeds the design temperature due to failure of upstream equipment's shall be provided to protect the FGD and all other sensitive downstream equipment against high flue gas temperatures. The water shall be supplied from an elevated tank (emergency water tank) installed near to the absorber. The tank volume and the |

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| | injection lances/nozzles shall be designed to protect the inlet duct and the lining of the absorber. The inlet duct shall be sloped towards the absorber. |
| **5.06.00** | **Design** |
| 5.06.01 | The design and arrangement of the absorber shall be field proven for successful long-term operation in conjunction with a coal fired power plant. |
| 5.06.02 | The design of flue gas ducts and inlet and outlet hoods of the FGD as well as guide vanes and baffle plates shall ensure a homogeneous flue gas flow with respect to the distributions of:<br>(i) temperature<br>(ii) velocity<br>(iii) dust content<br>(iv) slurry injection and distribution.<br><br>The above shall be proven by two phase Computational Fluid Dynamics simulations (liquid and gas). The scope of modelling shall include flue gas path inside the absorber vessel including inlet and outlet duct. Homogeneity shall be ensured, if the deviation from average is less than $\pm$10%. Further, in the Absorber outlet hood no internals such as guide vanes and baffle plates shall be allowed. |
| 5.06.03 | The fabrication of the absorber vessel shall follow common practice as there shall be no longitudinal seams located behind any attachment or obstruction which would prevent inspection of the welds. Nozzles, access ways, and their reinforcements shall not be located in or on any seam. Inaccessible gaps or hollow beams shall be avoided. |
| 5.06.04 | The absorber shell shall be designed for pressure loads, piping forces and moments, wind and seismic loads and all other loads imposed on the absorber. Bracing and reinforcement shall be adequate to prevent deflection and vibration. Internal supports for mist eliminator sections, etc. shall be designed to withstand the flooded weight of the supported section. The absorber and its structural supports shall be designed for the maximum operating loads including design positive & negative internal pressure, static head, external attachment loads (such as exerted by piping) wind load using the allowable stresses permitted by the applied standards. |
| 5.06.05 | It shall be possible to reach the $SO_2$ emission guarantees, at Guarantee point condition, with at least one spray level continuously out of service (in case the absorber is equipped with several spray levels) or one spare pump continuously out of service. |
| 5.06.06 | Three stage chevron type Mist Eliminators (ME) made of polysulfone or stainless steel shall be provided at the exit of the absorber. Provision shall be made for continuous washing of both ends of the first & second stage and the front section of the third stage of mist eliminators. Wash water arrangement shall also be provided at the back end of the second stage of mist eliminator. If the mist eliminator washing system is designed for cyclic washing of different sections, all the valves required for cycling shall be motorized or pneumatically operated. The automatic valve for the |

spray system shall be easily accessible on a platforms close to the mist eliminator. Entrained slurry shall be collected by mist eliminators downstream of the slurry spray system to avoid carry-over of slurry to the stack.

The ME system shall be equipped with washing and drain provisions, where drains are directed into the absorber. Washing provisions shall include external and internal piping systems with replaceable nozzles, water pressure booster pumps (if required) complete with all piping, valves, instrumentation and controls. The mist eliminator wash piping/header shall be constructed of rubber lined carbon steel or glass fiber reinforced plastics. Polypropylene or PVC is also acceptable for mist eliminator wash headers provided Contractor or its Collaborator has proven experience for the same. Ease of replace ability and placement of the mist eliminator on maintenance platforms is an important requirement. The ME shall be designed to allow for efficient cleaning in process. Test ports shall be provided downstream of the mist eliminator to enable performance testing.

The mist eliminator system shall be capable of withstanding high velocity spray water jets typically employed during manual cleanings. The ME shall be constructed in individual cells. The design shall safely avoid ME vibration and/or humming. The individual cells shall be sized so that no more than two maintenance personnel are needed to handle them manually when they are fully scaled or plugged, and the cells shall be capable of passing through the access doors for the mist elimination section. Easy access for placement and replacement of the mist eliminator shall be incorporated in the design of the mist eliminator arrangement and the absorber vessel.

Walkways shall be arranged and also measures shall be taken as appropriate to permit the internal components to be disassembled and reassembled during repairs without the necessity for time-consuming preparatory work. The headroom shall have a height of more than 2200 mm. The mist eliminator support beams shall be designed to act as maintenance walkways approximately 300 mm wide and shall allow for a minimum 500 Kg/m2 load. The support beam/walkways shall provide personnel access to all mist eliminator modules, wash headers and wash nozzles.

Adequate number of viewing ports with flushing devices connected to automatically operating washing system shall be delivered at following locations:

(i) upstream of 1st stage
(ii) between 1st and 2nd stage
(iii) downstream of 2nd stage.
(iv) downstream of 3rd stage

The regular flushing shall be done in a defined time sequence.

5.06.07 The absorber oxidation tank shall be provided with an over flow line (for spray tower process) complete with sealing pot, over flow and drain line. The absorber over flow shall be taken to a sump in the absorber region, from where the slurry shall be pumped back to the absorber by a sump pump.

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| 5.06.08 | Materials used shall be suitable for the chemistry of the absorber process and resist abrasion from any particulate contained in the incoming flue gas and from the particulate of desulphurization process. |
| 5.06.09 | All equipment located in the gas path or connected to such equipment shall be designed to withstand the maximum inlet gas temperature fluctuations. There shall be no damage whatsoever to any equipment as a result of these fluctuations. |
| 5.06.10 | The raw gas inlet duct of the absorber shall be equipped with a flushing device of the side walls and the ground, which shall operate continuously as well as intermittently. |
| 5.06.11 | The complete absorber vessel (absorber oxidation tank, absorber tower & absorber outlet duct upto absorber outlet flange) shall be made of clad sheet of C276 / Alloy 59 (minimum 2 mm thickness) by explosion bonding or hot rolling, having minimum 7 mm thick carbon steel as base material. |
| 5.06.12 | The material of process equipment of flue gas desulphurization system shall be appropriate for the chloride content and pH level at which the process is to operate. |
| 5.06.13 | All internal members shall be lined with minimum 2 mm Alloy 59/ C276 . All metallic fasteners which are provided inside the absorber/absorber wet-dry interface ducting shall be of Alloy 59/ C276. |
| 5.06.14 | The absorber wet-dry interface shall be made of solid Alloy 59 or C276 of minimum 6 mm thickness. |
| 5.06.15 | The other bridges (supports) shall be lined with minimum 2 mm Alloy 59/ C276. |
| 5.06.16 | Lining material and technical application requirements shall be furnished by manufacturer experienced with similar FGD plants. Proof of such experience shall be provided by the Contractor. |
| 5.06.17 | The spray headers (if provided) and air supply headers shall be made of FRP or Carbon Steel with rubber lining (minimum 10 mm natural rubber lining), corrosions and erosion resistant in the inner and outer side (Silicon Carbide coating on metal/FRP surface exposed to slurry). Optionally ceramic coating is also acceptable provided bidder/Collaborator has proven experience for the same. The slurry spraying system shall be made of material resistant to erosion and corrosion. During the lifetime of the plant, only the nozzles shall be replaced. The distribution system of the slurry shall be hydraulically optimized. The spray nozzles shall be of silicon carbide or ceramic or equivalent having a minimum guaranteed life of 20,000 hrs. The design of the spray nozzles shall be such that rapid wear, encrustation and plugging are avoided. Nozzle pipes and slurry spray nozzles shall be with bolted flanged connections. Nozzle pipes shall be installed easily to be removed partially through absorber modules. |

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| 5.06.18 | In case the absorber is equipped with several spray levels they shall be designed as follows:<br><br>(i) For spray type Absorber, the last spray level upstream the mist eliminator shall be operated only in counter-flow.<br>(ii) Depositions at downstream spray level and mist eliminator by co-flow injection of slurry shall be avoided.<br>(iii) The spray lances shall be equipped with bars for installation of scaffolding without any offset. The spray levels shall be designed for a load of min. 500 kgf/$m^2$.<br>(iv) A flushing device of the spray levels with water shall be installed. Flushing shall take place if spray levels are out of operation. |
| 5.06.19 | The absorber shall be self-supported from the bottom to suit site conditions. Absorbers which are externally supported from the structure are also acceptable provided Bidder or its Technology Collaborator has proven experience of supplying such Absorbers which are operating for more than 5 years. The absorber shall have adequate stiffening arrangement on the external side. Internal stiffeners shall be used only where it is not possible to provide proper external stiffening with approval of employer. |
| 5.06.20 | It should be possible to build platforms inside the absorber for access to all parts of the absorber during maintenance. In case the contractor offers a multiple spray level design, minimum distance of 1.5 m shall be maintained between individual spray levels. Arrangement shall be properly designed to facilitate access for maintenance and replacement of spray nozzles. |
| 5.06.21 | The spray piping, mist eliminators and its supporting structure shall be designed to carry sufficient load during maintenance. |
| 5.06.22 | The bottom of the absorber sump shall be designed so that there will be **an** easy entrance for a man with a wheelbarrow. Therefore the arrangement and dimensions of the inspection door of the absorber at ground level shall be designed to allow for this. The bottom of the absorber sump shall be designed in such a way that complete drainage of the absorption liquid/slurry is possible and is accessible without damage of lining. |
| 5.06.23 | In case of Spray Tower System, Suction screens shall be installed inside the Absorber vessel to protect the Slurry recirculation pumps. In case Bubbling type, suction strainers shall be installed at the suction line side of Gas Cooling Pumps. The Screens shall be made of made of Alloy 59 /C276 or abrasion resistant FRP/Polypropylene (in case Contractor/Collaborator has proven experience). For the agitators a flushing system for start ups shall be provided. |
| 5.06.24 | It should be possible to discharge the absorber sump into the Auxiliary Absorbent tank within 2 hours. |

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| 5.06.25 | At the head of the absorber two manholes shall be provided to reduce the draught of the stack during outage. |
| 5.06.26 | Equipment's required for internal & external inspection shall be furnished by the contractor in brand new condition. List of all such items shall be furnished along with the Bid. The formation of agglomeration, deposition & caking shall be avoided. For areas, where this might occur, (e.g. mist eliminators, spray levels) the Contractor shall submit a cleaning procedure including the required safety measures as part of the inspection concept. |
| **6.00.00** | **LIMESTONE GRINDING AND SLURRY PREPARATION SYSTEM** |
| **6.01.00** | **Type** |
| | A common limestone and slurry preparation system is envisaged for each project. Contractor shall supply wet limestone grinding and slurry preparation system complete with all auxiliaries and slurry storage tank of proven design. |
| **6.02.00** | **Limestone Silo:** |
| 6.02.01 | The Contractor shall provide 2X100% Limestone storage silos each silo having minimum 24 hours storage capacity equivalent to the requirements of FGD system of all the units operating at Design point. The storage silo shall be complete with supporting steel structure, platforms, staircase, air canons power operated gates, gravimetric feeders, level switches, air relief devices, etc.. |
| 6.02.02 | The storage silos and hopper cones shall be fabricated of minimum 10 mm thick carbon steel with a SS lining of grade SS304 of minimum 4 mm thickness in the complete cones to ensure reliable discharge of material. The design of storage silos shall confirm to IS 9178 (Part 1 to 3). The storage silo shall be capable of feeding the limestone by means of gravimetric feeder to the wet ball mills. The top of the unloading hopper shall be equipped with a grate to protect the downstream equipment from gravel lumps or tramp waste. |
| 6.02.03 | Each Silo shall be provided with minimum 02 no. of Level transmitters per silo. |
| 6.02.04 | Each silo shall be provided with minimum 3nos. of air canons at necessary location, capable of removing the jamming/clogging/blockage in the silos. |
| 6.02.05 | For dust free operation each silo should be provided with a covering arrangement and a self cleaning bag filter system of suitable capacity containing blower, automatic/on-load cleaning system, etc. |
| 6.02.06 | For each silo facilities shall be provided for unloading the bunker, through feeder, to a truck at ground level, along with all necessary chutes and diversion chutes. |
| 6.02.07 | Lime stone silo with hopper may be fabricated at factory in segments, transported and welded at site. |

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| **6.03.00** | **Bunker Shut-off Gates** |
| 6.03.01 | A bunker outlet chute shall be provided for feeding limestone from bunker to the feeder. The size of the opening chute shall be sufficient to ensure proper flow of the limestone. There shall be no reduction of section in the bunker outlet chute from bunker to feeder. The inlet chute shall be provided with suitable poke doors/holes in order to remove jamming/blockage. A motorized bunker shut-off gate shall be provided at the inlet to each feeder. |
| 6.03.02 | All parts of the gate in contact with limestone shall be of stainless steel construction. |
| 6.03.03 | The shut-off gates and its actuator shall ensure 100% closing of the gate even with 'bunker full of limestone'. |
| 6.03.04 | Facility shall be provided to open/close the bunker outlet gate, through actuator, from remote as well as local. |
| 6.03.05 | In addition, a hand wheel with proper access shall also be provided for manual operation of the gate. The force at the rim of the hand wheel shall not exceed 35 kg with bunker full of limestone. |
| 6.03.06 | For each bunker facilities shall be provided for unloading the bunker, through feeder, to a truck at ground level, along with all necessary chutes and diversion chutes. |
| **6.04.00** | **Gravimetric Feeders** |
| 6.04.01 | Gravimetric feeders shall be sized to meet 110% of the maximum mill capacity. |
| 6.04.02 | The limestone feeder belt shall be of seamless rubber construction. It should be possible to adjust the belt tension from outside without opening the feeder body. |
| 6.04.03 | All parts in contact with limestone except belt shall be of stainless steel construction. |
| 6.04.04 | The feeder shall have adequate instrumentation to detect `loss of flow'. |
| 6.04.05 | The feeder shall have a motor/pneumatic operated gate at the outlet. |
| **6.05.00** | **Wet Ball Mill** |
| 6.05.01 | There shall be 2X100% wet Ball mills for grinding of limestone. Each mill shall be sized to meet 110% of the maximum limestone requirement of all the units in a project operating under the following conditions, all occurring together.<br>(i) Load — Design point flow<br>(ii) Flow — 110% of limestone requirement of all the |

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| | | | absorbers at Design point |
| | (iii) | Input Limestone Size | 1" (max.) |
| | (iv) | Output Fineness | Output Fineness 90% or higher (as per the requirement of absorber) through 325 mesh (for spray tower process) OR 90% or higher (as per the requirement of the absorber) through 200 mesh (for bubbling process) |
| | (v) | Mill Wear Part Conditions | Near Guaranteed Wear Part Life. |
| | (vi) | Limestone bond index(kWh/sh.T) | 13 (min) |

6.05.02 All integral auxiliaries of the mills like hydro-cyclones, separator tank & mill circuit pumps shall be sized to meet the above conditions. A 100% stand-by pump shall be provided for the mill circuit pump.

6.05.03 The mill hydro-cyclone set shall have sufficient redundancy. A minimum 10% spare hydro-cyclone shall be provided in each set of hydro-cyclone. Hydro-cyclones shall be of modular construction. It shall be possible to remove and replace individual hydro-cyclone with the set in service. Individual isolation valve shall be provided for each hydro-cyclone for this purpose. The hydro-cyclone shall be of proven design and shall be provided with replaceable rubber lining. The hydro-cyclone shall be provided with replaceable rubber lining of thickness 12 mm for the feed chamber and 12 mm for the overflow launder.. The liners shall have a minimum wear life of not less than 8000 hrs.

6.05.04 All parts of the mill including mill body, trunnion, hydro-cyclones, integral pipes, mill circuit pumps and other parts in contact with limestone slurry shall be provided with replaceable rubber wear liners. The wear liners or wear parts shall have a minimum guaranteed wear life of not less than 8000 hrs without reversal of the liners. The guaranteed capacity and fineness of the mill shall not be affected within the guaranteed life of the mil wear parts.

6.05.05 The material of the balls shall be chosen to ensure that the balls do not lose their original shape and to ensure minimum ball consumption. The contractor shall also guarantee ball consumption per ton of limestone throughput. The contractor shall furnish the minimum ball diameter below which the balls shall be replaced.

6.05.06 Facility shall be provided for on-load loading of steel balls to the mill.

6.05.07 The ball mill shall be driven by a motor through a peripheral gear/ central drive system. An auxiliary motor shall also be provided for inching of mills after trip and during maintenance.

6.05.08 The lube oil system shall have 100% stand-by arrangement for lube oil pumps and oil coolers of each circuit with independent pump / cooler. Wherever required duplex oil filters shall be provided.

6.05.09 The mill auxiliaries like separator tanks, mill circuit pump, hydro-cyclones and all connecting pipes handling limestone slurry shall have replaceable rubber linings.

6.05.10 The design and manufacturing of wet ball mill shall follow the latest applicable Indian / International (ASME / EN / Japanese) Standards.

**6.06.00 Limestone Slurry Preparation / Storage Tank**

6.06.01 The contractor shall provide two (2 nos.) slurry storage tank, common for all mills. Each tank shall be sized to meet 12 hours continuous limestone requirement of all the units operating at Design point. For tank volume calculation, solid concentration (by weight) in the slurry shall be assumed, not more than 20% or actual required whichever is lower.

6.06.02 The storage tanks shall be equipped with sufficient number of agitators, to avoid settling of limestone, as per the proven practice of the supplier. The agitators shall be designed to meet the requirements stipulated in Cl. No. 11.00.00 of this Sub-Section.

6.06.03 The limestone mill circulation tanks shall be installed indoor beneath the hydro cyclone stations. The slurry storage tank shall be located outdoor.

6.06.04 The slurry preparation tank shall be CS construction with replaceable chlorobutyl/bromobutyl rubber lining of minimum 5 mm thickness.

**6.07.00 Limestone Slurry Supply Pumps & Piping**

6.07.01 2x100% centrifugal type limestone slurry pump shall be provided for each unit. Each limestone slurry pump shall be sized to supply the limestone requirement of one (1 no.) unit, under the following conditions all occurring together.

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| (i) | Load | Design point |
| (ii) | Flow | 110% of one absorber requirement with the limestone requirement at Design point. |
| (iii) | Head | As per system requirement. |
| (iv) | Margins | Flow 10% (minimum)<br>Heads 15% (minimum) |

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| | (v) | Solids Concentration | Max. 30% by weight or actual as per suppliers practice, whichever is minimum. |

6.07.02 The limestone slurry pumps shall be designed to meet the requirements stipulated in Cl. No.8.00.00. of this Sub-Section.

6.07.03 The limestone slurry pipes shall be sized to minimize erosion and avoid settling of the limestone at part load operation. The slurry pipes shall be lined with replaceable wear resistant natural rubber lining of minimum 6 mm thickness. Additional thickness of 2 mm in rubber lining shall be provided at bends.

6.07.04 Automatic flushing equipment for all lime slurry pumps and pipes shall be supplied.

**7.00.00 GYPSUM DEWATERING SYSTEM**

7.01.00 A common gypsum dewatering system for all the units operating at Design point is envisaged. Contractor shall supply a two stage gypsum dewatering system, consisting of a primary stage of sets of hydro-cyclones and secondary stage of vacuum belt filters for dewatering of gypsum from absorber up to less than 10% moisture. All the equipments supplied shall be proven design with previous installations for similar capacities.

7.02.00 The Contractor shall provide 2x100% gypsum dewatering system with each stream sized to dewater 110% of the maximum gypsum produced by all the units operating at Design point. All other stipulations with respect to sizing and design of the dewatering system, auxiliaries and other systems shall be in line with this specification.

**7.03.00 Primary Dewatering Hydro-cyclones**

7.03.01 Each set of primary dewatering hydro-cyclone shall be sized to dewater the gypsum slurry produced by all the units operating at Design point with an additional 10% margin. The outlet water content in the gypsum shall be as per the requirement of the vacuum belt filters.

7.03.02 Each set of primary hydro-cyclone shall be provided with 10% spare hydro-cyclones. The capacity defined in the previous clause shall be met with spare hydro-cyclones out of service.

7.03.03 The primary hydro-cyclone shall be installed directly above the belt filters. The overflow of the hydro-cyclones shall be taken to Hydro-cyclone Waste Water tank via secondary hydro-cyclone feed tank and secondary waste water hydrocyclone as shown in the relevant tender drawing.

7.03.04 Hydro-cyclones shall be of modular construction. It shall be possible to remove and replace individual hydro-cyclone with the set in service. Individual isolation valve

shall be provided for each hydro-cyclone for this purpose.

7.03.05 The hydro-cyclone shall be of proven design. The primary hydro-cyclone shall be made up of polyurethane or urethane materials. It shall be possible to remove and replace individual hydro-cyclone with the set in service. Individual isolation valve shall be provided for each hydro-cyclone for this purpose. The feed chamber shall be provided with a minimum rubber lining thickness of 12mm. The liners shall have a minimum wear life of not less than 7000 hrs.

**7.04.00 Vacuum Belt Filters**

7.04.01 Each vacuum belt filter shall be sized to meet the following requirements, all occurring together, with an inlet solid concentration of not more than 45% or outlet of hydro-cyclones whichever is minimum:

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| a. | Capcity | 110% of gypsum produced by Absorbers of all the units operating at Design point. |
| b. | Outlet Moisture | 10% max. |
| c. | Gypsum Purity | 90% (minimum) |
| d. | Chloride content | < 100 ppm |

7.04.02 The vacuum belt filter shall be proven design in operation for similar capacities. The filter cloth shall be polyester or polypropylene as per the proven design of the supplier and shall be guaranteed for a minimum life of not less than 7000 hrs.

7.04.03 The complete frame of the filter and all parts in contact with gypsum shall be made with corrosion resistant material.

7.04.04 In case, the contractor offers a design with an underlying belt for carrying the filter cloth, the same shall be endless, factory vulcanized rubber belts. The belt shrouds and the sealing belts shall provide a leak tight arrangement to prevent overflow of gypsum slurry. The sealing belt shall have minimum life of not less than 7000 hrs.

7.04.05 The vacuum box shall ensure tight sealing with the belt/cloth and shall be of proven design.

7.04.06 The belt filter shall have an automatic cloth tracking mechanism and shall be provided with all required instrumentation as per the supplier's proven practice. The belt filter shall have an automatic cloth tensioning mechanism.

7.04.07 The filter shall be provided with minimum 2 stages of cake washing for removing

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| | impurities in the gypsum. For cake washing only clarified water shall be used. For this purpose, one (1) clarified water storage tank (minimum 1 hr storage) shall be provided along with 2x100 cake washing pumps for each Vacuum Belt Filter . One stage of cloth washing arrangement shall also be provided along with 2x100 cloth washing pumps for each Vacuum Belt Filter. |
| 7.04.08 | The filtrate from gypsum slurry and from cake washing shall be taken to a common or separate vacuum receiver tank(s) as per the proven practice of the supplier. Each belt filter shall have an independent vacuum pump. |
| 7.04.09 | Gypsum cake from each belt filter shall be discharged through a hopper onto belt conveyor being provided by the Contractor. |
| 7.04.10 | A 2 m (min.) wide platform shall be provided around each belt filter for easy approach & maintenance. Handling facilities for replacement of heavy components of the belt shall also be provided. |
| 7.04.11 | The design and manufacturing of vacuum belt fil-ter shall follow the latest applicable Indian / International (ASME / EN / Japanese) Standards. |
| **7.05.00** | **Vacuum System** |
| 7.05.01 | The filtrate from each belt filter, cake washing & cloth washing shall be taken to a common or separate receiver tank(s) as per the supplier's proven practice. |
| 7.05.02 | Each belt filter shall be provided with an independent vacuum pump sized to meet the requirements of the belt filter operating at its maximum capacity. An additional margin of 10% (min.) over the above capacity shall be provided for each vacuum pump. |
| 7.05.03 | The vacuum pump shall be of low speed liquid ring type of proven design. The design of the vacuum pumps shall avoid cavitations under all operating conditions. The seals shall be of proven design. |
| 7.05.04 | Silencers shall be provided, if required, to limit the noise level to values stipulated elsewhere in this specification. |
| 7.05.05 | The vacuum receiver and pump internals shall be suitably lined to protect against the corrosive environment. The material selected for vacuum pumps & vacuum receivers shall be proven for similar application. |
| 7.05.06 | Each vacuum receiver tank(s) shall be provided with slide plate type pneumatic vacuum breaker. The plate shall be stainless steel with a min. thickness of 3 mm. |
| **7.06.00** | **Filtrate System** |

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| 7.06.01 | Water from vacuum receiver tank(s) and the secondary waste water hydrocyclone underflow shall be taken to a common filtrate tank for recirculation to the absorber tanks. |
| 7.06.02 | 2x100% horizontal centrifugal pumps shall be provided for recirculation of filtrate water to absorber. 2x100% horizontal centrifugal pumps shall be provided for wash water requirements of belt filter. Alternatively, wash water pump may take suction from the vacuums receiver tanks. Each pump shall be provided with 100% standby in such a case. |
| 7.06.03 | The pump shall be capable of pumping of filtrate water with solid concentration of not less than 10% & particle lumps of 6-7mm. A 10% margin shall be provided in each of the pump. |
| **7.07.00** | **Waste Water System** |
| 7.07.01 | The overflow of the primary hydro-cyclones shall be taken to a secondary hydrocyclone feed tank for feeding the secondary waste water hydro-cyclones. |
| 7.07.02 | The secondary hydrocyclone feed tank shall be sized to provide a minimum storage of 1 hr of primary hydro-cyclone overflow with all the units operating at Design Point and no outflow from the tank. |
| 7.07.03 | 2x100% horizontal centrifugal pumps shall be provided to feed the secondary hydro-cyclones. |
| 7.07.04 | Each set of hydro-cyclone shall be sized to process the maximum discharge from the secondary hydro-cyclone feed pumps. A minimum 10% spare hydro-cyclones shall be provided in each set. Secondary Hydro-cyclones shall be of modular construction and of proven design. The secondary hydro-cyclone shall be made up of polyurethane or urethane materials. It shall be possible to remove and replace individual hydro-cyclone with the set in service. Individual isolation valve shall be provided for each hydro-cyclone for this purpose. |
| 7.07.05 | The secondary waste water underflow shall be taken to the adequately sized filtrate tank, while the overflow shall be taken to a waste water tank.<br><br>In case Bidder opts to provide additionally Lamella separator before the waste water tank and after the secondary hydro cyclone for removing impurities from the system, the solids concentration in waste water up to max 10% can be acceptable .However, the required moisture content in Gypsum & required Gypsum quality shall be complied. |
| 7.07.06 | 1x100% Waste water tank shall be provided which shall be sized for 8 hrs storage of waste water with all the units operating at Design point and no out flow from the tank. The Waste water Tank shall be complete with Agitator, level transmitters etc. The waste water collection tank shall be of Steel construction with Vinyl Ester based |

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| | flake glass lining of minimum 3 mm thickness. 2x100% horizontal centrifugal pumps shall be provided for pumping the waste water from waste water tank at required pressure to waste water terminal point as indicated in Sub-section IV, Part A, Section VI of the Technical Specification. The material of Casing and impeller shall be rubber lined Cast Iron (IS:210 Gr FG260). Shaft and Shaft Sleeves shall be Stainless Steel-410. |
| 7.07.07 | All piping, valves & instrumentation upto the employer's terminal point shall be in the contractor's scope. Contractor shall provide the complete lime dosing system to correct the pH of the waste water by lime (83% purity) dosing shall be provided and after mixing of the effluent (using re-circulation system of the pumping system), the effluent shall be discharged once the waste water has been neutralized to desired pH. A pH monitor shall be provided at the discharge of the pumps for measurement and control. Complete lime storage, feeding & dosing system shall be in contractor scope. The complete waste water neutralization system shall be automated and controlled from the control room. |
| 7.07.08 | Contractor shall provide 2x 100% Lime Neutralization tanks which shall be of minimum 8 hr capacity made of carbon steel with rubber lining along with 2x100% Lime storage silos. The tanks shall be provided with SS dissolving basket, Agitator of SS construction, drain, over flow and dosing connection, level transmitters, Agitators etc. The storage silos and hopper cones shall be fabricated of minimum 10 mm thick carbon steel with a SS lining of grade SS304 of minimum 4 mm thickness in the complete cones to ensure reliable discharge of material. The design of storage silos shall confirm to IS 9178 or any other proven international standards. The storage silo shall be capable of feeding the lime by motorized rotary feeding system to the Lime Neutralization tank. |
| 7.07.09 | Contractor shall provide 2x 100% Lime Storage Silos for feeding lime to the Lime Neutralization tanks. The lime storage silo shall be of minimum 24 hr capacity equivalent to the requirements of FGD system of all the units at Design point and shall be complete with supporting steel structure, platforms, power operated outlet gates, level switches, air relief devices, etc. For dust free operation each silo should be provided with a covering arrangement and a self cleaning bag filter system of suitable capacity containing blower, automatic/on-load cleaning system, etc. |
| 7.07.10 | Bucket conveyors shall be provided by the contractor to feed lime to each of the lime storage silos from ground level. The Bucket conveyors shall be sized to completely feed each lime silo within 2 hrs. Adequate storage and feeding system required for feeding the lime to the Bucket conveyors is also in the Contractor's scope. |
| 7.07.11 | A storage room for storing minimum one (1) month requirement of lime for all the units shall also be provided by the contractor. |
| **7.08.00** | **Auxiliary Absorbent Tank** |
| 7.08.01 | The Contractor shall provide an auxiliary absorbent tank, for the unit, sized to |

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| | contain the complete slurry of one absorber tank at its maximum level equipped with all necessary pumps, valves, piping and controls to transfer the tank's contents back to the absorber to refill the absorber sump It should be possible to discharge the each absorber into the Auxiliary Absorbent tank within 2 hours. |
| 7.08.02 | The contractor shall provide 1 x100% pump to pump back the slurry from the sump back to the absorber in a maximum time of 8 hours. |
| 7.08.03 | Agitation shall be provided to prevent settlement of slurry by side entry agitators with emergency flush start system. Sufficient number of agitators shall be provided in the tank by the contractor to prevent the solids from settling down. |
| 7.08.04 | The Auxiliary Absorbent tank shall be made of minimum 7 mm thick carbon steel with minimum 4 mm thick rubber lining of best quality bromine butyl rubber and shall also be equipped with all necessary pumps, valves, piping and controls to transfer the tank's contents back to the absorber. |
| 7.08.05 | The Auxiliary Absorbent tank shall be equipped with an opening to enable easy entry of a man with wheelbarrow. |
| 7.08.06 | Suction screens shall be installed to protect the pump. |
| **8.00.00** | **SLURRY PUMPS** |
| 8.01.00 | This Clause covers the design, manufacture and erection of all slurry pumps for the FGD system including the Absorber slurry recirculation pumps, Gypsum bleed pumps, Limestone slurry feed pumps, Mill circuit pumps and any other pump handling slurries. |
| 8.02.00 | The Contractor shall offer only proven design in successful operation in similar application at previous installations. The design, manufacture, installation and testing of the pumps shall follow the latest applicable Indian / International (ASME / EN / Japanese) Standards. |
| 8.03.00 | The pumps shall be designed for continuous operation. The pump shall be single stage centrifugal type capable of delivering the rated flow at rated head with margins as specified in the respective clauses. The slurry concentration in the pump shall not exceed 30% by weight except for Mill circuit slurry pumps for which the slurry concentration in the pump shall not exceed 55% by weight. |
| 8.04.00 | All the slurry pumps shall be provided with motorized suction and discharge valves. In addition, flushing water lines with motorized/ pneumatic valves shall be provided for each pump for automatic flushing of the pump after each shut down. The flushing water for the pumps shall be taken from the process water supply. The process water lines shall be provided with pneumatic/motorized valves as per the proven |

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| | practice of the Bidder. |
| 8.05.00 | In case of pump with rubber lined casing, the casing should be radially split to allow easy removal of impeller. |
| 8.06.00 | All the pump wear parts in contact with the slurry shall be provided with replaceable rubber/elastomer liners suitable for the fluid handled. The Bidder can also offer an hi chrome alloy line pump if the Bidder has previous experience of the same for similar applications. The material used by the contractor shall be proven in previous installations. |
| 8.07.00 | For absorber recirculation service a Silicon carbide/hi-chrome impeller and SiC lining for casing can also be accepted if the manufacturer has supplied a similar pump for a previous installation for similar service. |
| 8.08.00 | The material and thickness of the liners shall ensure a minimum service life of 2 years before replacement. All the wear parts of the pump shall be guaranteed for a minimum wear life of not less than 14000 hrs. |
| 8.09.00 | The design of the shaft shall ensure that the operating speed is at least 20% above the critical speed of the shaft. |
| 8.10.00 | The pump shall be provided with seals of proven type and shall be designed for minimization of seal water consumption. The shaft shall be supported on heavy duty ball/roller bearings. |
| **9.00.00** | **VERTICAL SUMP PUMPS** |
| 9.01.00 | Contractor shall provide sumps of adequate capacity in the each absorber area, limestone grinding area and gypsum dewatering area for containing the over flow from the respective systems. Acid resistant tiles or other suitable material of standard thickness as per bidders proven practice shall be provided as liner. Contractor shall make arrangements for pumping the drainage water back to the respective system with vertical sump pumps. Agitators shall also be provided to avoid settling of solids in the sump. Adequate redundancy in line with the standard practice adopted by the bidder shall be provided. This Clause covers the design, manufacture and erection of all vertical sump pumps for the FGD system. |
| 9.02.00 | The contractor shall offer only proven design in successful operation in similar application at previous installations. The design, manufacture, installation and testing of the pumps shall follow the latest applicable Indian / International (ASME / EN / Japanese) Standards. |
| 9.03.00 | The pumps shall be designed for continuous operation. The pump shall be single stage centrifugal type with semi open or open impeller. The pump impeller shall be cantilever type and shall not be supported below the base plate for easy withdrawal. |

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| 9.04.00 | The pump shall deliver the rated flow at rated head with margins as specified in the respective clauses. The pump shall be capable of pumping of filtrate water with solid concentration upto 10% & particle lumps of 6-7mm. Sump pumps handling slurry shall be designed with a maximum concentration of 30% solid by weight. |
| 9.05.00 | The material chosen for the pump components shall be suitable for the fluid handled and shall be proven in similar application. |
| 9.06.00 | The pumps shall not be supported below the base plate level for easy withdrawal without entering the sump. |
| **10.00.00** | **SLURRY & PROCESS WATER TANKS** |
| 10.01.00 | All the slurry tanks (Slurry Tanks, Filtrate Tank, Secondary hydro cyclone feed tank, vacuum receiver tank, Waste water Tank, Lime Neutralization tanks etc.) shall be designed, fabricated, erected and tested in accordance with the IS:803, latest edition. Additional Corrosion allowance of 1.5 mm on the minimum tank shell thickness as calculated by IS:803, latest edition shall be provided by the Contractor. Tanks shall be made from IS:2062 quality mild steel plates of tested quality. The tanks shall be of welded construction. Interior surface of the tanks shall be lined with the following:<br><br>Wastewater tank, Filtrate tank, Secondary hydro cyclone feed tank: Vinyl Ester based flake glass lining of minimum 3 mm thickness<br><br>Slurry tanks: Replaceable Chlorobutyl/ Bromobutyl rubber lining of minimum 4 mm thickness<br><br>The outside surface of the tanks shall be coated with paint as approved by the Employer.<br><br>Coarse-screen(s) at suction-side of slurry recirculation pumps shall be provided. |
| **11.00.00** | **AGITATORS** |
| 11.01.00 | Agitators shall be supplied in tanks and vessels to prevent caking and settlement of particles out of the slurry, e.g. in the absorber vessel, limestone mill recycle tanks, limestone slurry tank, Auxiliary Absorbent tank, and sumps etc. |
| 11.02.00 | All agitators shall be designed for continuous operation unless otherwise specified. Horizontal agitators shall be used for Absorber. Vertical agitators can also be used for Absorber, if it is only the standard & proven practice of the Contractor for the offered Absorber design. In other vessels and tanks vertical agitators are also acceptable if they are of proven make and the Bidders standard practice which can be proven by means of suitable references. The design of the agitators shall be of proven type. |
| 11.03.00 | Standard type agitators with suitable characteristics shall be used wherever |

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| | practical. The agitators shall be complete with motor, gearbox, agitator shaft, coupling, safety guards, mechanical seal (for side entry agitators), impeller, support legs, agitator mounting flange including bolts nuts and gasket etc. |
| 11.04.00 | All agitator parts and accessories in contact with the stirred fluid shall be constructed of materials specifically designed for the conditions and nature of the stirred fluid and be resistant to erosion and corrosion. |
| 11.05.00 | The material for the shaft (which is continuously in contact with slurry) and agitator blades of the Absorber Agitators shall be made with Alloy 926 or better material. For Agitators in other tanks, agitator blades shall be made with Alloy 926 or better material & shaft can be rubber lined. This does not release the Contractor of the responsibility for selecting the correct materials. |
| 11.06.00 | Each agitator and its associated equipment shall be arranged in such a manner as to permit easy access for operation, maintenance and agitator removal without interrupting plant operation. It shall be possible to remove the sealing devices of the Agitators of the absorber vessel without having to drain completely the absorber. |
| 11.07.00 | To prevent mechanical blocking load start-up after standstill of pumps, piping and agitators for slurries shall be applied with C-hose connection. |
| 11.08.00 | Lifting lugs and eyes and other special tackle shall be provided as necessary to permit easy handling of the agitators and their components. |
| 11.09.00 | Static and dynamic (as far as applicable) balancing of all agitators shall be carried out after assembly. |
| 11.10.00 | All agitator parts and components shall be designed and calculated for fatigue life, considering maximum bending loads, induced by fluctuating hydraulic forces and torsional loads, based on the installed motor power. For side entry agitators the alternating bending moment resulting from impeller and shaft weight has to be considered additionally. |
| 11.11.00 | All exposed moving parts shall be covered by guards. |
| 11.12.00 | Side entry agitator shall be flange mounted. |
| 11.13.00 | The shape of the impeller blades of side entry agitators shall be designed to avoid wear on the impellers which will affect the agitator performance as specified for a minimum period of 2 years of continuous operation under design conditions for the range of coal & limestone specified in the specification. In order to avoid excessive wear impeller tip speeds must not exceed 12 m/s. |
| 11.14.00 | Belt drives (if applied) shall be properly designed to provide a minimum lifetime of 2 years under design conditions |
| **12.00.00** | **SLURRY LINES AND VALVES** |
| 12.01.00 | Slurry pipes shall be designed to keep the velocity above the settling velocity under all operating conditions. The contractor may provide a recirculation line with motorized isolation valve / restriction orifice made of erosion resistant material for the above purpose. |

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| 12.02.00 | All the pipes handling slurry shall be provided with replaceable rubber lining of proven quality. The Contractor can provide slurry pipes of size lower than 300 NB made up of FRP material (silicon carbide coating on slurry exposed surface) if it has previous experience of providing the same. Outer surface of the pipes should be fire retardant. |
| 12.03.00 | The isolation valves provided in all the slurry lines shall be of knife gate type/butterfly type unless specifically mentioned. Motorized actuators shall be provided for valves requiring frequent operation as indicated in the relevant scheme. |
| 12.04.00 | The valves shall be of proven type and the contractor shall submit a detailed valve schedule for employer's approval. Reference list for previous installations for similar application shall also be furnished to the employer. |
| 12.05.00 | Bidder shall provide all necessary arrangements for purging & flushing of all the process pipelines, equipments etc. |
| **13.00.00** | **PROCESS WATER STORAGE TANKS & PUMPS** |
| 13.01.00 | Two (2) Process water Storage tanks (each tank catering to the requirements of all the units operating at Design Point) along with two numbers of 2x100 % Booster water pumps, if required, (Each pump catering to the process water requirements of all the units operating at Design Point) along with all necessary piping, valves, control & instrumentation to feed the clarified water shall be provided by the Contractor. Process water Storage level shall be automatically controlled at operating level by controlling the water flow from the makeup water from terminal point. The process water storage tank shall be designed to store 30 minutes of total maximum water required for the entire FGD process (including absorber system and mist eliminator washing system, limestone grinding and slurry preparation system and gypsum dewatering system, etc.) for the units operating at Design point. All the process water storage tanks shall be designed, fabricated, erected and tested in accordance with the IS:803, latest edition. Additional Corrosion allowance of 1.50 mm on the minimum tank shell thickness as calculated by IS:803, latest edition shall be provided by the bidder. Tanks shall be made from IS:2062 quality mild steel plates of tested quality. The tank shall receive water supplied (as identified in Subsection titled "Terminal points" in Part-A of Technical Specification) by Employer. The Tanks shall be provided with drain, manholes, over flow & inlet level control valves etc. |
| 13.02.00 | 2x100% Process Water Pumps shall be provided for each unit connected to each of the Process water Storage tanks along with all necessary piping, valves, control & instrumentation. Each pump catering to process water requirement of one unit. The capacity of the pumps shall be such that it shall meet the maximum process water requirement of each unit. A further 10% margin shall be provided over the above capacity for all the above pumps. |

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| 13.03.00 | 2x100% Mist Eliminator Wash Water Pump for each unit connected to each of the Process water Storage tanks along with all necessary piping, valves, control & instrumentation shall be provided by the Contractor. Alternatively, Contractor can use process water pumps for mist eliminator washing if it is the standard & proven practice of the Contractor or its Technology Collaborator. Each pump shall cater to maximum mist washing requirement of one unit. The capacity of the pumps shall be such that the total capacity of working pumps is sufficient to meet the maximum wash water requirements of mist eliminators of the absorber. A further 10% margin shall be provided over the above capacity for all the above pumps. |
| 13.03.04 | Two (2) clarified water Storage tanks (each with minimum 1 hr storage) along with two numbers of 2x100 % clarified Booster water pumps from terminal point shall be provided by the Contractor. The two tanks shall be interconnected with an isolation valve. |
| 13.03.05 | 2x100% clarified water Pumps connected to each of the clarified water Storage tanks for each dewatering stream. Each pump catering to clarified water requirement of each dewatering stream. |
| 13.03.06 | The type of pumps shall be horizontal centrifugal type designed for continuous operation with semi open or closed impeller. Casing, Gland and Stuffing Box shall be of 2.5 Ni Cast Iron to IS:210 Grade FG 260 or equivalent. Impeller, Wearing rings (as applicable) shall be of Stainless Steel -316 grade and Shaft & Shaft sleeves shall be of SS-410 grade. Pump re-circulation line shall be provided for pumping system. Pumps shall be provided with accessories such as Y-type suction strainers, Coupling guard, drain plugs, vent valves etc. |
| 13.03.07 | All the Process water tanks (Process water Storage tanks, Clarified water tank, Emergency water storage tanks etc.) shall be designed, fabricated, erected and tested in accordance with the IS:803, latest edition. Additional Corrosion allowance of 1.5 mm on the minimum tank shell thickness as calculated by IS:803, latest edition shall be provided by the Contractor. Tanks shall be made from IS:2062 quality mild steel plates of tested quality. The tanks shall be of welded construction. Interior surface of the tanks shall be lined with replacable chlorobuty/bromobutyl rubber lining of minimum 4 mm thickness or with vinly ester based flake glass lining of minimum 3 mm thickness or Epoxy lining minimum three coats of 150 micron thickness and the outside surface shall be coated with paint as approved by the Employer. The Tanks shall be provided with drain, manholes, over flow & inlet level control valves etc. |
| **14.00.00** | **Approach and Handling Facilities** |
| 14.01.00 | Proper approach shall be provided for access to all equipments during normal operation and maintenance. Operating platform to be provided for each equipment |

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| | and drive. Unless otherwise specified, platforms, staircase and ladders shall follow the stipulations specified elsewhere in this specification. |
| 14.02.00 | Equipments requiring monitoring during regular operation shall be approachable from the ground floor through staircase. Staircase with minimum width of 1200 mm shall be provided for approach to elevated structures at 5m height from the nearest platform. Below this height a vertical ladder with minimum clear width of 600 mm may also be acceptable. |
| 14.03.00 | Platform with a minimum clear width of 1000 mm shall be provided all around the lowest absorber spray levels and mist eliminators. Similar platforms shall be provided at subsequent elevations if they are more than 3000 mm apart from each other. An adequately sized manhole with platform (min. 2 sq. m) shall be provided above each spray level. Ladders/staircase shall be provided for the access to the platform. |
| 14.04.00 | The absorber slurry recirculation pumps, gypsum bleed pumps and limestone feed pumps shall be mounted on the ground level. Suitable approach and platforms shall be provided for all the valves required during regular operation. |
| 14.05.00 | A 1500 mm space shall be provided around all pumps, except absorber recirculation pumps, where a 2000 mm space shall be provided. |
| 14.06.00 | Platform with a minimum width of 1500 mm shall be provided all around the pulverizers and feeders. Approach along with suitable platforms shall be provided for ball loading hoppers. |
| 14.07.00 | A 1000 mm wide platform with suitable approach shall be provided around each hydro-cyclone. |
| 14.08.00 | A 2000 mm wide floor/platform shall be provided all around each belt filter. |
| 14.09.00 | Contractor shall provide motorized hoists and trolleys for all items requiring maintenance and weighing 500 kg or more. All auxiliary structures, monorails, runway beams for all lifting tackles, hoists etc., are included in Contractor's scope of supply. Access ladders with suitable platform shall also be provided for approach to all motorized hoists/trolleys mounted on their runway beams for the maintenance of hoists/trolleys. Items weighing more than 50 kg and required to be replaced for maintenance shall be provided with manual hoists/trolleys with runway beams/supporting structure etc. |
| 14.10.00 | The regular basement floor is not acceptable in FGD area. Further local Pits/trenches shall be avoided as far as possible. |

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| 14.11.00 | Handling arrangement of milling system, Booster fans, Slurry recirculation pumps, oxidation blower, belt feeder system etc. complete with crane/monorail along with removal space for maintenance shall be provided by the Contractor. |
| 14.12.00 | Approach for removal of equipment for maintenance shall be provided. |
| 14.13.00 | All other safety requirements as per the Factories Act, National Electricity code shall be complied with while developing Layout. |
| 14.14.00 | Cable trenches/slits, if unavoidable, shall be provided with adequate cushioning of sand and the same shall be covered with PCC. |
| 14.15.00 | Each Equipment room shall be provided with alternate exits in case of fire/accidents as per requirements of Factories Act and Statutory bodies/insurance companies. |
| 14.16.00 | Minimum Headroom (free height) under all floors, ducts, walkways and stairs shall be 2.50 M. |
| 14.17.00 | Inter-connecting pipes/cables between various facilities of FGD plant shall be routed on the steel trestles to be provided by the Contractor. The clear head room for the same shall be minimum 8 M. |
| **15.00.00** | **ELEVATORS** |
| 15.01.00 | Elevators shall be designed based on following criteria : |

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| (i) | Type of service | One (1) no. Passenger cum goods elevator per Absorber (higher than 20 m) & for Mill Building |
| (ii) | Design/construction/installation codes | (a) Latest edition of IS:14665 (All parts) AND also meeting any additional requirements of IS:4666, IS:1860 and IS:3534.<br>(b) Any other equivalent code, subject to Employer's approval.Load carrying capacity |
| (iii) | Capacity | 1000 kg (minimum). |
| (iv) | Rated speed | 1.0 m/s. |
| (v) | Total Travel | As per FGD supplier's recommendations subject to Employer's |

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| | | | approval. |
| | (vi) | Number of floors to be served | As per requirement and subject to Employer's approval |
| | (vii) | Entrance | As per requirement and subject to Employer's approval |
| | (viii) | Entrance and platform size | As per design/installation codes at (ii) above |
| | (ix) | Drive/motor | As per Electrical Specifications. |
| | (x) | Method of control | As per Electrical Specifications. |
| | (xi) | Machine room and lift Shaft | Pressurized dust proof or Airconditioned machine room as per the requirement of lift manufacturers. |
| | (xii) | Position of machine room | Directly above the lift shaft. |
| | (xiii) | Power Supply | As detailed in Electrical Specification |

15.02.00 Landing doors of the elevators shall have fire resistance of at least one hour. These doors shall also be smoke tight as far as possible.

15.03.00 Construction of the elevators shall specifically meet all requirements of the codes indicated at Cl. 15.01.00 (ii) and shall have following additional features:

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| (i) | Flooring of Cabin | : | 6 mm thick Checkered Plate flooring. |
| (ii) | Design, Construction and finish of car & car door | : | Car inside enclosure including inner side of door shall be of stainless steel plate of grade SS:304 of bright finish. |
| (iii) | Car entrance and landing doors | : | As per BS:476 (Part 20 & 22) |
| (iv) | Door construction | : | Hollow metal construction from 16 guage thick steel sheet spray painted. |
| (v) | Signals | : | Car position informer in car both visual and audio, hall position indicator at all floors, telltale lights at all floors, battery operated alarm bell and emergency light with suitable battery, charger & |

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| | controls. |
| | (vi) Type of Indicators : Soft touch keys and digital luminous display in car operating panel and on all floors landings. (All fixtures in stainless steel face plates). |
| 15.04.00 | Technical requirements of Electrical items shall be as per details given in Electrical Sub-Section, Part-B. |
| 15.05.00 | Provide sound reducing material below machines in machine room. |
| 15.06.00 | Provide special corrosion resistant treatment on all elevator components. The protective treatment shall be subject to Employer's approval. |
| 15.07.00 | Elevators shall have provisions to meet following operational requirements: |
| | (i) Selective collective, automatic operation with or without operator through illuminated push button station located inside the lift car. |
| | (ii) Power operated with automatic opening/closing car and landing doors. |
| | (iii) Two push buttons, one for upward movement and the other for downward movement at each intermediate landing, and one push button at each terminal landing shall be provided in order to call the car. |
| | (iv) Push buttons shall be fixed in the car for holding the doors open for any length of the time required. |
| 15.08.00 | Fireman's switch shall be provided for each elevator. |
| **16.00.00** | **DUCT WORK AND DAMPERS:** |
| 16.01.00 | **Duct Work** |
| 16.01.01 | **Sizing Criteria:** |
| | 1. Allowable velocities in the duct work. |
| | Maximum gas velocity shall be 15 m/sec at Design point condition. |
| 16.01.02 | **Loads for Duct and Structure Design** |
| | The duct design shall take into account following loads all occurring together: |
| | 1. Wind loads as specified. |

2. Dead weight including weight of insulation, lining, wash water and the vertical live load.

3. Ash load :

   All ducts to be designed for one tenth of duct full of ash. The ash density for the purpose of loading shall be at least 1300 kg/$m^3$.

4. Expansion joint reaction.

5. Seismic Load

6. The following minimum load factors shall be applied to the design loads:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Temperature (Deg.C) | : | 27 | 38 | 93 | 149 | 205 | 260 | 316 | 321 |
| Load Factor | : | 1.00 | 1.02 | 1.12 | 1.19 | 1.25 | 1.29 | 1.34 | 1.42 |

16.01.03 **Duct Design Pressure**

The flue gas duct upto Booster Fan inlet shall be designed for ± 660 mm w.g. at 67% of yield strength of material. The flue gas duct from Booster Fan outlet shall be designed for + 660 mm& - 150 mm wg or maximum conceivable pressure of the Booster Fan, whichever is higher, at 67% of yield strength of material.

16.01.04 **Duct Slope**

All ducts shall have a sufficient slope with respect to horizontal so that any chance of accumulation of ash particles or water in the duct can be avoided under all normal/abnormal operating conditions. The inlet duct shall be sloped towards the absorber.

16.01.05 **Type of duct construction:**

The duct shall be of rectangular cross-section and shall be of all welded construction. For rectangular ducts following requirements shall be complied with:

a) Minimum 7 mm thick steel plates for gas ducts & Duct stiffening shall be by means of rolled sections of duct material.

b) A corrosion allowance of 1.5 mm shall be considered for stress calculation for the flue gas ducting.

c) Duct stiffening shall be by means of rolled sections. No internal stiffeners shall be used for ducts from Absorber outlet to chimney inlet.

16.01.06 **Insulation & Lagging**

a) Thermal insulation shall be applied to all air/gas ducts to comply with the requirements of as specified at clause no 17.00.00 of this chapter.

b) Acoustic insulation shall be used, if required, in gas ducts to restrict the noise level to specified values.

16.01.07 **Specific Requirements**

a) The stiffeners provided on the ducts walls shall be of such a design and layout that no rainwater can accumulate on the duct surfaces.

b) The flanges at the bolted joints shall have adequate stiffeners to avoid damages to the flanges.

c) All necessary wall boxes and floor collars shall be provided where the ductwork pass through walls, floor and roof.

d) The floor collars shall be fitted with a high combing to prevent water and dust falling through the hole.

e) The ductwork shall be fitted with a steel hood to cover the opening.

f) Weatherproof flashing shall also be provided wherever necessary.

g) The configuration and design of ducts shall be coordinated with the pulveriser parts removal requirement.

h) Air and gas ducts shall not counter internal bracings, which cause excessive pressure drop.

i) Duct plates shall be designed for one-way beam action over stiffeners and considered fully continuous over all supports.

j) Bidder to ensure proper draining facilities for the complete system including proper drainage of acidic fluids from the ducts so as to avoid any accumulation of acidic fluids.

k) The deflection of the plate, assumed continuous, shall be less than one-half the plate thickness.

16.01.08 **Duct Work Structure**

a) Ductwork sections between expansion joints shall be investigated with regard to their ability to transmit loads to supports. Care shall be exercised to identify uplift condition.

b) Internal stiffeners:

(i) Duct shape shall be maintained by providing internal stiffening elements at or near supports. However, these internal stiffeners shall be used, if and only if, it is not possible to provide external stiffeners.

(ii) Internal stiffening elements shall consist of trusses, preferably comprised of extra-strong steel pipes (min. dia. 76.2 mm) acting in conjunction with external stiffeners. Such internal stiffeners for the flue gas duty between boiler and ESP shall be provided with erosion protection shields.

(iii) The number of internal trusses shall be limited to the minimum required for structural integrity and shaped so as to offer least resistance to gas flow and to minimize the accumulation of fly ash in the bottom of duct.

(iv) Conceptual data of internal stiffeners of the ducting shall be furnished along with the offer.

(v) All the detailed design data shall be furnished to the Employer before the duct support column foundation data submission.

c) Corner angles shall be used on all inside corners of all ducts to provide adequate continuity.

d) Inside welds of corner angles to duct plate shall be continuous and seal welded. Where inside surface of ducts will be coated, welds shall be full throat.

e) Field welding and all connections of bracing (stiffening elements) to stiffeners shall be well designed in order to develop full strength of the members. The gusset plates shall be of 10 mm minimum thickness.

f) The duct, plates, trusses, stiffeners, bracings and ductwork shall be designed as structures in accordance with relevant Indian Standards.

g) All openings in ducts shall be reinforced for all design loads.

h) Ductwork supports may be hangers or sliding bearing, guides and anchorages. A coefficient of sliding friction of 10% can be used with self-lubricated plates such as "LUBRITE" or "MECHANITE", a coefficient of sliding friction of not less than 35% shall be used for steel-on-steel contact. The allowable bearing stress for self-lubricated plates shall be 70 Kg/sq.cm.

16.01.09 **Fabrication Requirements**

a) Fabrication shall be as per IS specification for Design, fabrication and erection of 'Structural Steel for Building.

b) Welding shall be in accordance with Section IX of ASME code.

c) Ducts shall be strength welded and seal welded to produce a gas tight duct. Alignment holes shall be provided in mating flange sections.

d) Ducting shall be detailed and fabricated in a few pieces as practical, taking into account, shipping and erection considerations.

e) Materials improperly detailed or fabricated necessitating extra work during erection on field, shall be the responsibility of the Contractor.

**17.00.00 THERMAL INSULATION AND CLADDING**

17.01.00 Thermal Insulation along with aluminum cladding shall be provided for all the equipments/surfaces having skin temperature more than 60 degree Celsius except for absorber. Further, Thermal insulation of min 70 mm shall be provided for absorber outlet flue gas duct irrespective of skin temperature. The specification of the insulation including type, density, thickness, heat conductivity and finish shall be designed based on criteria specified below. The insulation thickness shall be designed based on following criteria.

| | **Criteria** | **Design Conditions** |
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| (i) | Ambient Temperature | 45°C |
| (ii) | Surface wind velocity | 0.25 m/sec. |
| (iii) | Emissivity of Aluminium | 0.2 |
| (iv) | Cladding surface temperature | 60°C (max.) |
| (v) | Thermal conductivity of insulation | Not less than the Maximum |

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| | | material | values as per IS:8183 |
| | (vi) | Pipe/Equipment wall temperature | Maximum fluid design temperature |
| | (vii) | Overall heat transfer coefficient and insulation thickness | To be calculated as per ASTM C 680-89 |

However, the minimum insulation thickness, however, shall not be less than 75 mm.

17.02.00 Material and application of insulation material, protective cladding, wire mesh etc. shall be conforming to latest edition of following codes:

(a) IS:8183

(b) IS:3677

(c) IS:3144

(d) IS: 14164

(e) IS:280

(f) ASTM-B 209

17.03.00 Insulation material for all equipments, ducting, etc. shall conform to following requirements:

| | **Parameters** | **Requirement** |
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| (i) | Material | (a) Lightly resin bonded mineral wool of best grade conforming to IS:8183. (Hand made mattresses is not acceptable). Material shall be rock wool only. Slag wool or slag wool inclusion shall not be accepted.<br><br>(b) Lightly resin bonded glass wool mattress, having density 64 Kg/m$^3$ (min.), self stitched in shop can also be accepted for temperature less than 400°C. |
| (ii) | Bulk density of lightly resin bonded mineral rock wool mattresses | |

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| | (a) For use upto 400°C | - | 100 Kg/m³ |
| | (b) For use above 400°C | - | 150 Kg/m³ |
| | (iii) **Physical requirements -** | | |
| | Following shall be met by testing as per relevant clauses of IS:3144. | | |
| | (a) Shot content | | 5% by weight (maxm.), size of any shot not to exceed 5 mm in diameter |
| | (b) Bulk density | | To comply with 16.03.00(i) & (ii) above. |
| | (c) Weight gain by moisture absorption | | 2% (maxm.) |
| | (d) Sulphur Content | | Not exceeding 0.6% |
| | (e) Alkalinity as percentage of $Na_2O$ | | Not exceeding 0.6% |
| | (f) Maximum oil content | | Not exceeding 0.3% by weight |
| | (g) Total carbon content | | Not exceeding 0.3% by weight |
| | (h) Settlement | | Nil (When tested as per Cl. 21.1 & 21.2 of IS:3144) |
| | (i) Handability | | Fully handable, without any lump formation and disintegration of material |
| | (k) Loss of weight after combustibility test | | Not exceeding 5% by weight |
| 17.04.00 | The Insulation mattress shall be rated incombustible when tested by the method prescribed in clause 15 of IS:3144 and shall meet the requirement of the Mercantile Marine department, Lloyd's Register of shipping, underwriter, fire hazards codes and other International standards. | | |
| 17.05.00 | In addition to requirements as mentioned above, insulation material (and protective covering) shall: | | |

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| | (a) Be fresh, incombustible, rust proof, non hygroscopic, |
| | (b) Be capable of withstanding continuously and without deterioration the maximum temperature to which they will be subjected. |
| | (c) Not react chemically, either to itself or with other components. |
| | (d) Not sustain any fungi, or vermin and must not pose health hazards. |
| 17.06.00 | The Mineral wool shall: |
| | (a) Pass standard combustibility test both immediately after application and after subjected to maximum operating temperature for not less than 100 hrs. |
| | (b) Not suffer permanent deterioration as a result of contact with moisture due to condensation and shall be free from objectionable odor. |
| | (c) Not cause corrosion of the surface being insulated or of cladding on it under normal site conditions. |
| | (d) Not suffer any quality deterioration under specified service conditions (both cold/hot face temp.) of use. |
| 17.07.00 | The use of insulation of finishing materials containing asbestos in any form is not permitted. |
| 17.08.00 | Insulation mattress/section shall be supplied in thickness of 25,40,50 and 75 mm. Insulation of higher thickness shall be made up in multiple layers using mattress/slabs of thickness specified above. However, if the required thickness is such that by using above mattress/slabs the calculated thickness is not achieved, the mattress/slabs in increment of 5 mm shall be acceptable for outer layers. The min. thickness however, shall not be less than 25 mm and number of layers shall be minimum and innermost layer shall be thickest. |
| 17.09.00 | **Sheathing Material**<br><br>Sheathing material for all insulated surfaces, equipments, piping etc. confirming to ASTM B-209-1060 temper H-14 or IS:737 Gr 19000/H2, shall be provided. The thickness of aluminium sheathing to be used shall be 22 SWG (0.71mm). |
| 17.10.00 | Binding and lacing wires shall be 20 SWG Galvanised Steel wire |
| 17.11.00 | All Straps and bands shall be Galvanized Steel. Bands shall be 20 mm wide and 0.6 mm thick. For securing Aluminum sheathing material, stainless steel or anodized aluminum bends shall be used. |

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| 17.11.01 | Screws shall be of galvanized steel, check headed, self tapping type. Above 400 degree Celsius temperature, screws shall be stainless steel. |
| 17.12.00 | Hexagonal wire mesh netting shall be 10-13 mm aperture and atleast 0.56mm diameter conforming to following Galvanized Steel wire. |
| 17.12.01 | Non metallic components like 3 mm thick mill board, aluminum pigment sealant, white glass cloth, insulating cement, neoprene washer shall be provided. |
| 17.13.00 | **Application of Insulation** |
| 17.13.01 | **General**<br>(a) All surfaces to be insulated shall be cleaned of all foreign materials such as dirt, grease, rust etc. and shall be dry before the application of insulation.<br>(b) Before applying the insulation the contractor shall check that all instrument tapping, clamps, lugs and other connections on the surface to be insulated have been properly installed as per the relevant erection drawing.<br>(c) All flanged joints shall be insulated only after the final tightening and testing.<br>(d) The insulation shall be applied to all surfaces when they are at ambient temp. Ample provision shall be made for the maximum possible thermal movement and the insulation shall be applied so as to avoid breaking/telescoping due to alternate periods of expansion and contraction.<br>(e) All cracks voids and depressions shall be filled with finishing cement, suitable for the equipment operating temp. so as to form a smooth base for the application of cladding. |
| 17.13.02 | All the refractory and insulation materials required for complete field application of insulation, cladding etc. covered under these documents and specifications shall be furnished with the equipment. They shall conform to the requirements of the various relevant ISI standards or other approved equivalents. All items such as insulating cement, sealing material, insulation material, screws, washers, etc., needed to complete the work in the course of the application of insulation and refractory shall be furnished. All insulating materials shall be chemically inert in both the dry and wet state and shall withstand the full working temperature conditions to which they are exposed without any deterioration. The gas ducts shall be insulated with mineral wool block or mineral wool blanket and all other equipment operating at elevated temp. not enclosed in the boiler casing shall be insulated with calcium silicate blocks, mineral wool blocks or mineral wool blanket insulation. |
| 17.13.03 | **Application on Piping** |

(a) All vertical pipes shall be provided with the suitable insulation supports to prevent collapsing/crushing of insulation due to its self weight. Support rings shall be provided on all vertical piping with a difference in elevation of 4 meter or above, and there shall not be more than 3 m straight length between support rings.

(b) Longitudinal joints of insulation mattress sections of horizontal piping shall be on the bottom or at the sides of the pipe.

(c) When more than one layer of insulation mattress/section is required on piping the circumferential joints on adjacent layers shall be staggered by at least 150 mm and longitudinal joints shall be staggered by at least 50 mm.

(d) The mattress type insulation shall be formed to fit the pipe and applied with the mattress edges drawn together at the longitudinal joints and secured by lacing wire. Pipe section insulation shall be fitted on pipe using binding wires.

(e) Where insulation is applied in two or more layers each layer of mattress shall be backed with hexagonal wire mesh. For the first layer of insulation and in case of single layer insulation, hexagonal wire mesh shall be provided on both the surface of the mattress. For pipe sections, the sections shall be held in place by binding wires without any wire mesh.

(f) The ends of all wire loops shall be firmly twisted together with pliers, bent over and carefully pressed into the surface of the insulation. Any gap in the insulation shall be filled with loose mineral wool or finishing cement.

(g) Insulation mattress/section ends shall be terminated at a sufficient distance from the flanges to facilitate removal of bolts.

(h) The insulation shall be held in place by fastening over with binding wire for insulation surface with diameter upto and including 550 mm and with metal bends for insulation surfaces with diameter over 550 mm. The fastening shall be done at intervals of 250 mm except where specified otherwise. The ends of the binding wires shall be hooked and embedded in the insulation. The straps shall be mechanically stretched and fastened with metallic clamping seals of the same materials as the strap.

(i) Insulation for application on bends and elbows shall be cut into mitred segments, sufficiently short to form a reasonably smooth internal surface. After the application of insulation material place, insulating cement shall be applied as required to obtain a smooth surface.

(j) Weather hoods shall be provided for insulated piping passing through floors/walls.

(k) All pipe attachments coming on horizontal pipes, inclined pipes and bends shall be insulated along with pipe such that there will be no insulation applied to hanger rod and the component connecting hanger rod to pipe attachment. All pipe attachments exposed to weather shall be provided with weather proof covering.

(l) Upstream of all drain lines and the lines connected to steam traps, shall be insulated upto and including first isolating valve for heat conservation. Rest of such lines such as downstream of the drain valves, traps etc. and other lines such as safety valve discharges, vents, etc. shall be insulated for personnel protection.

17.13.04 **Application on Valves and Fittings**

(a) All valves fittings and specialties shall be insulated with the same type and thickness of insulation as specified for the connected piping with the special provisions and or exceptions as given below.

(b) All valves and flanges shall be provided with removable box type of insulation covered with box fabricated from aluminium sheets of thickness same as the connected pipe cladding. Adjoining pipe insulation shall be bevelled back to permit removal bolts and nuts or bands. The portion of the valve which can not be covered by box type insulation shall be filled by loose insulating material of packing density at least equal to that of the insulating material of adjoining pipe. The insulation for valves/flanges shall be applied after the finishing has been applied over the connected piping. The cladding shall be applied in such a manner that the bonnet flange can be exposed easily without disturbing the complete insulation and cladding.

(c) Flanges on lines having temperature upto and including 150 deg.C shall not be insulated.

(d) Union shall not be insulated.

(e) Expansion joints, metallic or rubber, shall not be insulated unless otherwise specifically indicated.

(f) Safety valves shall be insulated.

17.14.00 While applying mineral wool blanket insulation:

(a) Provide expended metal or hexagonal wire mesh on both sides for single layer mattress and on first layer in case of multilayer insulation. Subsequent layers of multilayer insulation to have only one side wire netting.

(b) The edges of adjacent blankets to be leased together, by appropriate lacing wire as per Clause 16.08.00.

(c) Any gap between joints between insulation layers shall be filled by loose mineral wool confirming to IS:3677.

(d) All insulation to be secured by 1.63 mm dia wire netting over blankets with ends of wire tightly twisted, and pressed in to insulation surface.

(e) Impelling pins shall be placed on centers not exceeding 300 mm.

17.15.00 Flue Gas ducts with external stiffeners shall have first layer of insulation between the stiffeners and a second layer of insulation over stiffeners so that stiffeners are also insulated and a level surface is achieved. Other requirements are same as given in Clause 18.09.00.

17.16.00 **Application of Metal Cladding**

All insulated surfaces of the FGD shall be provided with metal cladding in accordance with the following requirements.

(a) All insulation procedure of metal cladding shall have prior approval of the Owner.

(b) All insulated surfaces of FGD shall be covered with aluminium cladding.

(c) Cladding for FGD components are to be finished with plain aluminium sheeting of thickness not less than the values specified. Wherever an inner casing plate is necessary to effect a gas tight enclosure, the plate shall be of mild steel of required thickness, but not less than four (4) mm suitably stiffened and supported.

(d) Cladding on straight surfaces shall be finished with aluminium sheeting of at least 20 SWG thicknesses suitably pressed along diagonals to form diamond shape or otherwise formed.

(e) Cladding for insulated circular surfaces will be constructed from aluminium sheets of thickness not less than 20 SWG.

(f) Weather proof flashings shall be installed where the panels intersect with columns and at other similar joints.

17.17.00 **Application**

All metal cladding shall be fabricated and installed to ensure a neat appearance and no open ended sections of cladding shall be left uncovered. The following provisions shall also be complied with:

(a) All closures, flashings and seals required shall be provided and installed.

(b) An asphalt and craft paper moisture barrier shall be provided to the aluminium cladding for all out door applications. Such moisture barriers shall be fixed to the inner surface of the cladding or shall be cemented to the outside surface of the insulation before application of cladding.

(c) All the used in the out door cladding shall be provided with Neoprene washers.

(d) All openings and joints in outdoor cladding for piping connections, supports or access shall be suitably flashed and weather-proofed. Where such flashings or weather-proofing can not effectively control the entry of moisture, then such openings and joints shall be weather-proofed by application of aluminium pigmented sealer.

(e) Cladding on the top surfaces of the FGD, duct work and equipment shall be suitably reinforced to prevent damage by personnel walking thereon.

17.18.00 **Protection of Equipment during insulation application**

All equipment and structure shall be suitably protected from damage while applying insulation. After completion all equipment and structures shall be thoroughly cleaned of insulating materials which might have fallen on them.

**18.00.00 TYPE TEST**

18.01.00 Full scale type tests using actual equipment shall be conducted by the Contractor for the equipment mentioned in the subsequent clauses below:

18.01.01 Full range and full scale performance testing shall be conducted at shop on one number each of the following Fans as per BS 848, Part-1:

(a) Booster Fan

The performance testing at shop shall be conducted using actual fans

18.01.02 Leak tightness testing of dampers for each type and size of damper at shop to demonstrate the guaranteed gas tightness efficiency (on flow). The minimum

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| | guaranteed gas tightness efficiency of dampers shall not be less than that indicated in clause no. 3.03.08 of this Sub-Section. |
| 18.02.00 | The Bidder shall indicate the charges for each of these type tests separately in the relevant price schedule of Bid Proposal Sheet (BPS) and the same shall be considered for the evaluation of the Bids. The type test charges shall be paid only for the test(s) actually conducted successfully under this contract and upon certification by the Employer's Engineer. |
| 18.03.00 | The type tests shall be carried out in presence of the Employer's representative. Contractor shall inform the Employer about his readiness for conducting the type test and issue such notice to the Employer 30 days in advance, along with schedule of the type tests. The Contractor shall obtain the Employer's approval for the type test procedure before notifying the Employer about his readiness for conducting the type test. The type test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out. |
| 18.04.00 | Irrespective of the requirement of conducting the type tests under this contract, The Contractor shall submit the reports of the type tests carried out for the equipments listed above in clause no. 18.01.00 and These reports should be for the tests conducted on the equipment for the model / type / size / rating to those proposed to be supplied under this contract and the test(s) should have been either be conducted at an test facility/shop/independent laboratory or should have been witnessed by a client. The Employer reserves the right to waive conducting of any or all of the specified type tests under this contract, in which case the type test charges shall not be payable for the type tests waived by the Employer. |
| 18.05.00 | All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price. |

# SUB-SECTION-I-M2

# AIR CONDITIONING & VENTILATION SYSTEM

**1.00.00 GENERAL**

1.01.00 This section of specification covers details of system specifications, detailing the areas to be air conditioned, basis of design, brief description of the system, equipment and services to be furnished by bidder.

The Design, Engineering, Supply, Construction, Erection, and Testing & Commissioning of all the equipments & works listed here shall be on the basis of single point responsibility in bidder's scope of work for satisfactory completion of the system in all respect.

**2.00.00 AREAS TO BE AIR CONDITIONED**

2.01.00 The areas to be air-conditioned shall be as follows:

a) Air cooled condensing units (D-X type) type air conditioners with AHU of suitable capacity with 100 % redundancy (as per actual heat load calculation) shall be provided for FGD Control room building.

b) Cassette and Hi-wall Air-conditioners for Other auxiliary control room /control room buildings not listed above but covered in the scope of Bidder.

**3.00.00 AREAS TO BE VENTILATED**

3.01.00 (i) Modular type UAF units of suitable capacity (1x100%) shall be provided for non-air-conditioned area of FGD control room building considering design philosophy for evaporative type ventilation system mentioned in sub section-V (salient design data and sizing), Part-A of technical specification section VI. All non-air-conditioned area of FGD (cable gallery& MCC room shall be positively ventilated and exhaust shall be through gravity damper.

(ii) Mechanical Ventilation (using Roof extractors/ Supply and/or Exhaust fans) shall be provided for various other areas/buildings in the scope of bidder as under:

a) Grinding system building
b) Gypsum dewatering building
c) Recirculation pump & Oxidation blower/compressor building.

(iii) Toilets etc in above building (i) & (ii). Any other area not listed above but covered in the scope of Bidder.

(iv) For other miscellaneous areas/ buildings not listed above but covered in the scope of Bidder, mechanical type ventilation system using Supply and/or exhaust air fans/ roof exhausters shall be provided.

3.02.00 All non-air-conditioned areas covered under this package shall be ventilated by a combination of supply/exhaust fans and fresh air in-take / back draft louvers as detailed below:

| S.No | Area | Type of Ventilation system |
|---|---|---|
| (i) | General area like pump house, buildings etc | Combination of Supply air fan & Exhaust air fans |
| (ii) | MCCs and Switchgear room etc | Supply air fan & Back draft dampers |
| (iii) | Battery rooms & Oil rooms and fumes/odor generates | Combination of intake louvers & Exhaust air/ roof extractor fans. Motors shall be flame proof. |
| (iv) | Toilet/pantry etc | Propeller type exhaust air fan |

**4.00.00 EQUIPMENT DESCRIPTION – AIR CONDITIONING SYSTEM**

4.01.00 **Condensing Unit (Air-Cooled D-X type)**

Condensing unit

Type : Air cooled scroll type

Vibration isolators : Steel spring / Neoprene rubber cushy foot type with isolation efficiency not less than 85%.

Compressor

Type : The Compressor shall be scroll, serviceable, either hermetic type or semi-hermetic type with automatic capacity control (minimum 3 steps).

Type of drive : Motor driven, direct or through V-belt.

Refrigerant : The refrigerant shall be R-134a/ R-410A/R-407C or any other environment friendly refrigerant.

Accessories : High/Low pressure cutouts, oil pressure switches, relief valves, pressure gauges at each stage, lube oil and control oil pressure gauges, suction & discharge stop valves, Muffler, Crank case heaters, oil filters, magnetic oil separators, temperature indicators for lube oil/heaters, oil level indicators, safety thermostat for crank case heater, vibration isolators, etc.

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| | Motor Rating | : | 10% more than the power required by the compressor at 50 deg C design ambient temperature. |
| | Capacity | : | Minimum capacity shall be suitable for the identified/selected at evaporating temperature and condensing temperature and shall be indicated. |

4.02.00 **Air Handling Unit (AHU)**

4.02.01 Each AHU shall consist of casing, fan impeller section, cooling coil section, damper section, steel frame with anti vibration mountings (AVMs) having minimum 85% vibration dampening efficiency and flame retardant, water proof neoprene impregnated flexible connection on fan discharge. Isolation dampers at the suction and discharge of each AHU shall be provided, in case return air duct is directly connected to AHU. However, in case AHU room is used for return air, isolation dampers are required to be provided only at AHU discharge of each AHU. Pre-filter at the suction and fine (micro-vee type) and absolute (HEPA type) filters (wherever applicable) at the discharge of each individual AHU, and heater section in the common discharge of AHUs shall be provided.

4.02.02 The casing of AHUs shall be of double skin construction. Double skin sandwich panels (inside and outside) shall be fabricated using minimum 0.63 mm (24g) galvanized steel sheet (thickness of galvanization as per manufacturer's standard) , with 25mm thick polyurethane foam insulation of minimum 38 Kg/Cum density in between. Suitable reinforcements shall be provided to give structural strength to prevent any deformation/buckling.

4.02.03 Sloping condensate drain pan shall be made of minimum 1.2 mm thick Stainless Sheet Steel. It shall be isolated from bottom floor panel through 25mm thick heavy duty treated for Fire (TF) quality expanded polystyrene or polyurethane foam. Drain pan shall extend beyond the coil.

4.02.04 Cooling coil (min. 4 row deep) shall be made of seamless copper tubes with aluminium fins firmly bonded to copper tubes and shall be provided with suitable drains and vents connections.

4.02.05 All filter plenum shall be provided with a walking platform inside the plenum chamber for filter cleaning purpose. Inspection door shall be provided at the plenum chamber and a removable type ladder shall be attached to plenum.

4.02.06 **Centrifugal fan for AHU**

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| a) | Fan Type | : | Double Width Double Inlet (DWDI) Centrifugal Type |
| b) | Fan impeller | : | Backward curved blades |

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| | c) | Casing material | : | GI /Mild steel with minimum thickness of 3 mm. |
| | d) | Impeller material | : | Carbon steel |
| | e) | Shaft | : | EN 8 Steel |
| | f) | Fan bearings | : | Self aligning type, permanently lubricated, heavy duty with a design life of 10,000 operating hours. |
| | g) | Critical speed | : | First critical speed of rotating assembly shall be at least 25% above the operating speed. |
| | h) | Drive | : | Motor driven with removable belt guard. Motor driven with removable belt guard. Motor rating (at 50 deg.C ambient) shall be atleast fifteen percent (15%) above the maximum load demand of drives at the design duty point. |
| | i) | Fans | : | The fans shall be provided with V-belts and sheaves. All belts shall be sized for 150% rated HP. |

4.02.07 **Mixing Box:**

Mixing box shall be complete with fresh and return air dampers. Mixing box shall be provided whenever the return air is ducted back to the AHU. Further, wherever return air is led back directly to AHU room, no mixing box is required.

4.02.08 **Pan Humidifier:**

Pan humidifier shall be made of 22 gauge SS 304 tank, duly insulated with 25 mm thick resin bonded fiber glass insulation (min. 24 Kg/m3 density) with 0.5 mm GSS cladding. The humidifier shall be complete with stainless steel immersion heaters, safety thermostat, float valve with stainless steel ball, sight glass, overflow and drain connections, steam outlet nozzle and float switch. Step controller shall be provided for switching on / off heater banks as per system requirement.

**4.03.00 HI-WALL SPLIT/CASSETTE AIR-CONDITIONERS**

4.03.01 Hi-wall Split/cassette air conditioners shall in general consist of the following:

i) Casing

ii) Hermetically sealed rotary/scroll Compressor

iii) Condenser and condenser cooling fan

iv) Evaporator along with fan

v) Cooling coil

vi) Filters

vii) Piping, valves, refrigerant strainer, etc.

viii) Controls, instruments, control panel/starter panels.

ix) Vibration isolator pads, etc as required.

x) Refrigerant as per manufacturer practice.

4.03.02 Indoor unit of Ceiling Mounted Cassette Type Unit (Multi Flow Type):

The housing of the unit shall be powder coated galvanized steel. All the indoor units regardless of their difference in capacity should have same decorative panel size for harmonious aesthetic point of view.

Unit shall have four way supply air grills on sides and return air grill in center.

Each unit shall have high lift drain pump and very low operating sound.

4.04.00 **SPLIT/PACKAGED AIR CONDITIONERS**

**4.04.01** Split/packaged air conditioners shall in general consist of following:

I. Casing
II. Compressor
III. Condenser
IV. Evaporator and condenser cooling fan
V. Cooling Coil
VI. Filters
VII. Piping, Valves, refrigerant strainer etc.
VIII. Control, instruments, control panel/starter panels.
IX. Vibration isolator pads, ducting (if applicable) etc as required.

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| **5.00.00** | **EQUIPMENT DESCRIPTION - VENTILATION SYSTEM** |
| **5.01.00** | **Unitary Air Filtration** |
| 5.01.01 | Each modular unitary air filtration shall consist of Casing, Tanks, Fans, Distribution plates, Moisture eliminator and water repellant type nylon filter with frame and support, Header and standpipe with support, Spray and flooding type nozzle. Screen type suction strainer, Pumps, Necessary controls & Instrumentation, and all other required accessories. |
| 5.01.02 | The housing/ casing of air washer unit shall be double skin construction. Double skin panels shall be made of 22G galvanized sheet on outer side and 20G galvanized sheet inside with 25mm thick polyurethane foam insulation of minimum 38 kg/cub. Mtr. Density in between. Frame work for section shall be joined together with soft rubber gasket in between to make the joints air tight. The entire fan section shall be mounted on rolled formed GSS channel frame work. |
| 5.01.03 | The unitary air filtration tank shall be fabricated from MS plate of minimum 6 mm thick and inside and outside surface of the tank shall be spray galvanized **(minimum 60 microns DFT).** Minimum depth of the tank shall be 600 mm. Tank construction shall be such that the suction screen can be replaced while the unit is operating. Tank shall be provided with overflow, drain with valve, float valve makeup connection with a gate valve backup, quick fill connection with globe valve etc. The overflow pipe shall be connected to drain pipe after isolating valve on drain pipe. |
| 5.01.04 | The distribution plate shall be fabricated out of 18G galvanized steel sheets & galvanized steel angle supports with minimum 50% free area. |
| 5.01.05 | Unitary air filtration shall be one-bank construction. All header and stand pipes shall be galvanised. Cat walks of suitable width shall be provided for maintenance of nozzle, filter etc. |

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| 5.01.06 | The spray nozzles shall be of brass or bronze with chrome plating and shall be self cleaning type. The nozzle shall be designed to produce fine atomised spray and shall be properly spaced to give a uniform coverage of the air washer section. The pressure drop through the nozzle should be in the range of 1.4 to 2.4 Kg/cm2. |
| 5.01.07 | The eliminator plates shall be of 24G thick GS sheets class 275 or from 100% virgin PVC of minimum finished thickness of 2 mm. The eliminator section made of GSS shall have minimum six bends. The PVC eliminators shall be UV stabilised using Titanium di-oxide and shall withstand the weathering test as per IS:4892 for 500 hrs. Type test report of the compound testing carried out in any reputed laboratory shall be submitted for approval. All supports, tie rods and space bar shall be of either galvanised steel or PVC construction and shall be complete with suitable drip tray and drain pipe. |
| 5.01.08 | Air tight inspection doors of suitable size shall be provided for suction chamber. Spray chamber and fan suction for easy accessibility and maintenance and a water marine light be provided for each unitary air filtration. |
| 5.01.09 | Suitable number of brass screen shall be provided in the air washer tank to arrest the dirt entering the circulating water pump suction. Suitable GI grid shall be used inside the screen for reinforcement. |
| 5.01.10 | The specification for centrifugal fans shall generally be as indicated below. However, the fan shall be of DIDW type for UAF unit. |
| 5.01.11 | Saturation efficiency of Unitary Air Filtration units shall be minimum 60%. |
| **5.02.00** | **Centrifugal Fan** |
| 5.02.01 | The casing shall be of welded construction fabricated with heavy gauge galvanised sheet steel or MS sheet with spray galvanization (**minimum** 60 micron DFT). The minimum thickness of casing shall be 3 mm. It shall be rigidly reinforced and supported by structural angles. The seams shall be permanently sealed air-tight. Split casings shall be provided on larger sizes of fans. Casing drain with valves shall be provided wherever required.<br><br>The impeller shall have die-formed backward-curved blades tie welded to the rim and back plate to have a non overloading characteristic of the fan. Rim shall be spun to have a smooth contour. If required intermediate stiffening rings shall be provided. Shaft sleeves shall be furnished wherever required. The impeller, pulley and shaft sleeves shall be secured to the shaft by key and/or nuts. |
| 5.02.02 | The bearing shall be self aligning, heavy duly ball, roller or sleeve bearing. They shall be adequately supported. They shall be easily accessible and lubricated properly from outside. |
| 5.02.03 | Inlet guard shall be spun to have a smooth contour. Inlet screen, if provided, shall be of galvanised wire mesh of 25 mm square. |
| 5.02.04 | Base plate with necessary number of spring type vibration isolators or ribbed neoprene rubber pad or cushy foot mounting shall be provided. The vibration isolators should have a minimum of 70% efficiency. |

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| 5.02.05 | The first critical speed of the rotating assembly shall be at least 25% above the opening speed. |
| 5.02.06 | The fans shall be provided with V-belts and sheaves. All belts shall be sized for 150% rated HP. All V-belt shall be equipped with removable belt guards that do not impede the air flow to the fan inlet. There shall be a minimum of two belts per drive. Motor rating (at 50 deg.C ambient) shall be atleast fifteen percent (15%) above the maximum load demand of drives at the design duty point. |
| **5.03.0** type. | **Roof Ventilators (If applicable)**5.03.01 The roof extractors shall be "COWL" |
| 5.03.02 | Impeller shall be of axial flow type, cast Aluminium in one piece and dynamically balanced. Casing shall be heavy gauge sheet steel construction of 3 mm thick for impeller upto 750 mm diameter and 5 mm for fans with impeller of diameter 750 and above. In casing, access door with locking arrangement be provided. |
| 5.03.03 | The cowl shall be designed for weather protection of the fan also inside of the roof on which the extractor is installed. Galvanised bird screen of 15 mm Square be provided with the cowl. All accessories, steel supports as required will be provided. |
| 5.03.04 | The speed of the fan be limited as per limitation given above for axial fans. |
| 5.03.05 | All accessories rain protection exhaust hood, transformation piece, vibration isolators, steel supports vibration isolators, bird screen, etc. as required shall be provided. |
| 5.03.06 | The vibration level for fans shall be as per ISO: 14694. |
| **5.04.00** | **Centrifugal Pumps** |

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| a) | Type | : | Horizontal Centrifugal, Axially or radial split type casing pump or end suction, top discharge horizontal centrifugal pump |
| b) | Impeller | : | Closed type |
| c) | Material of Construction | | |
| | i) Casing | : | 2% Ni Cast Iron : IS:210 Gr. FG-260 |
| | ii) Impeller | : | Bronze IS:318 Gr-2 |
| | iii) Wearing rings | : | Bronze |
| | iv) Shaft | : | SS 316 |
| | v) Shaft sleeve | : | SS 316 |
| | vi) Lantern ring | : | Brass / Bronze |

| | | | |
|---|---|---|---|
| | vii) Packing | : | Asbestos free |
| | viii) Base Plate | : | Carbon steel as per IS:2062 |
| | ix) Speed | : | Maximum 1500 rpm |
| | x) Other requirements | : | To refer to **Annexure-I** titled "Horizontal Pumps" of this sub section. |

**5.05.0 Axial Fans**

5.05.01 These fans shall have fixed / variable pitch cast aluminum blades of aerofoil design.

5.05.02 The fan casing shall be of heavy gauge sheet steel construction.

5.05.03 Necessary rain protection cowl, inlet and outlet cones, bird protection screen, adjustable damper, vibration isolators, back draft dampers etc. shall be provided.

5.05.04 The speed of the fan shall not exceed 960 rpm for fan with impeller diameter above 450 mm and 1400 rpm for fan with impeller diameter 450 mm or less. However for fans having static pressure of 30 mm WC or above the speed of the fan shall not exceed 1440 rpm for fan with impeller diameter of above 450 mm and 2800 rpm for fan with impeller diameter of 450 mm or less. The first critical speed of rotating assembly shall be atleast 25% above the operating speed.

5.05.05 All other accessories like supporting structure etc. as required shall be provided.

5.05.06 Fans of capacity 1000 $m^3$/hr & lower shall be of propeller exhaust type.

**6.00.00 BALANCE EQUIPMENT SPECIFICATION**

6.01.00 **Material of Construction for Piping & Fittings**

| | | | |
|---|---|---|---|
| a) | Piping for Chilled and Condenser water lines | : | Heavy grade-IS:1239 or Equivalent upto150 NB and IS:3589 or Equivalent for pipes beyond 200 NB with thickness as indicated in **Annexure-II** |
| b) | Refrigerant piping : | : | Seamless steel tubes conforming heavy grade IS:1239 or copper tubes as per IS:2501 (copper material as per IS:191 hard copper grade). |
| c) | Drain piping | : | Same as (a) above & galvanized as per IS:4736. |

| | |
|---|---|
| | d) Fittings : 1) The steel fittings shall conform to ASTM A234 Gr. WPB and dimensional standard to ANSI B 16.9/ANSI B16.11 / equivalent for sizes 65 NB and above.<br>2) For sizes 50 NB and below, the material shall conform to ASTM A-105.<br>3) All steel flanges shall be of slip on type and shall conform to ANSI B 16.5<br>4) For pipe sizes above 350 NB, fabricated fittings from sheets of adequate thickness may be used. The bend radius in case of mitre bends shall be minimum 1.5 times the nominal pipe diameter and angle between two adjacent sections shall not be more than 22.5 deg and shall be as per BS:2633/BS:534.<br>5) Fittings, flanges and pipe joints of refrigerant piping shall conform to ANSI B31.5 |
| 6.02.00 | **VALVES** |
| 6.02.01 | Valves shall have full sizes port and suitable for horizontal and as well as vertical installation. |
| 6.02.02 | Valves for regulating duty shall be of globe type suitable for controlling throughout its lift. |
| 6.02.03 | All safety /relief valves shall be so constructed that the failure of any part does not obstruct the free discharge. |
| 6.02.04 | Valves shall be furnished with back seating arrangement for repacking while working under full working pressure. |
| 6.02.05 | Manual gear operators be provided for valves of size 200 NB and above. |
| 6.02.06 | All valves shall be supplied with companion flanges, nut, bolts & washers, etc. |
| 6.02.07 | The refrigerant line valves shall have steel or brass body with TEFLON gland packing. The construction of disc shall be either globe or angle type. The valve seat shall have white metal lining or equivalent. |
| 6.02.08 | Gate valves shall be of Cast Iron body (confirming to IS:210 Gr FG 220/equivalent) for sizes 65 NB and above conforming to fIS :14846. Gun Metal construction for |

sizes less than 65NB shall be as per IS:778. Butterfly valves shall conform to latest revision of BS:5155 or equivalent standard of required class/rating.

6.03.00 **AIR FILTERS**

6.03.01 **Pre Filter**

1) Type : Flange / Cassette

2) Pre-filter shall contain washable non-woven synthetic fiber or High density Polyethylene (HDPE) media having 18G GSS / 16G Al alloy frame. The filter media shall be supported with HDPE mesh on air inlet side & Aluminium expanded metal on exit side or G.I. wire mesh on both sides.

3) **Other requirements : (as applicable)**

   a) Suitable aluminium spacers be provided for uniform air flow;

   b) Casing shall be provided with neoprene sponge rubber sealing.

   c) Capable of being cleaned by water flushing.

   d) Density of filter medium shall increase in the direction of air flow in case of metallic filter.

   e) Filter media shall be fire retardant and resistant to moisture, fungi, bacteria & frost.

4) **Efficiency :**

   Average arrestance of 65 - 80 % when tested in accordance with BS:6540/ASHRAE – 52 – 76 / EN-779.

5) Minimum thickness : 50 mm

6) Face Velocity : Not more than 2.5 m/sec.

7) Pressure drop : Initial pressure drop - Not to exceed 5.0 mm WC at rated flow.

   Final pressure drop - Upto 7.5 mm WC.

8) Location : a) At the suction of each AHUs

   : b) At the suction of each Fresh air fan

6.03.02 **Fine Filters (Microvee type)**

1) Type : Flange / Cassette

2) Fine filter shall contain washable non-woven synthetic fibre or High density Polyethylene (HDPE) media having 18G GSS / 16G Al alloy frame. The filter media shall be supported with HDPE mesh on air inlet side & Aluminium expanded metal on exit side or G.I. wire mesh on both sides.

3) Other requirements :
   a) A neoprene sponge rubber sealing shall be provided on either face of the filter frame.
   b) Capable of being cleaned by air or water flushing.
   c) Filter media shall be fire retardant and resistant to moisture, fungi, bacteria & frost.

4) Efficiency : Average arrestance > 90% when tested in accordance with BS:6540/ASHRAE–52-76 / EN-779.

5) Minimum thickness : 150 mm or 300 mm.

6) Face Velocity : Not more than 1.2 m/sec for 150 mm and not more than 2.4 m/sec. for 300 mm.

7) Pressure drop : Initial pressure drop - Not to exceed 10 mm WC at rated flow ; Final pressure drop-Up to 25 mm WC.

8) Location : i) At the discharge of each individual AHU.
   ii) At the discharge of each Fresh air fan.

6.04.00 **LOW PRESSURE AIR DISTRIBUTION SYSTEM**

6.04.01 Material of air distribution system shall be through galvanized steel sheet (Conforming to Class 275 of IS :277) or Aluminium alloy (grade 19000 / SIC or 3100 / NS3 of IS:737). GI Sheets should be galvanized and galvanizing shall be of 275 gms/sq.m. (total coating on both sides) both for site fabricated and factory fabricated ducts.

6.04.02 **Thickness of rectangular ducts shall be as follows:**

| Larger Dimension of duct (mm) | Thickness of GI sheet(mm) | Thickness of Aluminium sheet (mm) |
|---|---|---|
| up to 750 mm | 0.63 (24 G) | 0.80 |

| | | | |
|---|---|---|---|
| | 751 to 1500 | 0.80 (22 G) | 1.00 |
| | 1501 to 2250 | 1.00 (20 G) | 1.50 |
| | 2251 & above | 1.25 (18 G) | 1.80 |

6.04.03 **Thickness of round ducts shall be as follows:**

| Diameter of Round duct (mm) | Thickness of GI sheet(mm) | Thickness of Aluminium sheet (mm) |
|---|---|---|
| 150 to 500 | 0.63 | 0.80 |
| 501 to 750 | 0.80 | 1.00 |
| 751 to 1000 | 0.80 | 1.00 |
| 1001 to 1250 | 1.00 | 1.50 |
| 1251 & above | 1.25 | 1.80 |

6.04.04 **Duct Fabrication and Supports:**

a) Duct fabrication shall be as per the latest relevant BIS/SMACNA standard.

b) Ducts for A/C system may be **site fabricated or factory fabricated**.

c) The ducts routed inside the buildings with larger side greater than 2250 mm shall be supported by 16mm MS rods and 50x50x3 mm MS double Angles while those below 2250 mm shall be supported by 10mm MS Rods and 40x40x3 MS angles. The duct supports shall be at a distance of not more than 2000 mm for A/C system. The MS rods for these ducts routed inside the building shall be hung from the existing floor beams/wall beams/roof beams/columns with provision of necessary auxiliary or special steel members or by hooks or can be provided by dash fasteners fixed to the ceiling slab. No supports shall be taken from horizontal/vertical bracings of the structures. All items of duct support including MS rods, MS angles and double angles, auxiliary or special steel members, hooks, dash fasteners coach screws and all other supporting material required shall be provided by the bidder. Where ever ducts are running outside the building and or at locations where it is not possible to support the ducts from ceiling/floor due to non-availability of the same, the base steel frame/truss work and other auxiliary steel members, hooks, rods, etc. for supporting the duct work shall also be provided by the Bidder.

d) Where the sheet metal duct connects to the intake or discharge of fan units a flexible connection of fire retarding, at least 150 mm width shall be provided of closely woven, rubber impregnated double layer asbestos/canvas or neoprene coated fibre glass.

e) All curves, bends, off-sets and other transformations shall be made for easy and noiseless flow of air. The throat of every branch duct shall be sized to have the same velocity as in the main duct to which the branch duct is connected.

f) Wherever duct passes through a wall, the opening between masonry and duct work shall be neatly caulked or sealed to prevent movement of air from one space to the adjoining space.

g) Wherever pipe hangers or rods pass through the ducts, light and streamline easement around the same shall be provided to maintain smooth flow of air.

h) Access doors shall be provided in the duct work or casing on the both sides of the equipment to be serviced. All access doors shall be of adequate size and shall be lined with substantial felt edging to prevent air leakage. Access doors shall be of built up construction, structurally strong and each shall have at least two hinges. Access doors shall have two rust proof window sash of approved type. All doors shall be set so as to flush with insulation or plaster finish on the duct.

6.04.05 Splitters and dampers shall be provided for equipment/area isolation and for proportional volume control of system. The same shall be minimum 16 gauge GS sheet of quadrant type with suitable locking device, mounted outside of duct in accessible position.

6.04.06 **Factory fabricated ducts :**

i) All ducting shall be fabricated of LFQ (Lock Forming Quality) grade prime G.I.

ii) Unless otherwise specified here, the construction, erection, testing and performance of the ducting system shall conform to the SMACNA-1995 standards ("HVAC Duct Construction Standards-Metal and Flexible-Second Edition-1995" SMACNA)

iii) All ductwork including straight sections, tapers, elbows, branches, show pieces, collars, terminal boxes and other transformation pieces must be factory fabricated by utilizing the machines and processes as specified in SMACNA or by equivalent technology. In equivalent method, the fabrication shall be done by utilizing the following machines and process to provide the requisite quality of ducts and speed of supply:

a) Coil lines to ensure location of longitudinal seams at corners/folded edges only to obtain the required duct rigidity and low leakage characteristics. No longitudinal seams permitted along any face side of the duct.

b) All ducts, transformation pieces and fittings to be made on CNC profile cutters for required accuracy of dimensions, location and dimensions of notches at the folding lines.

c) All edges to be machine treated using lock formers, flangers and roll-bending for turning up edges.

d) Sealant dispensing equipment should be used for applying built-in sealant in Pittsburgh lock where sealing of longitudinal joints are specified. Sealing of longitudinal joint is compulsory for the ducts over 2" w.g. static pressure

iv) All transverse connectors shall be 4-bolt slip-on flange system with built-in sealant, if any. To avoid any leakage additional sealant shall be used.

v) Factory fabricated ducts shall have the thickness of the sheet as follows:

| Sl.No. | **Size of Duct** | **Sheet Thickness** |
|---|---|---|
| i) | upto 750 mm | 0.63 mm |
| ii) | 751 mm to 1500 mm | 0.80 mm |
| iii) | 1501 mm to 2250 mm | 1.00 mm |
| iv) | 2251 mm and above | 1.25 mm |

**6.05.00 Diffusers, Grills & Dampers :**

6.05.01 Supply air diffusers/grills with factory fitted volume control dampers be provided for all air-conditioned areas.

6.05.02 Return air diffusers of air-conditioned areas shall be without volume control dampers.

6.05.03 The diffusers/grills shall be of extruded Aluminum of minimum 1.2 mm thick with powder coating. The colour of power coating shall be as per the interior décor.

6.05.04 Supply air grills shall be of double deflection type and return air grills shall be of single deflection type.

6.05.05 All volume control (VC) damper shall be operated by a key from the front of the grills/diffusers and shall be of GI sheet.

6.05.06 The thickness of VC dampers shall be of minimum 20 gauge and thickness of louvers shall be of minimum 22 gauge.

6.05.07 Suitable vanes shall be provided in the duct collar to have uniform and proper air distribution. Bank of Baffles wherever required shall also be provided.

6.05.08 Fire dampers shall be motor operated type and shall have fire rating of minimum 90 minutes.

6.05.09 All plenum chambers of connections to fans, dampers etc shall be constructed in 18 gauge GS sheet and supported on MS angle frames.

6.05.10 All ducting surfaces coming in contact with corrosive fumes or gases shall be painted with three coats of epoxy paint over a coat of suitable primer.

**6.06.0 Thermal and Acoustic Insulation**

**6.06.01 A) Application with Glass Wool / Rockwool**

(i) All surfaces to be insulated both thermally and acoustically shall be thoroughly cleaned, dried and an adhesive (CPRX compound of Shalimar Tar Products / Loid bond 83 or Equivalent) be applied @ 1.5 Kg /Sqm on the surface.

(ii) Insulation material (either expanded polystyrene foam or Glass Wool/ Glass fiber / Rockwool) shall be struck to the surface. All the joints shall be sealed with bitumen.

(iii) Insulation mass to be covered with 500 gauge polythene sheet with 50 mm overlaps and sealing all joints on hot side or alternatively aluminum foil can be used which can come as lamination over insulation.

(iv) Insulation Finish of types specified under shall be provided thereafter..

**B) Application with Nitrile Rubber**

(i) All surfaces to be insulated shall be properly cleaned.

(ii) A suitable adhesive such as SR 998 or equivalent shall be applied over the surfaces to be insulated and insulation material surfaces.

(iii) Insulating material shall than be pasted onto the surfaces in a manner to avoid stretching and any air entrapment within.

(iv) Two layers of Glass Cloth with a suitable adhesive as SR 998 or equivalent shall be then applied over the insulating material to avoid surface weathering.

**C) Application with Polyurethane Foam & Polyisocyanurate Foam**

i) All surfaces to be insulated shall be cleaned.

ii) A suitable adhesive such as CPRX or Loid Bond 83 or equivalent shall be applied over the surface to be insulated and insulation material surfaces.

iii) Insulating material with aluminum foil lamination shall then be pasted onto the surface in a manner to avoid stretching and any air entrapment within.

iv) Two layers of Glass Cloth with a suitable adhesive as Loid Bond 130 shall be then applied over the insulating material, to avoid surface weathering.

v) Insulation Finish of types specified under shall be provided thereafter.

**6.06.02** **Type of Insulation & Finish**

| Sl. No. | Surface | Insulation Material | Insulation Form | Thick (mm) | Finish (mm) |
|---|---|---|---|---|---|
| 1. | Supply & return air duct of AC System | Resin bonded glass wool or | Roll /Slab | 50 | F-3 |
| | | Closed Cell Elastomeric Nitrile Rubber | sheet | 19 | As per manufacturer std. |
| | | or Polyisocyanurate Foam | Slab | 30 | F-3 |
| 2. | Refrigerant (Suction and liquid lines) | Closed Cell Elastomeric Nitrile Rubber | tube | 19 | As per manufacturer std. |
| | | or Rigid Polyurethane Foam | Pipe Section | 50 | F-1 (a) |
| 3. | AHU drain pipe | Closed Cell Elastomeric Nitrile Rubber | tube | 19 | As per manufacturer std. |
| | | or Rigid Polyurethane Foam | Pipe Section | 50 | F-1 (a) |
| 4. | AHU condensate pan (insulation if required) | Mineral wool or resin bonded glass wool | Slab | 25 | As per manufacturer std. |
| 5. | Chilled water piping, valves & specialties | Resin bonded Mineral wool or resin bonded glass wool | Pipe section | 75 | F-1/F-3 |

| Sl. No. | Surface | Insulation Material | Insulation Form | Thick (mm) | Finish (mm) |
|---|---|---|---|---|---|
| | | or<br>Rigid Polyurethane Foam | Pipe Section | 50 | F-3 |
| 6. | Chiller (insulation if required) | ---------- As per manufacturer std.---------- | | | |
| 7. | Chilled water pumps | Resin bonded Rockwool wool or resin bonded glass wool | Slab | 75 | F-1/ F-3 |
| | | or<br>Rigid Polyurethane Foam | Slab | 50 | F-3 |
| 8. | Expansion tank with associated piping | Resin bonded Rockwool wool or resin bonded glass wool | Slab/ Pipe section | 75 | F-1/ F-3 |
| | | or<br>Rigid Polyurethane Foam | Slab | 50 | F-3 |
| 9. | Acoustic insulation of duct | Resin bonded Glass wool | Slab | 25 | As per specifications |
| 10. | Exposed air duct | Resin bonded Glass wool/Rockwool | Roll/Slab | 50 | F-4 |
| | | or<br>Polyisocyanurate Foam | Slab | 50 | F-4(a) |

6.06.03 **Specification for insulation shall be as follows: -**

| Insulation Material | Code | Thermal conductivity (w/m/$^{o}$C | Density Kg/m$^3$ |
|---|---|---|---|
| Resin bonded glass wool | IS:8183 | 0.049 at 50$^{o}$C<br><br>0.043 at 50$^{o}$C | i) 24 (For Glass wool)<br>ii) 48 (For Rockwool)<br>iii) 48(For acoustic insulation) |
| Mineral wool pipe section. Min.Gr.2 | IS:9842 | 0.043 at 50$^{o}$C | 144 |
| Closed Cell Elastomeric Nitrile Rubber | | 0.036 at 20$^{o}$C | 40 – 60 |
| Polyurethane Foam<br><br>Polyisocyanurate Foam | IS12436 | 0.03 at 50 $^{o}$C<br><br>0.03 at 50 $^{o}$C | 34 $\pm$ 2<br><br>34 $\pm$ 2 |
| Note : Insulation used for HVAC application shall be CFC/HCFC free | | | |

6.06.04 **The specification for various finishes shall be as follows**

| | |
|---|---|
| a) | **Finish F-1 ( with Resin Bonded Glass Wool/Resin Bonded Mineral Wool)** |
| | Step-1 Wrapping of Poly-Bonded Hessain (PBH – to act as vapour seal) on outer surface of insulation with 50 mm overlap stitching and sealing of overlap with synthetic adhesive like CPRX or Equivalent compound. |
| | Step-2 The surface then shall be wrapped with 19 mm mesh 24 SWG GI wire netting, butting all the joints and laced down with 22 SWG lacing wire. |
| | Step-3 Sand cement (4:1) plaster shall be applied in two layers totalling to 12.5 mm thick, the second layer being brought to a smooth finish. A water proofing compound shall be added to the cement before its application. |

| | |
|---|---|
| aa) | **Finish F-1(a) (With Polyurethane Foam & Polyisocyanurate Foam)**<br>Wrapping of two layers of 7 mil 10 x 10 mesh glass cloth dipped in suitable adhesive such as SR 998 or Loid Bond 130 equivalent |
| b) | **Finish F-2**<br>Step-1 Insulation shall be covered with 500g polythene with 50mm overlap and sealing of overlap with synthetic adhesive like CPRX/ Loid Bond 83 or Equivalent compound. |
| | Step-2 Same as Step-2 of Finish F-1 above. |
| | Step-3 Same as Step-3 of Finish F-1 above. |
| c) | **Finish F-3**<br>Step-1 Same as Step-1 of Finish F-2 above |
| | Step-2 The polythene shall be covered with 26 gauge Aluminium sheet and locking of joints with self-locking screws at a pitch of minimum 100 mm. |
| d) | **Finish F-4**<br>Step-1 Same as Step-1 of Finish F-1 above.<br>Step-2 Same as Step-2 of Finish F-1 above.<br>Step-3 Same as Step-3 of Finish F-1 above.<br>Step-4 Application of 3 mm thick coat of suitable water proofing compound and wrapped with fibre glass RP tissue followed by final coat of 3 mm thick water proofing compound over the RP tissue.<br>Step-5 After the above treatment, 22G Aluminium sheet cladding, properly stiched at all joints shall be provided over the external surface. |
| dd) | **Finish F-4(a) (With FR Closed Cell Chemically Cross Linked Polyethylene)**<br>Application of aluminium sheet 22G cladding to be provided over the XLPE insulating material. Cladding sheet is held in position with SDST screws @ 150 mm C/c over tongue-in-groove joints applied with a felt for sealing joint against water ingress.<br>All sheet joints to be done in a manner to shed water. |

6.06.05 For all inspection covers and hatches on equipment, pump casing, valve bodies and flanges (100 mm and above), insulation shall be applied so as to facilitate removal without minimum damage to the insulation by encasing the insulation in 24 gauge GI box or 22 gauge Aluminium sheet metal boxes which are bolted together around the equipment. However continuity of the vapour seal between the static and removable portions of the insulation is to be maintained.

6.06.06 **ACOUSTIC INSULATION**

a) All ducts up to a distance of 5 meters from AHU shall be acoustically lined from inside with 25 mm thick resin bonded glass wool of 48 Kg/Cu.M. density and 30 gauge perforated aluminium sheet having 5 mm dia perforation at 8 to 10 mm centre-to-centre distance. Insulation shall be fixed on wooden frame of 600 x 600 mm dimension.

b) Fibre glass tissue sheet shall be applied over the outer surface of insulation before applying perforated aluminium sheet. Application of acoustic insulation shall be inline with the requirements specified above.

**7.00.00 PLANT CONTROL**

7.01.00 Brief scheme of controlling the operation is described below. Detailed description of the control system for safe and efficient operation of the plant shall be elaborated, got approved from employer. The descriptions in the sub-sections of the control & instrument sections shall also be referred to.

7.02.00 **Control Scheme for Air-Conditioning System**

7.02.01 Contractor shall provide microprocessor/PLC/GIU based control system for control and monitoring of air conditioning and ventilation system as per manufacturer's standard practice. Control and monitoring of air conditioning and ventilation system from FGD control system is also acceptable.

7.03.00 **Air Handling Unit**

a) Humidity sensor and gyserstat located in the return air duct shall actuate the PAN humidifier to obtain the desired degree of humidification.

b) Humidity and temp. sensor shall be provided and interlocked in steps with winter heater / re-heater / strip heaters for monsoon and winter re-heating or heating as the case may be.

c) Heater banks shall be interlocked with the running of AHU, temperature of return air, humidity of return air and safety thermostat (airstat - located in front of the each heater in the supply air duct)

d) AHU shall be started either locally or from the main control room of AC system by means of Remote / Manual selection facility.

e) The closure of fire dampers, automatic tripping of AHU fans and fresh air fans shall be interlocked with Fire Detection System.

7.05.00 **Cassette /Hi-wall Split Air Conditioners**

Control and interlocks for these type of units shall be as per manufacturer's standard practice.

7.06.00 **Miscellaneous Control Requirements**

a) The fans (both supply and exhaust fans) associated with mechanical ventilation system shall be operated locally.

b) Relative humidity and temperature measurement of all control rooms and all major air-conditioned areas shall made be available in FGD control system.

**8.00.00 PAINTING:**

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

8.02.00 The surfaces of stainless steel, Galvanized steel, Gunmetal, brass, bronze and non-metallic components shall not be applied with any painting. The Contractor shall clean the external surfaces and internal surfaces before Erection by wire brushing and air blowing. The steel surface to be applied with painting shall be thoroughly cleaned before applying painting by brushing, shot blasting, etc. as per the agreed procedure.

8.03.00 For all the steel surfaces (external) exposed to atmosphere (outdoor installation), one(1) coat of red oxide primer of thickness 30 to 35 microns followed up with three (3) coats of synthetic enamel paint, with 25 microns as thickness of each coat, shall be applied.

8.04.00 For all the steel surfaces inside the building (indoor installation), One (1) Coat of red oxide primer of thickness 30 to 35 microns followed up with two (2) coats synthetic enamel paint, with 25 microns as thickness of each coat shall be applied.

8.05.00 For centrifugal fans - Casing shall have hot dip/ spray galvanization (**minimum** 60 micron DFT).

8.06.00 However, for all parts coming in contact with acid fumes (in Battery rooms), a coat of epoxy resin based zinc phosphate primer of minimum thickness 30 to 35 microns followed up with undercoat of epoxy resin based paint pigmented with Titanium dioxide of minimum thickness of 25 microns shall be applied and a top coat consisting of one coat of epoxy paint of approved shade and colour with glossy finish of minimum thickness of 25 microns.

**9.00.00 CODES & STANDARDS**

9.01.00 The design, manufacture and performance of equipment shall comply with all currently applicable statues, regulations and safety codes in the locality where the

| | |
|---|---|
| | equipments are to be installed. Nothing in this specification shall be considered to relieve the bidder of this responsibility. |
| 9.02.00 | Unless otherwise specified, equipment shall conform to the latest applicable Indian or IEC standard. Equipment complying with other authoritative standards such as British, USA, ASHRAE etc. will also be considered if it ensures performance equivalent or superior to Indian Standard. |

**Annexure –I**

## GENERAL SPECIFICATION FOR HORIZONTAL PUMPS

1) **SCOPE**

This specification covers the design, material, construction features, manufacture, inspection, testing the performance at the Vendor's/Sub-Vendor's Works and delivery to site of Horizontal Centrifugal Pumps.

2) **CODES AND STANDARDS**

The design, material, construction, manufacture inspection and performance testing of Horizontal Centrifugal Pumps shall comply with all currently applicable statutes, regulations and safety codes in the locality where the Equipment will be installed. Nothing in these specifications shall be construed to relieve the Vendor of this responsibility. The Equipment supplied shall comply with the latest applicable Indian Standards listed below. Other National Standards are acceptable, if they are established to be equal or superior to the Indian Standards.

3) List of Applicable Standards.

IS : 1520 : Horizontal Centrifugal Pumps for clear cold fresh water

IS : 5120 : Technical requirements of roto dynamic special purpose pumps

API : 610 : Centrifugal pumps for general refinery service.

IS : 5639 : Pumps Handling Chemicals & corrosion liquids

IS : 5659 : Pumps for process water

HIS : Hydraulic Institute Standards, USA

ASTM-1-165-65 Standards Methods for Liquid Penetration Inspection.

In case of any contradiction with aforesaid standards and the stipulations as per the technical specifications as specified hereinafter the stipulations of the technical specifications shall prevail.

4) **DESIGN REQUIREMENTS**

a) The Pump shall be capable of developing the required total head at rated capacity for continuous operation. Also the pumps shall be capable of being operated to give satisfactory performance at any point on the HQ characteristics curve. The operating range of the pump shall be 40% to 120% of the duty point unless otherwise mentioned elsewhere. The maximum efficiency of pump shall preferably be within ± 10% of the rated design flow as indicated in data sheets.

b) The total head capacity curve shall be continuously rising from the operating point towards shut-off without any zone of instability and with a minimum shut-off head of about 15% more than the design head.

**Annexure –I**

c) Pumps of a particular category shall be identical and shall be suitable for parallel operation with equal load division. The head Vs capacity and BHP Vs capacity characteristics should match to ensure even load sharing and trouble free operation throughout the range. Components of identical pumps shall be interchangeable.

d) Pumps shall run smoothly without undue noise and vibration. Peak to peak vibration limits shall be restricted to the following values during operation:

| Speed | Antifriction Bearing | Sleeve Bearing |
|---|---|---|
| 1500 rpm and below | 75.0 micron | 75.0 micron |
| 3000 rpm | 50.0 micron | 65.0 micron |

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.

e) The pumps shall be capable of starting with discharge valve fully open and close condition. Motors shall be selected to suit to the above requirements. Continuous Motor rating (at 50 deg.C ambient) shall be atleast ten percent (10%) above the maximum load demand of the pump in the entire operating range to take care of the system frequency variation and no case less than the maximum power requirement at any condition of the entire characteristic curve of the pump.

f) The kW rating of the drive unit shall be based on continuously driving the connected equipment for the conditions specified. However, in cases where parallel operation of the pumps are specified, the actual motor rating is to be selected by the Bidder considering overloading of the pumps in the event of tripping of operating pump(s).

g) Pumps shall be so designed that pump impellers and other accessories of the pumps are not damaged due to flow reversal.

h) The Contractor under this specification shall assume full responsibility in the operation of pump and motor as a unit.

5) **DESIGN CONSTRUCTION**

a) Design and construction of various components of the pumps shall conform to the following general specifications. For material of construction of the components, data sheets shall be referred to.

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b) **Pump Casing**

Pump casing shall have axially or radially split type construction as specified. The casing shall be designed to withstand the maximum shut-off pressure developed by the pump at the pumping temperature.

Pump casing shall be provided with a vent connection and piping with fittings & valves. Casing drain as required shall be provided complete with drain valves, piping and plugs. It shall be provided with a connection for suction and discharge pressure gauge as standard feature. It shall be structurally sound to provide housing for the pump assembly and shall be designed hydraulically to minimum radial load at part load operation.

c) **Impeller**

Impeller shall be closed, semi-closed or open type as specified elsewhere and designed in conformance with the detailed analysis of the liquid being handled.

The impeller shall be secured to the shaft, and shall be retained against circumferential movement by keying, pinning or lock rings. On pumps with overhung shaft, impellers shall be secured to the shaft by a lockout or cap screw which tightness in the direction of normal rotation.

d) **Impeller/Casing Wearing Rings**

Replaceable type wearing rings shall be provided at suitable locations of pumps. Suitable method of locking the wearing ring shall be used. Wearing rings shall be provided in pump casing and/or impeller as per manufacturer's standard practice.

e) **Shaft**

The critical speed shall be well away from the operating speed and in no case less than 130% of the rated speed.

The shaft shall be ground and polished to final dimensions and shall be adequately sized to withstand all stresses from rotor weight, hydraulic loads, vibration and torques coming in during operation.

f) **Shaft Sleeves**

Renewable type fine finished shaft sleeves shall be provided at the stuffing boxes/mechanical seals. Length of the shaft sleeves must extend beyond the outer faces of gland packing of seal end plates so as to distinguish between the leakage between shaft and shaft sleeve and that past the seals/gland.

Shaft sleeves shall be fastened to the shaft to prevent any leakage or loosening. Shaft and shaft sleeve assembly should ensure concentric rotation.

**Annexure –I**

g) **Bearings**

Heavy duty bearings, adequately designed for the type of service specified in the enclosed pump data sheet and for long, trouble free operation shall be furnished.

The bearings offered shall be capable of taking both the radial and axial thrust coming into play during operation. In case, sleeve bearings are offered additional thrust bearings shall be provided. Antifriction bearings of standard type, if provided, shall be selected for a minimum life 20,000 hrs. of continuous operation at maximum axial and radial loads and rated speed.

Proper lubricating arrangement for the bearings shall be provided. The design shall be such that the bearing lubricating element does not contaminate the liquid pumped. Where there is a possibility of liquid entering the bearings suitable arrangement in the form of deflectors or any other suitable arrangement must be provided ahead of bearings assembly.

Bearings shall be easily accessible without disturbing the pump assembly. A drain plug shall be provided at the bottom of each bearings housing.

h) **Stuffing Boxes**

Stuffing box design should permit replacement of packing without removing any part other than the gland.

Stuffing boxes of packed ring construction type shall be provided wherever specified. Packed ring stuffing boxes shall be properly lubricated and sealed as per service requirements and manufacturer's standards. If external gland sealing is required, it shall be done from the pump discharge. The Bidder shall provide the necessary piping valves, fittings etc. for the gland sealing connection.

i) **Mechanical Seals**

Wherever specified in pump data sheet, mechanical seals shall be provided. Unless otherwise recommended by the tenderer, mechanical seals shall be of single type with either sliding gasket or bellows between the axially moving face and shaft sleeves or any other suitable type. The sealing faces should be highly lapped surfaces of materials known for their low frictional coefficient and resistance to corrosion against the liquid being pumped.

j) The pump supplier shall coordinate with the seal maker in establishing the seal chamber of circulation rate for maintaining a stable film at the seal face. The seal piping system shall form an integral part of the pump assembly. For the seals under vacuum service, the seal design must ensure sealing against atmospheric pressure even when the pumps are not operating. Necessary provision for seal water supply along with complete piping fittings and valves as required shall form integral part of pump supply.

**Annexure –I**

k) **Pump Shaft Motor Shaft Coupling**

The pump and motor shafts shall be connected with an adequately sized flexible coupling of proven design with a spacer to facilitate dismantling of the pump without disturbing the motor. Necessary coupling guards shall also be provided.

l) **Base Plate**

A common base plate mounting both for the pump and motor shall be furnished. The base plate shall be fabricated steel and of rigid construction, suitably ribbed and reinforced. Base plate and pump supports shall be so constructed and the piping unit so mounted as to minimize misalignment caused by mechanical forces such as normal piping strain, internal differential thermal expansion and hydraulic piping thrust. Suitable drain troughs and drip lip shall be provided.

m) **Assembly and Dismantling**

Assembly and dismantling of each pump with drive motor shall be possible without disturbing the grouting base plate or alignment.

n) **Drive Motor (Prime Mover)**

The kW rating of the drive shall be based on continuously driving the connected equipment for the conditions specified. However, in cases where parallel operation of the pumps are specified, the actual motor rating is to be selected by the Bidder considering overloading of the pumps in the event of tripping of operating pump(s).

## ANNEXURE-II

**PIPING THICKNESS:** Pipes for sizes 200 NB & above shall confirm to IS: 3589 Grade 410. The thickness as mentioned below are the minimum specified nominal thickness as per IS: 3589. Tolerance as code shall be applicable.

| Nominal pipe Size (mm) | Outside Diameter (mm) | Wall Thickness (mm) |
|---|---|---|
| 200 NB | 219.1 | 4.5 |
| 250 NB | 273 | 5 |
| 300 NB | 323.9 | 5.6 |
| 350 NB | 355.6 | 5.6 |
| 400 NB | 406.4 | 6.3 |
| 450 NB | 457 | 6.3 |
| 500 NB | 508 | 6.3 |
| 600 NB | 610 | 6.3 |

# SUB-SECTION-I-M3

# COMPRESSED AIR SYSTEM

## COMPRESSED AIR SYSTEM

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| **1.00.00** | **SYSTEM DESCRIPTION** |
| 1.01.00 | The compressed air system shall consist of Air compressors & their motor drives, Air Drying (ADPs) Plants, air receivers for each Air compressors, instrumentation and control, control panels, compressed air piping, Instrument Air Piping network, service air piping network etc. |
| 1.02.00 | Air from air compressors shall be dried in respective Air Drying Plants in compressor house and delivered to the Air receivers. From the Compressed air piping header at the downstream of Air receivers, one common header to be provided to meet the service and instrument air requirement for FGD Plant. |
| **2.00.00** | **SCREW AIR COMPRESSORS** |
| | The minimum requirements of design and construction features of various components of Compressed air system (screw type air compressor, air dryer, air receiver, etc.) are described below. |
| 2.01.00 | **CODES AND STANDARDS** |
| 2.01.01 | The design, manufacture, testing and performance of the various components of the Rotary Screw type Air Compressors shall comply with the requirements of relevant codes ( IS-5456, IS-10431 [part -1], ASME PTC-9, IS-6206, IS-5727 and CAGI). |
| 2.01.02 | Other International Standards like American/BS/DIN etc. equivalent or superior to above mentioned standards are acceptable. Where IS specification is not available, the equipment shall conform to one such International Standard, which shall be indicated in the proposal. |
| 2.01.03 | The materials of the various components shall conform to the applicable IS/BS/ASTM/DIN Standards. |
| 2.02.00 | **DESIGN AND CONSTRUCTION** |
| 2.02.01 | The compressor shall be oil free multistage, horizontal, water cooled, rotary screw type, heavy duty, rugged construction. Their speed shall be so selected as to result in low maintenance and trouble-free operation under specified conditions. |
| 2.02.02 | The rotor and shaft shall be of single piece construction, made of forged steel (AISI C1141 or equivalent). The stator (casing) shall be of Cast-Iron (IS-210 grade) Construction with integral jacket cooling. The rotors shall be dynamically balanced to reduce vibration. |
| 2.02.03 | The seal rings and retainers shall be of stainless steel construction and be free for radial self adjustment along the rotor shafts. |
| 2.02.04 | Bearings shall be high precision antifriction type IS- 25 Grade 84). The axial thrust load shall be minimized by dividing the axial load of compression on the main and auxiliary bearings through suitable balancing arrangement. |
| 2.02.05 | Lubrication system shall be as per manufacturer standard practices |
| 2.03.00 | **Gear Box** |
| 2.03.01 | Gears shall have a rating of AGMA-12 or equivalent. Speed increasing gears between the motor and compressor stages shall consist of a common helical gear driving the pinion of each stage. Helical timing gears shall be mounted on the rotor shafts to maintain accurate relative rotor position. |

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| **3.00.00** | **PERFORMANCE REQUIREMENT** |
| 3.01.00 | Air Compressors (screw type) shall be designed for continuous operation with high efficiency to satisfy the performance requirement as per approved data sheet submitted by the bidder during detailed engineering. |
| 3.02.00 | The power rating of the driver shall be selected such that a minimum margin of **10%** is available over the power required to deliver rated capacity against rated pressure. |
| 3.03.00 | As more than one compressor with drive is specified, satisfactory operation in parallel shall be ensured without any uneven load sharing, undue vibration, keeping noise level within permissible limits for a number of compressors working simultaneously in the same room. |
| **4.00.00** | **INTERCOOLER, AFTERCOOLER & OIL COOLERS (FOR SCREW)** |
| 4.01.00 | Intercoolers, After coolers and Oil coolers shall be of water cooled & shell-and-tube type with water on the tube side. Intercoolers & after coolers shall be designed in accordance with Section VIII, Division 1 of ASME Code or equivalent. |
| 4.02.00 | Outlet temperature of air from intercooler shall be suitable to suit the equipment and outlet temperature of air from the compressor house outlet header shall be limited to 45 deg.C. However, the instruments or the pneumatic devices requires air temperature less than 45 deg.C., the same shall be achieved at the outlet header. |
| 4.03.00 | Coolers shall be provided with removable tube bundle design in accordance with design code TEMA Class C and shall be constructed with removable shell cover. |
| 4.04.00 | Oil Coolers shall be equipped with vent & drain connections on oil and water sides. Oil temperature control valve with manual override feature or bypass construction shall be provided to maintain constant temperature. Vent & drain connections for intercoolers and aftercoolers shall be provided. |
| 4.05.00 | Design pressure shall be 8 Kg/cm2 (g) or based on shut-off head of cooling water pumps. |
| 4.06.00 | The coolers shall be designed for maximum heat load and atleast 10 percent design margin shall be provided in the number of tubes. |
| 4.07.00 | Adequately sized safety valves shall be provided for both intercoolers and after coolers. |
| 4.08.00 | Each intercooler and aftercooler shall be provided with moisture separator units with suitable baffling. Moisture separator units shall be equipped with a level gauge glass with isolating cock. |
| 4.09.00 | Electrically operated automatic drain trap stations with bypass and isolating valves shall be provided for moisture separators for automatically draining of condensed moisture. The drain trap shall be timer based. Manual draining facility shall also be provided in the drain trap. |
| 4.10.00 | Cooler shells, channels and covers shall be of carbon steel (SA 285 Gr C / SA 516 Gr 70 / equivalent).Tube sheet shall be of Brass or SS and the tubes shall be of Admiralty brass or Aluminium brass or Copper or SS 304. |
| 4.11.00 | For the instrument air compressors offered with "Heat of compression" type air drying plants, the after coolers shall be provided at downstream of Air Drying Plant. |
| **5.00.00** | **AIR RECEIVERS** |
| 5.01.00 | The design pressure and temperature shall be minimum 10 $Kg/cm^2$ (g) and 50 deg.C respectively. Receivers shall be designed in accordance with Section VIII, Division 1 of ASME Code or equivalent. |
| 5.02.00 | Air receivers are to be provided with gasketted inspection manhole of minimum 500 mm diameter with cover plate, lifting handle, davit cap etc. |

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| 5.03.00 | Receivers shall be of welded construction with minimum number of joints. Longitudinal seam in adjacent sections shall not be in same line. Welding shall be as per relevant codes. Filler material to have composition & structure as that of material welded. Welding electrodes to be approved by Employer. Electrodes to be dried before use. |
| 5.04.00 | Relief valves shall be provided to suit compressor capacity and set pressure of the same shall be atleast 10% above working pressure. The spring in relief valve shall not reset for any pressure more than 10% above or below the design set pressure. |
| 5.05.00 | Each receiver shall be provided with drain connection with electrically operated automatic drain trap arrangement with isolation and bypass valves. |
| 5.06.00 | The material of construction of shell, dished ends, flanges, etc of the air receivers shall be of carbon steel as per IS:2062 or equivalent. |
| **6.00.00** | **INTAKE AIR FILTER AND SILENCER** |
| 6.01.00 | Filters with multiple elements quick removal type for easy cleaning shall be provided at suction of each air compressor and also be of heavy-duty dry type. |
| 6.02.00 | The filters shall be complete with integral silencers. Separate silencers, if specified, shall be provided. The filtering elements shall be easily removable for cleaning. |
| 6.03.00 | The filters shall be designed for an efficiency of not less than 99% for particles 2 microns and larger. |
| **7.00.00** | **AIR DRYING PLANTS** |
| 7.01.00 | One number Air drying plant shall be provided for each air compressor. Drying shall be by adsorption process through a desiccant medium. |
| 7.02.00 | Air Drying (ADP) Plant may be of "Open Through type (Blower reactivated)" OR “Heat of (HOC) Compression type". |
| 7.03.00 | Regeneration of desiccant shall be achieved by "open through" or "Heat of compression" method without any air purge loss. |
| 7.04.00 | Hot unsaturated compressed air shall be used for regeneration of exhausted desiccant in case of "Heat of compression type ADP" and air from blower shall be used for regeneration after heating by electrical heater in case of "Open through type ADP". |
| 7.05.00 | Each ADP shall be provided with two adsorber towers each sized for design drying cycle of minimum 8 hours. After this period, the adsorber tower which was under drying mode shall be put under regeneration/reactivation mode while the other tower will take over the drying duty. The change of drying mode to reactivation mode or vice-versa shall be automatic with provision for manual operation also. The change over from one mode to another shall be through automatic solenoid operated valves. |
| 7.06.00 | In "Open Through" type ADP, for regeneration of desiccant, atmospheric air shall be filtered, heated through an electric heater and passed through the desiccant before exhausted to atmosphere. The reactivated desiccant shall be cooled through same atmospheric air without heater in operation.<br><br>In case of HOC type drier, the reactivation shall be achieved by the heat of the compressed air itself. The hot unsaturated compressed air from the outlet of last stage of compressor shall be passed through the adsorber tower. The moist air shall be cooled in dehumidifier and passed through the second adsorber for final drying.<br><br>The design reactivation cycle/period of the tower shall be less than 8 hours including cooling period for desiccant for both the types of ADP. |

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| 7.07.00 | Each ADP shall be provided with two (2) numbers of 100 percent capacity pre-filters and two (2) numbers of 100 percent capacity after-filters at the upstream & downstream of towers. The filtering media shall be of ceramic candle type elements designed to withstand atleast 50% of static pressure as differential pressure. The pre-filters shall be provided with automatic electrically operated drain trap arrangement with isolation and bypass valves. |
| 7.08.00 | The electric heaters (if required) (2x100% capacity for each ADP) shall be provided with thermostatic control for heater and relief valve for safety and shall be flanged type to facilitate easy replacement of element. |
| 7.09.00 | Each electric motor driven blower (2x100% capacity for each ADP) shall be provided with individual dry type filters at inlet. |
| 7.10.00 | The adsorber tower shall be designed with sufficient cross sectional area resulting low air velocity and pressure drop. Minimum 20% of desiccant depth shall be provided as free board in adsorber vessels. Adsorber vessels to be provided with suitable number of inspection/sight windows of "Persplex" for observation of adsorbent condition. Desiccant filling and removal connections shall be provided for the adsorber vessels. |
| 7.11.00 | The coolers/heat exchangers/ dehumidifiers of ADP shall be designed & constructed as per the requirements specified for “Intercoolers, After coolers & Oil coolers" above. |
| 7.12.00 | All pressure vessels such as pre-filters, after-filters, adsorber vessels, heaters, heat exchangers/de-humidifiers / coolers etc associated with ADP shall be designed in accordance with Section VIII, Division 1, of ASME Code or equivalent. The pressure vessels shall be provided with air tight gasketted manholes/handholes and relief valves. |
| 7.13.00 | Quantity of desiccant to be calculated shall take into account residual moisture content at the end of regeneration cycle. |
| 714.00 | Adsorption capacity and density to be considered for silica gel shall not be more than 10% and 550 kg/$m^3$ respectively. In case of activated alumina the same shall be 8% (max) and 900 kg/$m^3$ (max.) respectively. |
| 7.15.00 | In case of Heat of compression type, adsorbers shall be sized so that even when the compressor is operating at part load, complete regeneration shall be achieved within the cycle time and quality of air (dew point) shall be maintained throughout the design cycle period. |
| 7.16.00 | Complete ADP equipment shall preferably be mounted on a skid. |
| 7.17.00 | Required sample connections in piping be provided for sampling of air at desired locations. |
| 7.18.00 | Non-lubricated two way / three way / four way valves ball valves with pneumatic actuators be provided. |
| 7.19.00 | The material of Construction for various components of ADP shall be as as per manufacturer’s proven standard. |
| 7.20.00 | HOC dryers of single rotating drum type design using packed dessicant with in-built regeneration and adsorption compartments are also acceptable in place of specified twin-tower type dryers, if the design ensures specified performance guarantee. In case, the Contractor offers such a type, the same shall be of proven design**.** |
| **8.00.00** | **INTERCONNECTING PIPING, FITTING AND VALVES** |
| | The interconnecting piping & valves within compressor house for compressed air & cooling water etc shall be designed in line with the specification furnished in subsection titled "Low Pressure Piping" of Part-B of this Technical Specification. |

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| **9.00.00** | **CONTROL PHILOSPHY** |
| **9.01.00** | **GENERAL** |
| 9.01.01 | The minimum requirements are specified herein and the same shall be elaborated by contractor. The Contractor shall include controls & instrumentation to facilitate safe, reliable and efficient operation for the system. The controls, protection, interlock and instrumentation system offered by the contractor shall be subjected to approval of the Employer during post award engineering stage. |
| 9.01.02 | Any of the compressor and Air drying Plant may be selectable for "shutdown", "working" or "standby" duty. |
| 9.01.03 | On tripping of working equipment, the standby equipment shall come into operation automatically in case of very low air pressure in the system. |
| 9.01.04 | All abnormal conditions used for tripping the compressor or any other equipment shall be provided with pre-trip audio-visual indication/annunciation in the control panel. |
| 9.01.05 | An electrically operated automatic valve shall be provided on cooling water supply line of each compressor & dryer (if applicable) which will automatically shut off the cooling water supply, in case any of the compressor/dryer is not running for more than set time duration. Suitable interlock shall also be provided for opening the valve before starting of any of the compressor. |
| 9.01.06 | The following indications shall be made available in the control panels for repeating the same in main plant Control System / Panels.<br>(a) Status of each compressor<br>(b) Instrument air pressure low/high<br>(c ) Service air pressure low/high<br>(d) Dew point of instrument air<br>(e) Status of each ADP |
| 9.01.07 | Lube oil pressure and temperature in the oil circuit of compressor shall be automatically controlled. |
| 9.01.08 | Unless otherwise mentioned in the relevant electrical sub-section, automatic motor overload control system shall be included to permit continuous operation of compressors at minimum ambient air without exceeding the name plate rating of the motor. |
| **9.02.00** | **Screw Compressor** |
| 9.02.01 | Each compressor shall be in the control panel to operate either in Base duty (Auto Load-Unload) or Standby duty (Auto On-Off) mode in case of Screw and unload/modulate/energy optimization (Auto Dual Mode) in case of centrifugal |
| 9.02.02 | In "Base duty" mode, whenever air supply from compressors exceeds the demand, control system shall operate the load-unload circuit at a predetermined set pressure, throttle the inlet valve and open the blow off valve. The compressor shall run in unloaded condition. When system pressure drops due to more demand, the load-unload circuit shall operate again to bring the compressor to 100% load after closing the blow -off valve. |
| 9.02.03 | In "Stand-by" mode the compressor shall automatically assist base load compressors during periods of peak air demand. When air pressure in the system reaches a pre-set lower limit, compressor should start in unloaded condition and the compressor shall be fully loaded. When the pressure in the system rises to pre-set high value, the compressor shall be unloaded and shall run in idling mode for a specific period (set by a timer). The compressor |

may be loaded to full load in case of drop in system pressure or compressor may be stopped in case the system pressure does not drop and compressor continues to idle for more than a pre-set time.

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

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

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

**9.03.00 Air Drying Plant**

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

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

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

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

**10.00.00 PAINTING**

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

The surface of SS, galvanized steel, Gun metal, Brass, Bronze and non-metallic components shall not be applied with any painting.

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

# SUB-SECTION-I-M4

# FIRE DETECTION & PROTECTION SYSTEM

## FIRE PROTECTION AND DETECTION SYSTEM

**1.00.00 GENERAL DESCRIPTION**

1.01.00 A comprehensive Fire Detection and Protection System covering all the areas of the power plant including Employer's facilities/ system /buildings (if applicable) is included in the scope of the Contract.

1.02.00 The complete Fire Detection and Protection Systems shall be as per the guidelines/ codes/ standards / rules of TAC/ NFPA / IS: 3034 / OISD etc. and all the systems, equipments and installation shall be got approved from TAC accredited professional(s)-India.

**2.00.00 HYDRANT SYSTEM**

Hydrant system shall consist of piping, isolation Valves (Gate Valves), hydrant valves, landing valve, water monitors, hoses, branch pipes, nozzle, hose boxes, etc.

2.01.00 **Areas to be Covered**

Complete FGD area and other auxiliary buildings / areas under the scope of the Bidder.

**3.00.00 HVW AND MVW SPRAY SYSTEM**

3.01.00 **General**

It shall consists of water mains network, deluge valves, isolation valves, Y type strainers, spray nozzles/ projectors, spray nozzles piping network, detection system, instrumentation, local control panels, cables etc.

3.02.00 **Areas to be covered by HVW Spray System**

i) All transformers For FGD System of rating 10MVA & above OR having oil capacity above 2000Ltrs & located with-in plant boundary.

3.03.00 **Areas to be covered under MVW Spray System**

i) All cable galleries/ cable vault/ cable spreader room in Bidder scope of work under FGD System.

**4.00.00 FIRE EXTINGUISHERS AND FIRE STATION EQUIPMENTS**

4.01.00 **Fire Extinguishers**

As indicated in Bidder's Scope, Part-A.

**5.00.00 FIRE DETECTION, ALARM AND CONTROL SYSTEM**

5.01.00 **Codes and Standards**

a. The design, manufacture, testing, performance, etc. of the various components of the analog addressable Fire Detection and Alarm System shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. Nothing in this specification shall be construed to relieve the contractor of this responsibility.

b. Unless otherwise specified, the Fire Detection and Alarm System and the components shall conform to the latest applicable Indian or IEC Standards. Equipment complying with any other authoritative National Standards such as British, USA, VDE, etc. will also be considered, provided the parameters specified are equivalent or better than the corresponding IS.

c. The Contractor shall be solely responsible for obtaining the required approval and clearance for the different components and systems of the Fire Detection and Alarm System from the following authorities, as applicable:

i. Department of Atomic Energy (Certification of safety from Radioactivity).
ii. Central Building Research Institute, Roorkee.
iii. Central Mining Research Station, Dhanbad.
iv. Local Fire Authorities.

d. The equipment and the system shall be of types approved by any of the following bodies, as applicable:

1. Loss Prevention Council, (LPC), U.K.
2. National Fire Protection Association, (NFPA), USA
3. Under-writers laboratories, (UL), USA
4. Factory mutual(FM)

5.02.00 **Areas to be covered under Fire detection and alarm System**

a) **Multisensor type detection system (Above and below the false ceiling or below the false flooring as the case may be)**

i) All switchgear / MCC/battery rooms of FGD control room building, various auxiliary buildings (if applicable), etc.

ii) Cable galleries of FGD control room building protected by MVW spray system. Further, multisensory detectors shall also be provided inside all cubicles/panels of control room, control equipment room and UPS / Battery charger areas.

iii) Above and Below false ceiling areas of all air-conditioned rooms of FGD control room building, various control rooms of auxiliaries as defined in Sl. No. (i) above.

b) **Linear heat sensing cable detection system**

Gypsum and lime conveyor of FGD system and Cable Galleries.

c) **Quartzoid bulb heat detection system**

Equipments protected by HVW spray system.

**5.03.00 General requirements for all types of Detectors**

5.03.01 Detectors shall be housed or mounted in suitable enclosure in such a way that their performance is in no way affected. Special maintenance procedures if any required for the satisfactory operation of the detectors shall be clearly stated in the bid.

5.03.02 Necessary mounting accessories shall be provided for all the detectors.

5.03.03 In case the detectors are offered with their output (on sensing a fire) in the form of an electrical contact, it shall be noted that the contact shall be 'NC' type such that under fire conditions, this contact will open to initiate the fire alarm system.

5.03.04 Detectors shall preferably be designed as plug-in units, which fit into various bases according to place and type of mounting. This would also enable interchangeability.

5.03.05 Detectors shall be provided with the necessary compression type cable terminating glands for the incoming cables of flameproof type or PVC/metallic flexible/rigid conduits.

5.03.06 Depending upon the environmental conditions in which detectors are installed, chlorinated rubber based or epoxy or equivalent paint shall be used for finishing the surface of the enclosure.

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| 5.03.07 | The coverage or the zone of protection afforded by the detector and recommended height of mounting shall be furnished by the Bidder. The bidder shall furnish the test certificate in support of this. |
| 5.03.08 | Any metal parts used for detector construction shall be inherently resistant to corrosion or shall be plated or otherwise suitably treated to afford protection against corrosion. The plating or treatment shall in no way affect the detector performance. |
| 5.03.09 | Any plastic material or any sealing compound used in the detector shall be such as it will not deform or fail under the maximum temperature to be expected. |
| 5.03.10 | No detector shall contain any moving parts subject to wear and tear and must be able to operate afresh after each alarm release, without its exchange or adjustment. |
| 5.03.11 | The detector shall be located where the largest combustion gas concentration can be expected. |
| 5.03.12 | Adequate compensation and considerations shall be made for effects for wind velocities such as air-conditioning system and exhaust fans where dilution of particles of combustion is greater. |
| 5.03.13 | The exact location of detectors shall be coordinated with other services like air-conditioning grills, light fittings, cable trays etc. to provide aesthetically pleasing appearance. The return air paths of air-conditioning shall be avoided for detector location. |
| 5.03.14 | The detectors shall not be affected by temperature, humidity; air flow or by drift failures and shall not give any false alarm due to above. |
| 5.03.15 | The detectors shall not be sensitive to vibrations. Any special mounting arrangements required to counteract vibration shall be included in the contractor scope. |
| 5.03.16 | The quantity of multi- sensor detectors in each zone shall be based on the coverage factor of 25-sq. meter per detector. However the actual quantity of detectors required, taking into consideration obstructions due to floor beams, ventilation, doors, windows etc., shall be worked out and supplied (based on the actual layout) and installed by the contractor. |
| 5.03.17 | The detectors shall not give false alarm due to high humidity, temperature, and velocity of air in the surroundings and static electricity conditions. |
| 5.03.18 | Process actuated switch devices such as pressure switches, flow switches, level switches, etc. shall be provided with suitable individual addressable interface (local or remote) units or modules so that these devices are addressable from the panel. |
| 5.05.00 | **Linear Heat Sensor Cables** |

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|---|---|
| Application | Detection of Stationary fire |
| Type | Digital |
| Operating voltage | 24 V DC |
| Approval | FM/UL |
| Conductor material | Steel |
| Insulation | Heat sensitive polymer |
| Outer Sheath | Black or colored PVC or flouropolymer suitable for the application |

environment

**Installation features for LHSC**

1. Mounting arrangement will be provided as per proven practice.

2. Linear heat sensing cable detector shall run in a zigzag fashion (with an included angle of 90 deg) on each top cable tray, bottom tray and every alternate intermediate trays of each section of cable tray without undue sagging and interfering the normal operations. All supporting materials for mounting of LHSC shall be provided by the bidder.

5.06.00 **Addressable Analog Intelligent Detectors**

In addition to the features specified under the item General requirements for all types of Detectors, the Addressable Analog Intelligent Detectors shall be provided with the following features:

(a.) Detectors not specifically listed for sensitivity testing from the control panel are not acceptable due to the expense involved with manual testing as required by NFPA 72E.

(b.) The detector shall be suitable for two-wire operation and two-way communication on the intelligent analog signaling circuit.

(c.) The detector shall display a steady LED when in the Alarm State. The LED shall flash when in stand by or normal mode.

(d.) Each detector in a loop shall have short circuit isolator suitable for style-7 wiring as per NFPA-72.

(e.) Address and sensitivity assignments shall be set preferably electronically. However, dip switches / rotary switches for the same are acceptable. The detectors shall be assigned a sensitivity level based on environment, time of day or any programmable function as required by the system user, and shall respond at that level whether in the “on line” or “default” mode.

(f.) The fire alarm control panel shall permit detector sensitivity adjustment through field programming of the system.

(g.) The detectors furnished shall be listed for use in environments as covered by Factory Mutual and UL and shall be installed according to the requirements of NFPA 72E for open area coverage.

5.07.00 **Multi sensor Detectors**

5.07.01 Multi sensor detectors shall incorporate a heat detection element and a photoelectric detection element. Both the elements shall be incorporated in a single unit. Both the elements shall be operative at all times and the fire signal shall be available from any or both elements combined together.

5.07.02 The detectors shall be sensitive to very low smoke densities of the order of say 0.05 g/$m^3$. Also it shall be possible to adjust this sensitivity on a step less basis over a range so that the optimum sensitivity could be selected at site to suit the conditions of installations. The coverage area of the smoke detection under standard NFPA test conditions shall not be less than 80-90$m^2$.

5.07.03 The detectors shall be complete with a mounting base that includes a terminal box into which the detector can be plugged in. Terminals for looping of the cables shall be provided.

| | |
|---|---|
| 5.07.04 | All detectors shall be provided with built-in response and indicating lamps which shall give local visual indication, when it has operated in dense smoke conditions. The failure of lamp shall not prevent the function of detector. |
| 5.07.05 | In areas such as false ceiling where detectors themselves are not easily accessible, the remote response indicators outside the enclosed areas shall be provided to indicate the fire condition. |
| 5.07.06 | It shall be possible to replace any type of detector head by a different type detector without requiring change in cabling/panel wiring and condition of the zone, originally covered by the detector. |
| 5.08.00 | **System Configuration** |
| 5.08.01 | The Addressable Fire Alarm panel shall be able to communicate with repeater annunciation panel located at different places. The detectors or other devices of any other unit/area shall be addressable only from the respective Addressable Fire Alarm Panel, so that each of the Addressable Fire Alarm Panel is under the control of designated operating personnel at that location. |
| 5.08.02 | At least one spare loop shall be provided in each of the addressable type fire alarm panel located in FGD control equipment room with complete loop card and all other accessories so that Employer can expand the system in future. Further, at least 10% of loop capacity be left free in each of the connected loop in all the panels, so that, additional devices may be connected to the system in any of the loop by Employer in future. |
| 5.08.03 | FGD Fire alarm system shall be provided with necessary interface hardware and software for communicating fire alarms from this fire alarm panel to the main plant fire alarm control panel through potential free contacts. |
| 5.09.00 | **Analog Addressable Fire Detection and Alarm System** |
| 5.09.01 | General Requirements |
| 5.09.02 | This specification in general covers the functional requirements, and general design aspects of Microprocessor based, Analog Addressable Fire Detection Alarm / Annunciation and Control System. |
| 5.09.03 | The following description intends to describe only the brief hardware and functional requirements, scope of hardware requirements etc. but the actual configuration of the system shall be in line with the prevalent normal practices in the industry and shall conform to latest product range of selected manufacturer.<br><br>The fire detection and control system offered shall be complete in all respects for the safe and reliable operation of the entire system. Any additional hardware/software than those mentioned herein required to make the system complete shall be included in the scope of the Bidder. |
| 5.09.04 | All the system and its equipment specifically detectors, interface modules, panels, power supply, battery chargers etc. shall be furnished from a single source and the same shall be new and latest state of the art products of manufacturer engaged in the manufacture of Integrated Microprocessor based Analog Addressable Fire Detection and Alarm System. |
| 5.09.05 | All equipments such as detectors, panels etc shall be approved and listed by UL/FM/LPCB/VDS. |
| 5.09.06 | All types of smoke detectors shall be of analogue addressable type. Conventional detectors with interface modules are not acceptable. Each zone of LHSC detector and each IR detector shall be provided with interface module. |

5.09.07 All the fire detection systems, process actuated switch devices such as pressure/flow/temperature switches and relays of control functions shall be hooked up with the analogue addressable fire detection and alarm system. Required addressable interface units shall be provided for various switch devices by the bidder to make them addressable.

5.09.08 The wiring shall be of class-A as per NFPA-72.

5.09.09 Bidder shall provide isolators at the start & end of the loop.

5.09.10 The complete system shall include, but not be limited to the following :

a) Master system CPU.

b) Analog Addressable Fire Detection and Alarm System panels including alarm modules, system supervisory control modules, auxiliary output control modules etc.

c) Power supplies, batteries and battery chargers.

d) Analog addressable type smoke detectors.

e) Non addressable type conventional detectors (Linear heat sensing cable detector/ infra red type heat detector) and switching devices each with its own addressable interface modules.

f) Software and hardware as required for complete operation of the system.

g) Complete Wiring/cabling including its conduits/trays/fixtures etc.

i) The fire alarm control panel shall function as a communication interface between central processing unit and sensors. This panel shall have facility to process the input signal and to control all the input data received from initiating and indicating devices.

j) Fire alarm control panel shall have filters to ignore false alarm and increase sensitivity to real fire from sensors. The sensitivity of each detector should be automatically raised if detectors are gradually polluted due to dust and dirt entering inside the detector. If detectors are more polluted the control panel shall give a warning. The trouble report shall indicate the location of device requiring service.

k) Fire alarm control panel shall have printer to print out the alarm/ trouble occurrences.

l) The CPU shall serve as the systems central processor. Software shall be designed especially for fire alarm annunciation system applications and shall monitor status of processing alarms according to priorities, controlling/processing communications and synchronizing all system activities.

n) The system shall be able to recognize and indicate an alarm condition in a degrade mode of operation, in the event of processor failure or the loss of system communications to the circuit interface panels.

o) All devices shall be individually identifiable for its type, its zone location, alarm set value, alarm and trouble indication by an unique alpha numerical label.

p) The software logic modules and system database shall be programmable using a MS - Windows compatible program (latest version) on PC at site and required hardware shall be included in scope of supply. The system software programme shall be password protected and shall include full upload and download capability and during program upload or download through the PC, the capability of alarm reporting shall be retained. The software shall be downloaded to a PC for editing. The software shall enable Employer to add the spare loop provided in the fire alarm panels or addition of additional devices/detectors in any of the fire alarm panel.

q) The system shall support the use of Color Graphic display terminal for the display of information in an appropriate format.

r) The system shall include software for system data base, historical event log, logic, and operating system. The system shall require no manual input to initialise in the event of a complete power down condition. It shall return to an on line state as an operating system performing all programmed functions upon power restoration.

s) Activation of any fire alarm initiating device shall display (LCD alpha numeric display) message in describing the device originating the alarm condition at the Central monitoring station, at alarm panel, simultaneously at the repeater annunciation panel and shall initiate the associated protection systems & other related control functions. Similarly activation of any supervisory circuit, (supervised valve closure, air pressure abnormal, fire pump trouble, water pressure low, etc.) or receipt of trouble report (primary power loss, open or grounded initiating or signaling circuit wiring, battery disconnect etc) shall display at the fire alarm control panel the origin of supervisory condition or origin of trouble condition as the case may be. It shall also record the occurrence of the event, the time of occurrence and the device initiating the same.

t) System configuration shall be menu driven and capable of being operated by, a person with no previous computer programming experience.

5.10.00 **System Functional Requirements**

5.10.01 The fire alarm panel shall evaluate the signals received from the detectors and shall handle the following functions:

1. System self monitoring and fault signaling.
2. Transmission of alarm and fault signals to the respective fire alarm panels and as well as in the repeater panel in fire station. Further, the panel shall activate a hooter/sounds in each of the area locally provided with fire/smoke detection system. Further, the system shall enable operation of spray system from the panel through monitoring station when the system operation is selected under remote, manual mode.
3. Initiate control functions like stoppage of conveyor, closure of fire doors, shutdown of draft fans, air-conditioning and ventilation plant/ equipment, opening smoke extraction vents, switching on smoke extraction equipment, emergency lighting etc.
4. Triggering stationary extinguishing systems such as clean agent system.
5. Supervising of unauthorised removal of a detector head from its base and giving a fault alarm on the control panel.
6. Supervising and monitoring the detection cabling, to indicate fault conditions in case of open/short circuit in the wiring.
7. Supervising by a separate annunciation window, changeover from mains supply to battery supply. “Mains On” indication shall be continuously on, as long as the main supply is available.
8. Facilitating simulation of fire conditions to enable the testing of circuits (without creating actual fire) under the test mode from the fire Alarm panel.

9. The control unit shall contain all the systems main switches lamps and fuses. Switches and lamps shall be easily identified even in closed casings.

10. All the circuits from the detectors to the panels and the circuits from panels to the actuating/operating devices of the respective extinguishing system shall be of closed loop type and shall be supervised for open-circuiting and short-circuiting of cables. The cable fault shall be audio-visually annunciated on the panels. Separate hooters with different tones shall be provided for 'fault' alarms and 'fire' alarms.

11. Actuate solenoid valve in spray system in case of fire from respective fire alarm panel. For achieving this if any additional hardware is required like relays, power supply and cables, the same may be provided.

5.10.02 **Analog Addressable Fire Detection and Alarm System shall also meet the following functional requirements:**

i. Each of the system shall support analog addressable detectors of all types, non-addressable type detectors/devices along with its addressable interface units/modules, Video display units etc.

ii. Each of the devices and/or detectors shall be individually, uniquely and continuously addressable by the panel to which it is connected.

iii. Detectors shall be interrogated for sensitivity settings from the control panel, logged for sensitivity changes indicating the requirement for cleaning and tested by a single technician using the field test routine. Sensitivity of each of the detectors made available in the panel shall be adjustable from the panel.

iv. The system shall be capable of self-adjustment to compensate for the accumulation of contaminants that would change the detector sensitivity in either a more or less sensitive direction to prevent false indications or failure to alarm in the actual fire conditions. The system shall annunciate a trouble condition when any analog addressable smoke detector reaches 80% of its alarm threshold due to gradual contamination, signaling the need for service and eliminating unwanted alarm.

v. Continuous supervision/monitoring of all the circuits and its components shall be made available from the panel for open, short circuits and grounding.

vi. The system shall be able to recognize and indicate and alarm condition in a degraded mode of operation, in the event of processor failure or the loss of system communications to the circuit interface panels.

vii. The system shall be programmable at site and required hardware shall be included in the scope of supply. The system software Programs shall be password protected and shall include full upload and download capability. During program upload or download the system shall retain the capability for alarm reporting. The system shall download to a PC for program editing. The software shall eligible employer to add the spare loop provided in the fire alarm panel or addition of additional devices/detectors in and of loop in any of the fire alarm panel.

viii. The system shall support the use of color interactive History Reporting video

display terminal for the display of information in an appropriate format.

ix. The system shall include software for system database, historical event log, logic and operating system. The system shall require no manual input to initialize in the event of a complete power down condition. It shall return to an on line state performing all programmed functions upon power restoration.

x. Software logic modules and system database shall be programmable using a windows compatible program on PC. It shall be possible to program or edit the system database off site after down loading from the panel.

xi. All detectors shall incorporate internal automatic temperature compensation to overcome the effects of either high or low ambient temperatures in the installed environment on the detector sensitivity. The detectors shall be tested at a specified frequency by raising the detector sensitivity level to the alarm threshold, to check the operation of the detector without system alarming automatically by the control panel.

xii. In an alarm or trouble condition the following shall occur on the monitoring station:

1. Sound an audible.
2. Write details of the actuation to a system log file on the PC.
3. Print the details of the actuation to the system printer.
4. Activate the color graphic display system controls, providing functions such as zooming, scrolling of Alarms, troubles, etc.

xiii. System configuration shall be menu driven and capable of being operated by a person with no previous computer programming experience.

5.11.00 **Panel Display Requirements.**

System display shall consist of minimum 80 character back lighted alphanumeric LCD display readable at any angle. Thirty-two character customer defined custom messages shall describe the location of the active device. In addition to the above, the following features shall be available.

a. The system shall be capable of programming to allow troubles occurred and restored in the system to be automatically removed from the display queue, eliminating the necessity for individual acknowledging of these events. This feature shall not affect the historical logging of events as programmed.

b. As a minimum an LED display for “Alarm”, “Audible Silenced”, “Supervisory”, “Trouble”, “Security”, “Power On”, And “Partial System Disabled”.

c. Touch activated membrane switches for “Alarm Acknowledge”, “Audible Silence”, “Supervisory Acknowledge”, “Security Acknowledge”, “Reset”, “Display Hold”, And “Display Next”.

d. All membrane switches shall be tactile with audible feedback when pressed.

5.12.00 **System Software Requirements**

i) The software shall control the operation, function and display of the graphic system and provide for automatic boot up and run from the hard disk drive of the computer.

ii) All project specifics actuating device programming shall be capable of being carried out on site via password access.

iii) The system shall monitor all alarm, supervisory; trouble and security conditions detected by the fire alarm control panel and provide separate disk based files, for each condition. These logs may be enabled, disabled, or cleared with password access.

This log information is not to be lost upon power failure or fire alarm control panel reset. A utility file shall be provided to sort the log data by date or by device and display this information either on the screen or the system printer.

iv) Selective memory storage up to 800 events, shall be stored in flash memory and displayed, printed or downloaded by classification for selective event reports.

a. Software shall allow selection of events to be logged, including; inputs as alarms, troubles, supervisors, securities, status changes and device verification; out puts, as audible control and output activation; action, as reset, set sensitivity, arm/disarm, override, password, set time and acknowledge.

b. Audible and visual indications shall be generated when memory is 80% and 90% full to allow downloading of data. The system shall be programmable circular logging, assuring that at least the last 400 events will always be stored in non-volatile memory.

v) Software has driven logic for adjusting the alarm threshold windows on detectors to compensate for accumulating contamination and keep detector response sensitivity constant. The software shall compensate for either over-sensitized or desensitized units, raising a system flag when a detector approaches the allowable limits of adjustment, indicating a requirement for cleaning.

a. Values shall be stored in non-volatile memory allowing activation of all tracking functions within 90 sec of system initiation from a "cold boot". During the boot sequence, alarms from detectors programmed with the feature shall be suppressed.

When the full data history is active all devices shall be checked and any active alarms displayed.

b. The control panel shall place each detector in the system in an alarm condition, transparent to the system user, every twenty-four hours as a dynamic check of the accuracy of the alarm threshold setting. Upon reception of the alarm report, the system detector shall be restored to its pretest state.

c. The system shall be capable of monitoring the stage of detectors and displaying a message when a detector is approaching the limits of adjustment as a result of contaminates. A second message shall be displayed when the detector reaches the limits of adjustment due to these contaminate.

d. The system shall be capable of recognizing that a detector has been cleaned, initiating a series of tests to determine if the cleaning was successful and display a detector cleaned message, readjusting that detectors normal sensitivity setting reference.

vi) When an alarm or trouble is registered at the fire alarm control panel the graphics system shall display the first screen image for the first actuated device. The system shall be capable of zooming in for further information if required. At all times when in the alarm or trouble mode the fire control panel status i.e. number of current alarms and or troubles is to be displayed on the graphics screen.

5.13.00 **Power Supply for Fire Alarm Panels & Repeater Alarm Panel**

5.13.01 One set of 24V DC redundant power supply system comprising of 2 x 100% chargers and 1 x 100% batteries shall be provided for fire alarm panel and repeater alarm panel. The batteries for fire alarm system shall be sealed maintenance free lead acid type. The battery backup for each fire alarm panel and repeater alarm panel shall be 24 hours and 30 minutes (in alarm conditions). At least 25% of the devices shall be considered to be active in alarm conditions. Each of the redundant chargers shall be sized to meet connected load requirements and keep the connected batteries full charged (Float Mode). Furthermore, the charger shall be sized to enable the boost charge of a fully discharged battery in 10 hours while feeding the load.

5.13.02 The batteries shall be sized as per relevant IEEE standard. For battery sizing calculation, an aging factor of 0.8, a temperature correction factor (based on temperature of 4 deg. C), voltage drop of 2V in cables. Capacity factor, Float Correction Factor, as per Battery Supplier Standard, shall be taken into consideration, if applicable and ambient temperature shall be considered as the electrolytic temperature. The sizing of the battery shall be as approved by Employer during detailed engineering.

5.13.03 The battery chargers and batteries shall be placed at a suitable location inside the fire alarm panel with partitions.

5.13.04 The detailed specification related to power supply system of fire detection & protection system shall be as specified in other sections of the technical specification.

5.14.00 **Control & Instrumentation requirements**

5.14.01 Not Used.

5.14.02 Not Used.

5.14.03 The specification related to Basic design criteria, Measuring Instruments, Process connection & piping, Control panels, Type test requirements etc shall be as specified in other sections of the technical specification.

5.15.00 **Cabling for fire alarm system**

All instrumentation cables twisted & shielded, FRLS PVC insulated and sheathed data highway / fibre optical cables, short term fire proof cables including prefabricated cables (with plug-in connectors) etc shall be provided by Contractor.

The contractor shall follow the cable philosophy as below:

| Application | | Type of cable |
|---|---|---|
| **From** | **To** | |
| PLC cabinets | PC, Printers etc. | As Mfr.'s Standard. However, connection between PLC and the remote I/Os shall be through fibre optic cable by Bidder if length is>300 M & coaxial cable if length<300 M |
| Detectors (including detectors mounted inside panels) /Any loop device | Detector (including detectors mounted inside panels) / Isolator/ Interface unit | Shielded, Twisted, PVC Cu. FRLS cables type "S" Refer Note 2, 3, 4 and 5 below. |
| Detectors (including detectors mounted inside panels) / Isolator / Interface Unit | JB | Shielded, Twisted, PVC Cu. FRLS cables type "S" Refer Note 2, 3, 4 and 5 below. |
| JB | Fire alarm Panel | Shielded, Twisted, PVC Cu. FRLS cables type "S" Refer Note 2, 3, 4 and 5 below. |

**Notes:**

1. 10% spare pair shall be provided for all cables having more than four pairs.
2. Type "S" cable shall be multicore control cable having overall shielding & specification similar to instrumentation cable except insulation thickness and voltage grade which shall be 1100 V. Type "S" cable shall also satisfy requirements of Article 760 of NFPA 70.
3. Over and above, contractor shall provide all the cables so as to complete the system.
4. Cable size of 2 core 1.5 sq.mm shall be used for loop wiring in-case of both control cable and short term fire proof cable.
5. Cable size of 2 core 2.5 sq.mm shall be used to provide power supply to various devices in the loop in-case of both control cable and short term fire proof cable.
6. The detailed specification of instrumentation cables and optical fiber cable shall be as specified in other sections of the technical specification.
7. Detector cables outside the building shall be corrugated steel taped armoured laid through cable trays wherever available and for rest of the areas, cable shall be buried at 600 mm depth with sand filling and brick covering at the top.
8. Detector cable within the building shall be either unarmoured & laid through galvanized iron (GI) conduits or armoured cables, as per the standard and proven practice of the manufacturer.

5.16.00 **Detection System for Conveyors**

i) **Linear Heat Sensor Cables:**

(a.) The LHS cable detector for each conveyor to be provided for both forward and return conveyors and shall be mounted as per the standard practice of the manufacturer/ supplier. Suspension of LHSC through flexible chains is a preferred arrangement. Further, LHS cable shall also be provided for return side of conveyors inside the bunker house.

(b.) The detection zone/loop divisions of LHSC system shall match with the MVW spray system.

(c.) The LHSC detector shall be provided with suitable interface unit, which shall generate/ make the signal compatible with fire alarm panel.

d) Type: Digital, Operating Voltage: 24V DC, Conductor Material: Steel, Approval: FM/UL

5.17.00 **Detection System of Cable Galleries**

i) In cable galleries, MVW spray system shall be actuated either by detection of fire by Linear Heat sensing cable detectors or by fire signal from Multisensor detection system. Apart from the automatic operation of spray system in the detected zone, the adjacent two zones shall also be sprayed with water automatically after a set time delay simultaneously.

ii) LHSC detector shall run in a zig-zag fashion (with an included angle of minimum $90^{o}$ atleast) in each of the top tray, bottom tray and in every alternate trays. The mounting arrangement of LHSC detector shall be as per manufacturer's standard practice.

iii) The detection zone/ loop divisions shall match with MVW spray zones.

5.18.00 **Multisensor Detection System**

i) Upon detection of fire, multisensor detector shall be annunciated in the respective panels and shall activate a local hooter/sounder in the areas where fire is activated and this fire signal shall be employed to initiate the fire extinguishing system of that area such as automatic MVW spray system of cable galleries, fire extinguishing system of Control rooms/Control Equipment Rooms.

ii) Cross zoning of the signal from two adjacent multisensor detectors shall be employed to initiate the fire extinguishing system of inert gas protected areas and MVW spray system of cable galleries.

iii) Multisensor detector shall be provided for return air ducts of main plant, which shall consist of intake probe, detector housing, and exhaust pipe etc. The detector shall be mounted outside the duct.

iv) The design coverage area for detectors (to be considered) shall not exceed 25 Sq.M. for each detector.

**6.00.00** **PIPING AND VALVES**

6.01.00 **General Data for Pipes etc.**

i) Mild steel as per IS:1239 (Part-I) medium grade (upto 150 NB) & as per IS:3589 Gr 410 (above 200 NB) or Equivalent for pipes normally filled with water.

ii) Mild steel as per IS:1239 (Part-I) medium grade (upto 150 NB) & as per IS:3589 Gr.410 (above 200 NB) or Equivalent and galvanised as per IS:4736 for pipes normally empty and periodically charged with water and foam system application.

iii) Pipe protection shall be as follows :

To prevent soil corrosion buried pipes / pipes in trench shall be properly lagged with corrosion protective tapes of coal tar type as per IS:15337 or AWWA C 203. The total thickness of protective tapes to be applied on buried pipes / pipes in trench shall be 4.0mm. This can be achieved by using 4.0mm thick tape in single layer or 2.0mm thick tape in double layer.

iv) Pipe thickness:

a) For Pipe sizes upto 150 NB and above: As per IS:1239 Part-I medium grade.

b) For Pipe sizes 200 NB and above refer Annexure-I.

v) All valves shall be as per applicable IS/BS codes & approved by TAC for specific fire protection system and shall be provided with locking arrangement (with locks) in open or close condition. Further, all gate/butterfly valves of size 200 mm & above shall be provided with spur gear reduction unit.

vi) All the flanges and counter flanges shall conform to ANSI B 16.5 Cl 150.

vii) Strainer Body as per IS:2062 (tested).

viii) Pipe Fittings

1) The material shall conform to ASTM A 234 Gr WPB or ASTM A 105 or equivalent and dimensional standard conforming to ANSI B 16.11 (socket & threaded type), ANSI B 16.9 (for butt welded fittings) and ANSI B 16.5 (for flanges and flanged fittings) as the case may be. Further, galvanised malleable cast iron fittings as per IS:1879 in Cast iron fitting as per BS-1641 are also acceptable.

2) **Grooved couplings :** Vendor may also use mechanical grooved couplings type fittings in GI pipe lines for HVW / MVW spray system. All materials and products shall be either Underwriters Laboratories (UL) Listed or Factory Mutual (FM) Approved and installed in accordance with NFPA Standard 13 / equivalent Standard.

3) The fittings shall be galvanised as per IS : 4736 for galvanised pipe application. In case of branching connections from GI mains for spray piping network, socket may be welded for more than two pipe reduction instead of standard tees.

4) Fabricated fittings shall not acceptable up to pipe size to 300 NB. For sizes 350 NB and above, fittings may be fabricated as per BS:2633/BS:534.

ix) Welding of galvanised iron pipes/fittings would be permitted provided the same is carried out by means of special electrodes suitable for the above application and the same shall be approved by Employer. After, welding, welded portions shall be applied with three coats of zinc silicate treatment/rich paint over one coat of suitable primer. Further, the Contractor shall provide proper zinc paint at the point of welding.

**7.00.00 PAINTING**

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

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

7.04.00 **All Steel Surfaces (external) exposed to atmosphere (outdoor installation)**

(i) **Surface Preparation :** The steel surfaces to be applied with painting shall be thoroughly cleaned before painting by wire brushing, air blowing, etc.

(ii) **Painting:** One (1) Coat of red oxide primer of thickness 30 to 35 microns followed up with three (3) coats synthetic enamel paint, with 25 microns as thickness of each coat. For plant at coastal area, epoxy resin based zinc phosphate primer followed by epoxy resin based paint pigmented with titanium di-oxide shall be used in place of enamel paints.

7.05.00 **All Steel Surfaces (external) inside the building (indoor installation)**

(i) **Surface Preparation :** The steel surfaces to be applied with painting shall be thoroughly cleaned before painting by wire brushing, air blowing, etc.

(ii) **Painting:** One (1) Coat of red oxide primer of thickness 30 to 35 microns followed up with two (2) coats synthetic enamel paint, with 25 microns as thickness of each coat. For plant at coastal area, epoxy resin based zinc phosphate primer followed by epoxy resin based paint pigmented with titanium di-oxide shall be used in place of enamel paints.

7.06.00 **Deluge Valves, Alarm Valves, Foam monitors, Water monitors, Foam Proportioning equipments, Foam makers, etc.**

Painting of all equipments /.components of FDPS package shall be as per manufacturer's standard practice or as detailed below whichever is superior in quality.

| Environment | Paint scheme | Total DFT |
|---|---|---|
| Normal / Mild Corrosive Environment | Primer- zinc filled epoxy<br>Finish – Aliphatic Polyurethane (shade RAL3000)(P.O Red) | Min 125 microns |
| Corrosive Environment (as in coastal areas) | Primer- zinc filled epoxy<br>Intermediate – Epoxy MIO<br>Finish – Aliphatic Polyurethane (shade RAL3000)(P.O Red) | Min 200 microns |

**ANNEXURE-I**

**PIPING THICKNESS:**

Pipes for sizes 200 NB & above shall confirm to IS: 3589 Grade 410. The final thickness shall not be less than that specified as per IS: 3589 as indicated below.

| Nominal pipe Size (mm) | Outside Diameter (mm) | Wall Thickness (mm) |
|---|---|---|
| 200 NB | 219.1 | 6.3 |
| 250 NB | 273 | 6.3 |
| 300 NB | 323.9 | 7.1 |
| 350 NB | 355.6 | 8.0 |
| 400 NB | 406.4 | 8.0 |
| 450 NB | 457 | 8.0 |
| 500 NB | 508 | 8.0 |
| 600 NB | 610 | 8.0 |

**Annexure-II**

**Technical Data:**

| | |
|---|---|
| 1. **Hydrant Valve** | Oblique female type as per IS:5290 |
| | MOC: Body/bonnet/stop valve/valve seat/trim : SS304/SS316 |
| 2. **Water monitor** | As per IS:8442 Type-I, Size: 75mm, Nozzle dia: 38mm |
| | MOC: Water barrel/reducer/elbow: CS (seamless)/SS<br>Nozzle: Copper alloy / SS confirm in to IS:3444 |
| 3. **Water branch pipe & nozzle** | As per IS:903 / IS:2871 |
| | MOC: Branch pipe: SS316 (Gr 4 of IS:3444) (both ends)<br>Nozzle : SS316 (Gr 4 of IS:3444), Size: min 16mm & max 25mm |
| 4. **Water line Gate / Sluice Valve** | - Design Code: a) IS:14846 or BS:5150 (for valves coming inside fire water pump house)<br>b) BS:5150 (for valves at other locations)<br>- Pressure rating: PN1.6 (as per IS:14846) / PN16 (as per BS:5150)<br>-Working Pr. :12Kg/cm2 |
| | MOC: Body/bonnet/Yoke/Wedge : CI to IS:210 FG-200<br>Spindle: SS to ASTM-A-276 type 410 |
| 5. **Butterfly Valve** | Design Code: Double flanged or lugged wafer type of low leakage rate confirming to BS:EN:593/API-609/AWWA C-504<br>Pressure class: PN 16 |
| | MOC: Body & Disc : Cast Iron, Shaft : SS 410 / SS 420<br>Seat Rings : EPDM |

# SUB-SECTION-I-M5

# EQUIPMENT COOLING WATER SYSTEM

# EQUIPMENT COOLING WATER SYSTEM

1.00.00 **BRIEF DESCRIPTION OF SYSTEM**

1.01.00 The Equipment Cooling Water System shall be provided for Flue Gas Desulphurization system Auxiliaries as described.

1.02.00 The Equipment cooling water system shall be common for all the three units. The cooling system for Flue Gas Desulphurization system Auxiliaries shall be of closed circuit type with demineralised (DM) water in the primary circuit. CW blowdown water tapped from CW pump discharge header would be used in the secondary circuit for cooling the primary circuit DM water. Alternatively, clarified water from existing clarified water tank may be taken as secondary cooling water in case enough water is not available in CW blowdown. Hence all materials of construction used in primary and secondary side of the equipment cooling water system should be suitable for the water quality. The scheme shall be as per relevant tender drawing listed elsewhere in the specification. The DM cooling water pumps shall be provided as indicated in the relevant tender drawing. However, bidder can use secondary circuit ACW water pumps as process water pumps or bidder may envisage separate booster pumps after PHE for FGD process water (as applicable) .

1.03.00 Quality of water

(a) Primary circuit - Demineralised (DM) water

(b) Secondary circuit - Condenser cooling water

1.04.00 The pH of DM water in the closed loop shall be continuously monitored and controlled at around 9.5. The control shall be achieved by dosing sodium hydroxide in DM water overhead tank. The dosing shall be done manually by operating dosing valve.

1.05.00 Maximum of 300cum/hr secondary cooling water will be available for 2x600MW units.

2.00.00 **SYSTEM DESIGN**

2.01.00 The ECW system design for Flue Gas Desulphurization system Auxiliaries shall be as follows:

A centralized/combined ECW system is envisaged for all FGD system auxiliaries. In the primary circuit, Demineralised cooling water (DMCW) pumps shall discharge cooling water through plate type heat exchangers (PHE) for cooling of the FGD system auxiliaries . The outlet header from plate heat exchangers shall be suitably branched off to supply cooling water to the to the individual Flue Gas Desulphurization system Auxiliaries coolers. No booster pumping system shall be provided in the primary system. Outlet from these auxiliary coolers shall be connected back into a common return header and led back to the suction of DMCW pumps to complete the closed loop primary cooling circuit.

2.02.00 The secondary circulating water system shall receive water through a tapping from CW blow down from the CW pumps discharge header/ clarified water tank. This water will be further pressurised by a set of auxiliary cooling water booster pumps and fed through the plate type heat exchangers and the discharge secondary water from PHEs shall be used as process water for FGD system.

2.03.00 For the primary cooling circuit, an overhead tank of minimum (normal) capacity of 5 Cu.M shall be provided by the bidder. Outlet of this tank shall be connected to the closed circuit return header . The normal capacity of the tank shall be at 60% of the tank height.to serve

2.04.00 Frame of each plate type heat exchanger shall have about 25% extra capacity i.e. the frame shall be able to accommodate about 25% extra plates.

2.05.00 Self cleaning Filters

To prevent fouling on the secondary cooling waterside of the PHE, self-cleaning type filters, (2 X 100%) shall be provided by the bidder on the secondary cooling water inlet header to the PHE.

2.05.00 Make up to the closed loop primary circuit shall be taken from the DM water transfer pumps located near DM water storage tank and emergency make up from the discharge of condensate transfer pumps. The make-up would be given to overhead storage tank.

2.06.00 Required orifices shall be provided in the primary and secondary circuit of Equipment Cooling Water system for balancing of pressure.

3.00.00 **CONSTRUCTION FEATURES**

3.01.00 **Pumps and Heat (PHE) Exchangers**

3.01.01 The general design and construction features of various pumps of the Equipment Cooling Water System shall be as per the Annexure titled "**General Specification For Pumps**" enclosed with this sub-section.

3.01.02 Specific features of various pumps and plate type heat exchangers of ECW system shall be as follows :-

**A) Pumps (ECW System )**

i) Type : Horizontal Centrifugal type

ii) Casing : Axially split type.

iii) Impeller type : Closed

iv) Speed : 1500 rpm (max.)

v) Drive transmission : Direct

vi) Seal : Mechanical seal for primary water pumps and Self water/gland for secondary side

vii) Lubrication : Oil/Grease/Self liquid.

viii) Coupling : Spacer type.

ix) Drain plug, vent, priming connection, ; Required.

x) Coupling guard, lifting lugs : Required

xi) Operating range : 40% to 120% of rated flow

xii) Pump characteristic : Non-overloading type & stable

xiii) Parallel operation : Required.

xv) Material of Construction:

| | **Primary Side DM Cooling Water Pumps** | **Secondary side Auxiliary Cooling Water Pumps** |
|---|---|---|
| a) Casing | ASTM-A-351 CF8M | 2.5% Ni CI to IS 210 GR FG-260 |
| b) Impeller | ASTM-A-351 CF8M | Bronze to IS 318 Gr. I/II or SS – 316 / CF8M |
| c) Impeller Wearing Rings | SS-316 | High leaded bronze to IS-318 Gr.V / SS -316 in case of SS Impeller. |
| d) Casing wearing rings | --------As per manufacturer's Standard ----- | |
| e) Shaft | SS-316 | SS-316 |
| f) Shaft Sleeve | SS-410 | SS-410 |
| g) Gland | ---------- | 2.5% Ni CI to IS 210 GR FG-260 |
| h) Lantern Ring | SS-316 | Bronze |
| i) Gland packing | ---------- | Teflon Impregnated /Manufacturer's standard (Non-Asbestos type) |
| i) Mechanical Seal | Manufacturer's Std | ---------- |
| j) Base plate | ---------- MS fabricated - IS:2062 ---------- | |
| k) Stuffing Box | ---------- | 2.5% Ni CI to IS 210 GR – FG-260 |

| | | |
|---|---|---|
| l) All fasteners | Stainless steel | Stainless steel |

**B) Plate type Heat Exchangers - Design Parameters**

(i) Type : Plate type, single pass

(ii) Design pressure : Maximum expected pressure to which PHE may be subjected plus 5% additional margin. Maximum expected pressure shall be based on the shut-off head of pumps (either the secondary or primary side whichever is maximum) plus the suction pressure of the pumps.

**Material of Construction**

| | | | |
|---|---|---|---|
| (i) | Heat transfer plate | : | SS-AISI-316 |
| (ii) | Compression / Fixed plates | : | IS:2062 |
| (iii) | Movable pressure plate | : | IS-2062 |
| (iv) | Guide rail | : | IS-2062 with stainless steel cladding |
| (v) | Support Beam/Column | : | IS 2062 |
| (vi) | Plate gasket | : | Nitrile Rubber |
| (vii) | Nozzle | : | Carbon steel |
| (viii) | Flanges | : | Carbon steel |
| (ix) | Nozzle flange Gasket | : | 3 mm wire inserted Red Rubber. |
| (x) | Nozzle flange Bolts/ Nuts | : | SA 193 B7/SA 194 2 H. |
| (xi) | Name plate | : | AISI-316 |
| (xii) | Tightening Rods | : | IS-1367 or equivalent |

**Other Features:**

(i) Double sealing arrangement should be provided at outer edge and around ports to avoid intermixing of fluids. The inter-space should be vented to atmosphere.

(ii) Plate thickness should be adequate to withstand all operating conditions but not less than 0.6 mm.

(iii) Frame of exchanger should be designed so that 25% additional plates can be added in future.

(iv) Flanges shall be per ANSI B 16.5 for equivalent.

(v) Thickness of pressure and frame plates as per ASME sec. VIII Div. I.

(vi) Minimum corrosion allowance for heat exchanger parts shall be 1.6 mm.

(vii) After pressing all the plates shall be tested by light box/vacuum/air chamber test as per manufacturers' standard practice.

(viii) The corrosion allowance for the heat exchanger plate such as pressure parts (support plates), nozzles, sliding channels and frame shall be 1.6mm (minimum).

3.02.00 **Piping, Valves /Tanks:**

Construction features of Piping, Valves and tanks shall be as per the sub-section titled "Low Pressure Piping" of this Technical specification

3.03.00 Self cleaning strainer**:**

(a) Body of filter shall conform to IS:210Gr. FG260 or ASTM-A-515 Gr. 75/IS: 2062 and internally painted with epoxy.

(b) Strainer element shall be constructed of perforated stainless steel plant linked with stainless steel (SS316) screen for fresh water and SS316L grade SS screen for sea water.

(c) The mesh size shall be selected on the basis of average clearance between the plates of the plate heat exchanger.

3.04.00 **Construction features of ECW overhead tank**

| **Sl. No.** | **Description** | | **Tech. Particulars** |
|---|---|---|---|
| I. | Quantity | : | One (1) |
| II. | Capacity | : | 5 Cu.M (Minimum.) |
| III. | Type | : | Horizontal Dished ends |
| IV. | Design Pressure | : | Atmospheric |
| V. | Design Standard | : | ASME Boiler and Pressure Vessel code Section-VIII/IS:2825 (Class 3) |
| VI. | Material of Construction | : | Plates to IS:2062/ ASTM A36.Minimum shell thickness shall be 6mm. |
| VII. | ACCESSORIES | | |
| | (a) Vent, overflow and drain | : | Required (Overflow drain to be taken upto '0' M plant drain) |

| | | | | |
|---|---|---|---|---|
| | (b) | $CO_2$ absorber for vent | : | Required |
| | (c) | Seal for overflow | : | Required |
| | (d) | Manhole & approach ladder/platform/ | : | Required |
| 3.05.00 | **Construction features of Alkali dosing tank.** | | | |
| | Quantity per Unit | | : | One (1) |
| | Useful Capacity of Each Tank | | : | Suitable for the system (Minimum 500 lt) |
| | Size (Dia. x Height) | | : | Adequate |
| | Type | | : | Vertical cylinder, dished bottom |
| | Design Pressure | | : | Atmospheric |
| | Design Standard | | : | ASME Boiler & Pressure vessles Code Section-VIII. Div.I/ IS:2825 (Class-3) |
| | Material of Construction | | : | MS Plates to IS:2062/ ASTM A36. with rubber lining of 4.5 mm thick & Minimum shell thickness shall be 6mm. OR SS plates of minimum thickness of 3 mm . |
| | Dissolving Basket | | : | AISI-316, |
| | Agitator | | : | stainless steel 316SS construction along with drive motor of suitable rating and protection class. (With Slow speed reduction gear unit) |
| | Accessories | | | |
| | (a) | Vent, overflow and Drain | : | Required |
| | (b) | Sample Connection | : | Required |
| 4.00.00 | **SIZING / DESIGN CRITERIA** | | | |
| 4.01.00 | **Pumps** | | | |
| | a) | Flow | : | Secondary Water pumps: |

| | | | | |
|---|---|---|---|---|
| | | | | Design flow – less than or equal to maximum flow available indicated in Annexure-II. |
| | | | | Primary Water pumps.<br><br>Design flow of all Flue Gas Desulphurization system Auxiliaries coolers.. |
| | b) | Head | : | As per system, requirement +10% margin on friction head. |
| | c) | Motor rating | : | Continuous motor rating (at 50 degree C ambient) for all pumps shall be at least ten percent (10%) above the maximum power requirement at any condition of the entire characteristic curve of the pump. |
| | d) | No. of Primary side pumps | : | As indicated in Part A of the specification. |
| | e) | No. of Secondary water pumps | : | As indicated in part A of the specification |
| | f) | Re-circulation control Valves, Piping & Pressure break down orifice. | : | Required |
| | g) | Additional design requirements | : | a) To be referred in the Annexure sub-section titled "GENERAL SPECIFICATION FOR HORIZONTAL PUMPS" enclosed with this section. |
| 4.02.00 | **Plate Type Heat Exchangers** | | | |
| | a) | Design Secondary water Inlet temperature | : | Not less than 36 deg. C |
| | b) | Secondary water outlet | : | Temperature as achieved subject to the maximum ACW flow indicated. |
| | d) | Overall fouling factor (minimum) (f) | : | $0.8 \times 10^{-4}$ Hr $M^2$ deg C/Kcal |
| | e) | No. of heat exchangers/ unit | : | As indicated in part A of the specification |
| | f) | Overall Heat transfer coefficient [U(o)] | : | As per manufacturer's design |
| | g) | Dirty Heat transfer Coefficient [U(d)] | : | [1 / (1/U(o) +f) ] |
| | h) | Heat Transfer Area (Sqm) | : | $\frac{\text{Total Heat Load (in Kcal/hr)}}{\text{U(d) x LMTD}}$ |
| | i) | Heat transfer area of PHE shall be selected such that each Sq.M of heat transfer plate shall transfer not more than 6500 Kcal/hr. | | |

| | |
|---|---|
| 5.00.00 | **INSTRUMENTATION** |
| 5.01.00 | All instruments, such as thermowell, temperature element alongwith temperature transmitter, flow element, pressure/DP and temperature gauge/transmitters/sensors/switches, DP switch, pH analyzer, Rotameter etc. alongwith associated devices should meet the requirement as specified in relevant sub-section of this Technical Specification and shall be sufficient to meet all interlock/protection & operation requirement. |
| 5.02.00 | Minimum instrumentation required for the Equipment Cooling water system shall be as per tender P & I Diagram wherever included in the specification. |
| 6.00.00 | **CONTROL / OPERATION PHILOSOPHY** |
| 6.02.00 | The pump suction valves, re-circulation valves and discharge valves shall be motor actuated type to enable remote operation. |
| 6.03.00 | Pump suction valves shall be provided with required limit switches for interlock & control. |
| 6.04.00 | The pumps shall be designed to operate under discharge valve open and as well as in close condition. |
| 6.05.00 | Wherever more than one sump/tank is provided, Suction header shall be interconnected such a way that any of the sump/tank may be selected from the panel for operation. |
| 6.06.00 | Any of the pump shall be selectable as standby duty. Standby pump shall come into operation on tripping of working pump or inadequate pressure in the discharge header. |
| 6.07.00 | Suction and Discharge valves of pumps shall be interlocked with start/stop of respective pumps. |
| 6.08.00 | Local emergency stop provision for each pump shall be provided. |
| 6.09.00 | All the working pumps shall be interlocked with the suction level or suction pressure condition as the case may be. Pumps operation shall be interlocked with the high discharge condition so that the pump may not operate at shut-off pressure. |
| 6.10.00 | Automatic inlet valves at supply line to each of the tank/sump shall be provided so that the valves shall open and close at low-level and very high-level respectively. |
| 6.11.00 | A control valve shall be provided to maintain a constant pressure differential between the main supply and return headers of DM water. The valve will bypass flow to maintain a constant return header pressure to compensate for fluctuations in |

| | |
|---|---|
| | coolant flow to the process heat exchangers due to modulating control valves on the process coolers or if any cooler goes out of service in DM circuit. |
| 6.12.00 | Alarm to indicate high differential pressure across self-cleaning filter strainers, heat exchangers as the case may be. |
| 6.13.00 | Manually operating globe / regulating valves shall be provided in the water side of each of the cooler outlet for control of flow as specified in respective equipment specification. |
| 6.14.00 | Detailed Interlock & protection logic to be implemented in FGD control system shall be provided by the contractor and the same shall be as finalized during detailed engineering. |
| 7.00.00 | **PAINTING** |
| 7.01.00 | All the equipments such as pumps, tanks and plate type exchangers of this system shall be protected against external corrosion by providing suitable painting as mentioned below. For painting of valves and piping, relevant section shall be referred to. |
| 7.02.00 | The surfaces of stainless steel, Gunmetal, brass, bronze and non-metallic components shall not be applied with any painting. |
| 7.03.00 | The steel surface to be applied with painting shall be thoroughly cleaned before applying painting by brushing, shot-blasting etc as per the agreed procedure. |
| 7.04.00 | For all the steel surfaces exposed to (outdoor installation) atmosphere, a coat of chlorinated rubber based zinc phosphate primer of minimum thickness DFT of 50 microns followed up with undercoat of chlorinated rubber paint of minimum DFT of 50 microns shall be applied. Then, intermediate coat consisting of one coat of chlorinated rubber based paint pigmented with Titanium di-oxide with minimum DFT of 50 microns and topcoat consisting of two coats of chlorinated rubber paint of approved shade and color with glossy finish and DFT of 100 microns shall be provided. Total DFT of paint system shall not be less than 200 microns. |
| 7.05.00 | For all the steel surfaces inside the (indoor installation) building, a coat of red oxide primer of minimum thickness of 50 microns followed up with undercoat of synthetic enamel paint of minimum thickness of 50 microns shall be applied. The top coat shall consist of two coats each of minimum thickness of 50 microns of synthetic enamel paint and thus total thickness shall be minimum 200 microns. |
| 7.06.00 | Internal surfaces of ECW over tank shall be painted with One coat of unmodified epoxy resin alongwith polyamide hardener and minimum two (2) coats unmodified epoxy resin alongwith Aromatic adduct hardener and total thickness of primer and paint should not be less than 400 microns. |

**Annexure-I to ECW system Specification**

## GENERAL SPECIFICATION FOR HORIZONTAL PUMPS

(1) **SCOPE**

This specification covers the design, material, construction features, manufacture, inspection, testing the performance at the Vendor's/Sub-Vendor's Works and delivery to site of Horizontal Centrifugal Pumps.

(2) **CODES AND STANDARDS**

The design, material, construction, manufacture inspection and performance testing of Horizontal Centrifugal Pumps shall comply with all currently applicable statutes, regulations and safety codes in the locality where the Equipment will be installed. Nothing in these specifications shall be construed to relieve the Vendor of this responsibility. The Equipment supplied shall comply with the latest applicable Indian Standards listed below. Other National Standards are acceptable, if they are established to be equal or superior to the Indian Standards.

(3) **LIST OF APPLICABLE STANDARDS**

| | | |
|---|---|---|
| IS : 1520 | : | Horizontal Centrifugal Pumps for clear cold fresh water |
| IS : 5120 | : | Technical requirements of rotodynamic special purpose pumps |
| API : 610 | : | Centrifugal pumps for general refinery service. |
| IS : 5639 | : | Pumps Handling Chemicals & corrosion liquids |
| IS : 5659 | : | Pumps for process water |
| HIS | : | Hydraulic Institute Standards, USA |
| ASTM-1-165-65: | | Standards Methods for Liquid Penetration Inspection. |

In case of any contradiction with aforesaid standards and the stipulations as per the technical specifications as specified hereinafter the stipulations of the technical specifications shall prevail.

(4) **DESIGN REQUIREMENTS**

(a) The Pump shall be capable of developing the required total head at rated capacity for continuous operation. Also the pumps shall be capable of being operated to give satisfactory performance at any point on the HQ characteristics curve. The operating range of the pump shall be 40% to 120% of the duty point unless otherwise mentioned elsewhere. The maximum efficiency

of pump shall preferably be within ± 10% of the rated design flow as indicated in data sheets.

(b) The total head capacity curve shall be continuously rising from the operating point towards shut – off without any zone of instability with the highest head at shut-off condition. Shut-off head shall be more than the rated design head by 15 % or more for radial flow pump and 25 % more than the design head for mixed flow/turbine type pumps.

(c) Pumps of a particular category shall be identical and shall be suitable for parallel operation with equal load division. The head Vs capacity and BHP Vs capacity characteristics should match to ensure even load sharing and trouble free operation throughout the range. Components of identical pumps shall be interchangeable.

(d) Pumps shall run smoothly without undue noise and vibration. Peak to peak vibration limits shall be restricted to the following values during operation:

| Speed | Antifriction Bearing | Sleeve Bearing |
|---|---|---|
| 1500 rpm and below | 75.0 micron | 75.0 micron |
| 3000 rpm | 50.0 micron | 65.0 micron |

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.

(e) The pumps shall be capable of starting with discharge valve fully open and close condition. Motors shall be selected to suit to the above requirements.

(f) Pumps shall be so designed that pump impellers and other accessories of the pumps are not damaged due to flow reversal.

(g) The Contractor under this specification shall assume full responsibility in the operation of pump and motor as a unit.

(5) **DESIGN CONSTRUCTION**

(a) Design and construction of various components of the pumps shall conform to the following general specifications. For material of construction of the components, data sheets shall be referred to.

(b) Pump Casing

Pump casing shall have axially or radially split type construction as specified. The casing shall be designed to withstand the maximum shut-off pressure developed by the pump at the pumping temperature.

Pump casing shall be provided with a vent connection and piping with fittings & valves. Casing drain as required shall be provided complete with drain valves, piping and plugs. It shall be provided with a connection for suction and

discharge pressure gauge as standard feature. It shall be structurally sound to provide housing for the pump assembly and shall be designed hydraulically to minimum radial load at part load operation.

(c) Impeller

Impeller shall be closed, semi-closed or open type as specified elsewhere and designed in conformance with the detailed analysis of the liquid being handled.

The impeller shall be secured to the shaft, and shall be retained against circumferential movement by keying, pinning or lock rings. On pumps with overhung shaft, impellers shall be secured to the shaft by a lockout or cap screw which tightness in the direction of normal rotation.

(d) Impeller/Casing Wearing Rings

Replaceable type wearing rings shall be provided at suitable locations of pumps as per manufacturer's standard practice. Suitable method of locking the wearing ring shall be used.

(e) Shaft

The critical speed shall be well away from the operating speed and in no case less than 130% of the rated speed.

The shaft shall be ground and polished to final dimensions and shall be adequately sized to withstand all stresses from rotor weight, hydraulic loads, vibration and torques coming in during operation.

(f) Shaft Sleeves

Renewable type fine finished shaft sleeves shall be provided at the stuffing boxes/mechanical seals. Length of the shaft sleeves must extend beyond the outer faces of gland packing of seal end plates so as to distinguish between the leakage between shaft and shaft sleeve and that past the seals/gland.

Shaft sleeves shall be fastened to the shaft to prevent any leakage or loosening. Shaft and shaft sleeve assembly should ensure concentric rotation.

(g) Bearings

Heavy duty bearings, adequately designed for the type of service specified in the enclosed pump data sheet and for long, trouble free operation shall be furnished.

The bearings offered shall be capable of taking both the radial and axial thrust coming into play during operation. In case, sleeve bearings are offered additional thrust bearings shall be provided. Antifriction bearings of standard type, if provided, shall be selected for a minimum life 20,000 hrs. of continuous operation at maximum axial and radial loads and rated speed.

Proper lubricating arrangement for the bearings shall be provided. The design shall be such that the bearing lubricating element does not contaminate the liquid pumped. Where there is a possibility of liquid entering the bearings suitable arrangement in the form of deflectors or any other suitable arrangement must be provided ahead of bearings assembly.

Bearings shall be easily accessible without disturbing the pump assembly. A drain plug shall be provided at the bottom of each bearings housing.

(h) Stuffing Boxes

Stuffing boxes of packed ring construction type shall be provided wherever specified. Packed ring stuffing boxes shall be properly lubricated and sealed as per service requirements and manufacturer's standards. If external gland sealing is required, it shall be done from the pump discharge. The Bidder shall provide the necessary piping valves, fittings etc. for the gland sealing connection.

(i) Mechanical Seals

Wherever specified in pump data sheet, mechanical seals shall be provided. Unless otherwise recommended by the tenderer, mechanical seals shall be of single type with either sliding gasket or bellows between the axially moving face and shaft sleeves or any other suitable type. The sealing faces should be highly lapped surfaces of materials known for their low frictional coefficient and resistance to corrosion against the liquid being pumped.

(j) The pump supplier shall coordinate with the seal maker in establishing the seal chamber of circulation rate for maintaining a stable film at the seal face. The seal piping system shall form an integral part of the pump assembly. For the seals under vacuum service, the seal design must ensure sealing against atmospheric pressure even when the pumps are not operating. Necessary provision for seal water supply along with complete piping fittings and valves as required shall form integral part of pump supply.

(k) Pump Shaft Motor Shaft Coupling

The pump and motor shafts shall be connected with an adequately sized flexible coupling of proven design with a spacer to facilitate dismantling of the pump without disturbing the motor. Necessary coupling guards shall also be provided.

(l) Base Plate

A common base plate mounting both for the pump and motor shall be furnished. The base plate shall be fabricated steel and of rigid construction, suitably ribbed and reinforced. Base plate and pump supports shall be so constructed and the piping unit so mounted as to minimize misalignment caused by mechanical forces such as normal piping strain, internal differential

thermal expansion and hydraulic piping thrust. Suitable drain troughs and drip lip shall be provided.

(m) Assembly and Dismantling

Assembly and dismantling of each pump with drive motor shall be possible without disturbing the grouting base plate or alignment.

(n) Drive Motor (Prime Mover)

Continuous Motor rating (at 50 0 C ambient) shall be at least ten percent (10%) above the maximum load demand of the pump in the entire operating range to take care of the system frequency variation and in no case less than the maximum power requirement at any condition of the entire characteristic curve of the pump. The KW rating of the drive unit shall be based on continuously driving the connected equipment for the conditions specified. However, in cases where parallel operation of the pumps are specified, the actual motor rating is to be selected by the Bidder considering overloading of the pumps in the event of tripping of operating pump(s).

# SUB-SECTION-I-M6

# LIMESTONE & GYPSUM HANDLING SYSTEM

**1.0.0 INTRODUCTION**

This section of the specification provides the detailed technical requirements for the Limestone & Gypsum Handling System.

**2.0.0 CODES AND SPECIFICATIONS**

2.1.0 All plant, equipment, systems and works covered under this contract shall comply with the latest editions including amendments of applicable codes, standards, statutes, regulations and safety rules as on the date of submission of bid. Particular care shall be exercised in observing compliance to the rules and regulations governing the locality where the plant is to be installed. Contractor's obligations in this regard shall not be limited to only those codes and standards mentioned in this contract. Nothing in these specifications shall be construed to relieve the Contractor of his responsibility.

2.2.0 In the event of any conflict between the applicable codes and standards and the requirements of this contract, the more stringent of the two shall govern.

2.3.0 The specific codes / standards followed for the design of the system are as below and relevant codes are also indicated against each equipment:

| | |
|---|---|
| CEMA | Conveyor Belt Manufacturing Association |
| IS:11592 - 2000 | Code of practice for selection and design of belt conveyors |
| IS:1891 - 1994 | Conveyor and elevator textile beltings spec.Part.1 General |
| IS:14386 -1996 | Belt conveyors-Traveling Tripper- Motorised for belt widths 650mm to 1600 mm- Dimensions |
| IS:8531-1986 | Specification for Pulleys for Belt conveyors |
| IS:8598 - 1987 | Specification for Idlers and idlers set for belt conveyors |
| IS 9295 - 1983 | Steel tubes for Idlers for Belt conveyors |
| ISO 5049/1 or IS 800 | Code of construction of structural works. |
| IS 16143 (Par 2& 4)/ ASTM C50// ASTM D2013 | Lime stone Sampling System |
| IS:2062 - 2006 | Steel for general structural purposes. |
| IS:1239 2004 part 1 | Spec for mild steel tubes tubular and other wrought steel |
| IS:3589 : 2001 | Steel pipes for water and sewage (168.3 to 2504mm outside diameter) |
| IS: 325 | Three Phase induction motors |
| ASHRAE :2007 | HVAC applications |

| | |
|---|---|
| IS 3832 : 2005 | Manual hoist / CPB |
| IS 3938 : 1983 | Electric hoist |
| IS 3177 : 1999 | EOT Crane |
| IS 4894 : 1987 | Specification for centrifugal fan |
| IS 7155(part 5):1990 | Code of Recommended Practice for Conveyor safety |

The extraction capacity of dust extraction system shall be based on "American Conference of Governmental Industrial Hygienists"(ACGIH).

**3.00.00 NOT USED**

**4.00.00 DESIGN CRITERIA**

**4.01.00 General**

Rated capacity of Limestone handling system shall be minimum 150 TPH. Similarly, the rated capacity of Gypsum handling system shall be 150TPH. The truck tipplers for unloading of limestone shall be rated for 5Tips/hr for 40 Ton payload. Following aspects shall be taken care in the design of the limestone/Gypsum handling system:

(i) The limestone delivered to power station shall be of size 250mm and below. However, occasionally 1-2% limestone of 400 mm lump size may also be encountered.

(ii) Occasionally, metal pieces like broken shovel teeth, brake shoe, wires, shale & sand stone as high as 20% etc. may also come along with Limestone.

(iii) The limestone as received' shall contain varying percentage of fines. This may form adhesive lumps particularly during monsoon when surface moisture is at its maximum value. The sizing and selection of all equipment shall take care of above.

(iv) For volumetric computations of limestone handling system the bulk density of limestone shall be taken as 1400 kg/m3. However for torque & drive requirements the density of lime stone shall be taken as 1700 kg/m3.

(v) For gypsum handling system, the bulk density shall be taken as 900 kg/m3 for volumetric computation and 1250 kg/m3 for torque and drive requirements.

**4.02.00 Conveying**

The design capacity of each belt conveyor shall be 110% of rated capacity. The belt speed shall not be more than 2m/sec, angle of belt conveyor shall be less than 14deg and width not less than 800mm upto crusher and after that minimum 650mm belt width upto limestone mill bunker shall be provided. For gypsum handling system the belt width shall be 650mm throughout. The motor rating shall selected for rated capacity with continuous duty at 50 deg C Ambient temperature.

Belt conveyor system shall be designed as per the 5th edition of 'Belt Conveyors for Bulk Materials' published by Conveyor Equipment Manufacturer's Association' or equivalent International Standard. Suitable crossover in the gallery shall be provided at an interval of 100mm.

All mechanical, Electrical, civil and structural system design shall consider:

a. Simultaneous running of both conveyors at rated capacity.
a. Starting of one stream with other stream in standstill condition.
b. Starting of one stream with other stream in operation at rated capacity.
c. Round the clock operation of Limestone & Gypsum Handing Plant.

**4.03.00 Equipment Sizing**

**4.03.01 Design capacities & margins**

| Sl no | Equipment | Duty requirement | Design capacity as %age of duty requirement |
|---|---|---|---|
| 1 | Crushers | 2x 100% | 110% |
| 2. | Vibrating Screen feeders | 2x 100% | 110% |
| 4 | Belt feeder | 2x 100% | 110% |
| 5. | Bucket elevator | 2x 100% | 110% |
| 6. | Travelling Tripper (if applicable) | 2x 100% | 110% |

**4.03.02 Drive equipment Rating**

Continuous Motor Rating (Name Plate Rating) at 50 Degree Centigrade Ambient temp. for Electric Motors

a) For conveyors of belt conveyor systems — *120% of actual power at drive motor output shaft at specified design capacity

b) Crushers, monorail hoists (travel and hoisting), elevators, rack and pinion gates, all the drives in sampling units, various pumps of DS/DE systems, service water systems, cooling water system, potable water system and sump pumps, Ventilation Fans. — *110% of actual power requirement at drive motor output shaft at guaranteed (rated) capacity.

*The actual power at drive motor output shaft shall be calculated after considering all the losses of down the line equipment's of the drive train.

**Gear Box Rating :**

**a)** For belt conveyor systems @ Service factor X {1.2 times the actual power requirement at drive pulley shaft at design capacity}
In any case, gear box rating shall not be less than motor nameplate rating

**b)** For other equipment @ Service factor X {1.2 times the actual power requirement of the driven equipment}

@ Service factor shall include all the components considered by the supplier and should be clearly indicated in manufacturer's gear box selection catalogues

**Coupling**
Not less than motor nameplate rating.

**BOX FEEDER OR BULK MATERIAL RECEIVING UNIT OR TRUCK UNLOADING SYSTEM OR SURFACE FEEDER:**

The Box Feeder should be a robust, proven, above the ground for unloading from trucks/ self-tipping trucks or from loader shovels. The unit should be designed for rapid intake and temporary live storage of material before transferring on to the crusher house. The intake and onward discharge capacity to be 150 TPH per Box Feeder.

**Truck Tippler**
a) The hydraulic Truck tippler shall consist of heavy duty steel fabricated frame with anti skid chquered plate welded on it, pair of heavy duty hydraulic cylinder for lifting, overturning arrestor, a pair of back stopper and mechanical locking arrangement.
b) The hydraulic power pack shall be totally enclosed and consist of hydraulic gear
pump, electric motor with starter panel, hydraulic oil tank, control valves, high pressure pipe line & hoses, control panel fitted with push button switches etc.
c) Capacity : 60 Tonne
Max. Titling angle : 55
Main Structure : Steel IS 2062/IS 1570

**4.03.03** **Hoists**
Drive

| | | |
|---|---|---|
| (i) | More than 2.0 tonne or more than 10.0 m lift or hoists coming out-side the buildings | Motor driven for both travel & lift. |
| (ii) | Other hoists including the hoists for handling takeup pulley and takeup weight | Manual for both travel & lift. |

**4.03.04** **Belt Scale**

Belt scale shall be designed for a range of 20% to 120% of rated capacity with an accuracy of at least (±) 0.25 percent throughout its range.

**4.03.05** **Belting and Pulleys for 150TPH rated conveying capacity**

Conveyor System

i. Rated capacity : 150 TPH
ii. Minimum Belt width : 800 mm upto crusher house & 650 mm onwards
iii. Maximum Belt speed : 2 M/sec.

(a) Belt ratings shall be selected in such a way that there are only three (3) ratings of belting. This however excludes and belting of belt feeders. Belting shall be completely interchangeable among same rating of belt.

(b) Minimum number of plies shall be three (3).

(c) For Pulley, following minimum parameters shall be followed:

- Maximum allowable deflection of shaft at hubs : 5 Minutes
- End disc plate thickness : 12 mm (min.)
- Shell plate thickness : 12 mm (min.)
- Diameter:
  (i) All drive pulleys : 630 dia (min)
  (ii) All balance pulleys : 500 dia (min)

(d) Maximum type of pulleys permitted based on pulley diameter and shaft diameter shall be limited to three (3) nos. These shall comprise of two (2) nos. drive pulleys & one (1) no. for all balance pulleys excluding tripper & SS pulleys.

4.04.00 **Dust extraction system**

Type Venturi scrubber type

Location
- Belt feeder after crusher
- Feeder at crusher house
- Limestone Storage Silo
- Gypsum Shed

4.05.00 **Service Water System**

Service water connections are to be provided in conveyor galleries & tunnels at 50 meter interval and one (1) no. on each floor of Transfer Points, toilets and minimum two (2) nos. on each floor of crusher house.

(a.) Flow at each valve : 5 m3/hr
(b.) Minimum discharge Pressure at tap point : 2 kg/sq.cm
(c) No. of valves operated Simultaneously : 6 nos.

4.06.00 **Ventilation System**

| | | |
|---|---|---|
| **A** | Mechanical Ventilation System | |
| | underground areas exhaust | Minimum 15 supply air changes and minimum 7 air changes per hour |
| | Other Areas | Minimum 10 supply air changes per hour |
| **B** | **Pressurized Ventilation System** | Minimum 15 supply air changes per hour |

4.07.00 **Chutes:**
Minimum clear cross section of chute: 800 mm X 550 mm (inside both ways for 800mm belt width) and 700 x 450mm (inside both ways for 650mm belt width)

4.08.00 **Fire Fighting System**
Suitable fire fighting system shall be for the limestone and gypsum handling system.

**BUCKET ELEVATOR SYSTEM**

**4.19.01 General Requirement**
The type (Centrifugal/Continuous) of the chain type Bucket Elevator shall be chosen by Bidder for the material and conditions specified. The Bucket Elevator shall be sized to handle the design capacity at the specified material bulk density & maximum material size. The equipment shall be complete with all necessary sub-systems and components and shall be designed and supplied in conformance with the attached datasheets, site conditions, specific Employer's requirements and applicable International, National, State and Local codes. The Equipment shall be complete in all aspects and all items required for erection/smooth operation shall be in Bidder's scope, unless otherwise noted in exclusions. Sizing of the equipment and components shall be the responsibility of the Bidder, based on the service conditions specified.

**4.19.02 Codes and Standards**
All design, fabrication, testing, supply and erection, if applicable, shall conform to the latest edition of all the relevant standards and regulations issued by the governing bodies.
Bidder shall follow the applicable INDIAN/INTERNATIONAL codes by the following organizations.
EN European Norm
IEC International Electro technical Commission
ISO International Organization for Standardization
DIN German Institute for Standardization (To be used when no EN standards exist)
Other internationally acceptable standards/codes, which ensure equal or higher performance than those specified, shall also be accepted. Nothing in this specification shall be construed to relieve the contractor of the required statutory responsibility. In case of any conflict in the standard and this specification, the decision of the Employer shall be final and binding.

**4.19.03 Design Requirement**

**4.19.04 Design Criteria**
The equipment shall be designed for continuous twenty-four hour service. The Equipment shall be designed for service in a heavy duty industrial application, handling abrasive materials in a dusty environment.

The Bucket Elevator should be sized to handle the design capacity as indicated on the Data Sheet with the minimum material bulk density and a maximum bucket filling of 75%.

**4.19.05 Casing**

Casing to be self-supported, dust-tight construction and capable of supporting head shaft, drive, and service platform.

Head section is to be split and equipped with handles or lifting lugs for easy removal. Access and inspection doors are to be provided.

Intermediate sections are to have a minimum plate thickness of 4 mm.

Boot section to be fabricated of minimum 6mm steel plate, with front and rear access panels.

A beam is to be provided in casing for servicing internal gravity take-up. The beam may be located either in the boot section or intermediate section as applicable.

**4.19.06 Buckets**

Size, capacity and type of buckets and appropriate reinforcement necessary for the application shall be adequately sized. Provide pin holes in bottom of buckets for air relief, as necessary, when handling materials such as Limestone or gypsum. Bucket width is to be a minimum of four times the maximum particle size.

**4.19.07 Belting**

Belting shall be provided as specified else where in the specification.

**4.19.08 Pulley**

Drive and guide pulleys shall be provided as specified else where in the specification and shall be at least the minimum recommended for belt conveyor pulleys.

**4.19.09 Head Shaft and Bearings**

The bearings on head shaft to be antifriction type with one bearing fixed and the other expansion. All bearings are to have an L10 life of 60000 hours.

**4.19.10 Foot Shaft and Bearings**

The tail shaft is to be of hardened steel with tool steel sleeves operating in heat treated white iron bearings. All bearings are to have an L10 life of 60000 hours.

**4.19.11 Take-up**

Take-up shall be screw or internal gravity type with guide rails and weights included.

**4.19.12 Drive**

Bucket elevator drive should be sized as follows:

Minimum power for drive, either:

100% bucket filling @ minimum material bulk density, or

75% bucket filling @ maximum material bulk density, whichever is greater.

**4.19.13 Inspection and Access Doors**

Inspection doors and access doors shall be loose-hinged type with quick-opening jamb bar fasteners and gaskets enclosed and retained in the door. Access doors shall be 1.5m minimum.

**4.19.14 Dust Vent**

A dust collecting vent in the head section and boot section shall be furnished with drilled flanges. Bidder quote is to include recommended vent volumes for the boot and head sections of the elevator. The Pick-Up velocity shall not be greater than 2.5m/sec.

**4.19.15 Drive Equipment**

The Drive Equipment for Bucket Elevator shall be as specified elsewhere in the specification.

4.20.0 **Crushed Limestone Storage Silo:**

The crushed limestone storage silo shall be fabricated of minimum 12 mm thick (including corrosion allowances) carbon steel with a SS lining of grade SS304 of minimum 4 mm thickness in the complete conical portion to ensure reliable discharge of material. The design of storage silos shall confirm to IS 9178 (part 1 of 3)

**5.0.0 DATA SHEET OF MAJOR EQUIPMENT OF THE PROPOSED SYSTEM**

**DATA SHEET: BELT CONVEYOR**

| | | |
|---|---|---|
| 1.0.0 | **GENERAL** | |
| 1.1.0 | Design Capacity | 110% of rated (guaranteed) capacity for all conveyors. |
| 1.2.0 | Maximum slope | 14 deg |
| 1.3.0 | Max. belt Sag between idlers | 2% |
| 1.4.0 | Minimum Radius | |
| | (i) Concave curve | 250 m (In case of travelling trippers, the requirement of minimum radius shall be decided based on the space availability) |
| | (ii) Convex Curve | 50 m |
| 1.5.0 | Limestone Parameters | As specified elsewhere |
| 2.0.0 | **DESIGN & CONSTRUCTION** | |
| 2.1.0 | **Belting** | |
| 2.1.1 | Type | Synthetic Fabric of Nylon / Nylon |
| 2.1.2 | Cover Grade | a) Flame test : Conforming to ISO:340<br>b) Drum Friction and Electrical Surface Resistance Test: Conforming to Canadian standard association CAN / CSA M-422- M87 Grade - C. |
| 2.1.3 | Cover Thickness (without –ve tolerances). | Synthetic belting |
| | (a) Face | 5.0 mm (min.) |
| | (b) Bottom | 2.0 mm (min.) |
| 2.1.4 | No. of plies | Minimum 3 |
| 2.1.5 | Drive Arrangement | Snub drive |
| 2.1.6 | Factor of Safety | - 10 (Minimum) for N-N belt.<br>- 7 (minimum) for Steel Cord Belt. |
| 2.1.7 | Normal Working tension at design capacity | Less than 80% of max. allowable working tension |
| 2.2.0 | **Idlers** | |
| 2.2.1 | Type | |
| | (a) Carrying | Three roll, 35 degree troughing, 2 degree forward tilt |
| | (b) Return | Single Roll, For conveyors upto 400 m c/c length. Two roll with 10 degree angle for conveyors more than 400 m c/c length |
| | (c) Loading point | Impact type |
| 2.2.2 | Spacing | |
| | (a) Carrying idlers | 1.2 m (0.6 m for convex curves). |
| | (b) Return idlers | 3.0 m (for convex curves not more than 1.5 m.) |
| | (c) Loading point | Minimum six (6) with 400 mm spacing. |
| | (d) Self-aligning troughing idlers | At 10 m distance from head & Tail pulleys with intermediate spacing 15m |
| | (e) Self - aligning return idlers | At 10 m distance from Head & Tail pulleys with intermediate spacing 20m. (Not required for conveyors more than 400m c/c long where 2 roll return idlers are provided). |

| | | |
|---|---|---|
| 2.2.3 | Bearings | |
| | (a) Carrying | Ball Bearings of deep groove type or seize resistance type of min. 30 mm size, lubricated for life. |
| | (b) Return | Ball Bearings of deep groove type or seize resistance type of min. 20 mm size, lubricated for life. |
| 2.2.4 | Material | |
| | (a) Roller | ERW Steel tube min. wall thickness 4.0 mm |
| | (b) Spindle | EN- 8 or equivalent. |
| 2.3.0 | **Belt Cleaners** | |
| 2.3.1 | External | Spring loaded scraper type cleaner with modular, segmented and replaceable PU blades with separate main-cleaner & pre-cleaner etc. |
| 2.3.2 | Internal | V-Plough type, mild steel flats with hard rubber strips. |
| 2.4.0 | **Belt Take up** | |
| 2.4.1 | Type | Automatic Gravity Type. |
| 2.4.2 | Location | In relation to the drive to keep belt tension at minimum. |
| 2.4.3 | Take-up travel | To suit all operating conditions or (2.5% for synthetic belt and 0.5% for steel/cord belt) of conveyor center to center length whichever is larger. Further the initial location of take-up shall be decided in such a way that it is possible to carryout min. two (2) nos. Vulcanizing Joints without adding any external belt. |
| 2.5.0 | Hold Back Device | Integral with gear Box |
| 2.6.0 | **Pulleys** | |
| 2.6.1 | General (for all types of Pulleys) | |
| | Pulley shaft diameter | Margin of minimum 20% shall be Considered on maximum tension at design capacity for arriving at the shaft dia. |
| 2.6.2 | Drive Pulleys | |
| | (1) Lagging | Hot lagged with vulcanized natural rubber |
| | (2) Lagging thickness | 12 mm thick grooved in diamond pattern with grooves 6 mm wide x 6 mm deep |
| | (3) Minimum angle of wrap | 210° degrees |
| | (4) Maximum Out of roundness | 0.5% of nominal diameter |
| 2.6.3 | Other pulleys | |
| | (1) Lagging | Hot lagged with vulcanized natural rubber |
| | (2) Lagging thickness | 12 mm thick plain |
| 2.6.4 | Rubber for lagging | |
| | (1) Type | Natural rubber blended with styrene Butadiene rubber. |
| | (2) Hardness | 55 to 65 durometer (Shore A) |
| | (3) Elongation | Over 300% |
| | (4) Strength | 160-245 kg/cm$^2$ |
| | (5) Abrasion loss | 250 mm3 (max.) as per DIN 53516 |
| | (6) Specific Gravity | Max. 1.5 |
| | (7) Adhesion Strength | 10 kg/cm (minimum) |

| | | |
|---|---|---|
| 2.6.5 | Bearings for Pulleys | |
| | (1) Type | Heavy duty roller type |
| | (2) Casing | Horizontal Split Type |
| | (3) Sealing | Dust tight with double labyrinth seals. |
| | (4) Lubrication | Greasing arrangement with conical head shape nipples. |
| 2.6.6 | Pulley Material | Mild steel conforming IS:226 / IS : 2062 |
| 2.6.7 | Shaft Material | Forged Steel shaft EN-8 or equivalent material. |
| 2.7.0 | **Belt Protection Equipment** | |
| 2.7.1 | Emergency Stop Switch System | |
| | (1) Type | Pull chord type (manually reset) |
| | (2) Location | Both sides of conveyor for entire length |
| | (3) Spacing | Approx 30 m |
| 2.7.2 | Belt Sway Switches | |
| | (1) Type | Limit switches snap action. |
| | (2) Spacing | One pair at 50m interval (Minimum two (2) pairs) |
| 2.7.3 | Zero Speed Switches | |
| | (1) Type, Location | Proximity switch, mounted on Bend pulley of GTU. |
| 2.8.0 | **Drive Motors** | |
| 2.8.1 | Type | Three Phase Squirrel Cage Induction Motors |
| 2.8.2 | Mounting (for conveyors) | Base mounted |
| 2.8.3 | Continuous motor rating (Name plate rating) at 50$^{O}$C Ambient | 120% of actual power requirement at motor output shaft at design capacity. |
| 2.9.0 | **Conveyor Bridges** | |
| 2.9.1 | Walkways | |
| | (a) Construction | Chequered plate with antiskid arrangement. Chequered plate steps shall be provided where conveyor slope exceeds 10 degrees. (Totally sealed so that no water falls down while washing.) |
| | (b) Central walkway width | 1100 mm |
| | (c) Side walkway width | 800 mm (for single conveyors, the width of side walkways shall be 800 mm on one side and 1100 mm on the other) |
| 2.9.2 | Side Windows | |
| | (a) Spacing (Center to center) | 25.0 m on each side (in staggered fashion) |
| | (b) Size | 1.2 m x 1.5 m |
| | (c) Window material | Refer Civil Section |
| 2.10.0 | **Trestles** | |
| 2.10.1 | Spacing of monkey ladders on trestles | |
| | (a) Where height of conveyor gallery (walkway level) is 10 m or more. | : On every trestle |
| | (b) Where height of conveyor gallery (Walkway level) is less than 10m. | : On alternate trestle |

## DATA SHEET: BRAKES AND CLAMPS

| | | |
|---|---|---|
| 1.0.0 | **GENERAL** | |
| 1.1.0 | Brakes | (i) For decelerating of conveyors & rotating equipment's.<br>(ii) Brakes are mandatory for H.T. drives involving scoop type coupling. |
| 1.2.0 | Rail Clamps | For various mobile equipment travelling on rails. |
| 2.0.0 | **DESIGN & CONSTRUCTION REQUIREMENT** | |
| 2.1.0 | **Brakes** | |
| 2.1.1 | Type | Electro Hydraulic Thruster brakes A.C. operated or Disc brakes. |
| 2.1.2 | Braking Torque | Adjustable from 0 to 100% of rated braking torque. |
| 2.1.3 | Brake Shoes | Operated directly by spring |
| 2.1.4 | Shoe lining | Asbestos with interwoven brass wires. |
| 2.1.5 | Max. Temperature for shoe lining | 200 degree C. |
| 2.1.6 | Thrustor | Class-B insulation, IP-65 protection. |
| 2.2.0 | **Clamps** | |
| 2.2.1 | Rail Clamp support | Independent from the rails. |
| 2.2.2 | Limit Switches | "ENGAGED" & "DISENGAGED" signals. |
| 2.2.3 | Clearance between Rail clamp face & Rail surface | Minimum 50 mm |
| 2.2.4 | Material for Rail clamp Mechanism | Forged steel |
| 2.2.5 | Thruster | Class-B insulation, IP-65 Protection |
| 2.2.6 | Type | Electro hydraulic thruster, manual |

## DATA SHEET: MONORAILS AND HOISTS

| | | |
|---|---|---|
| 1.0.0 | **GENERAL** | |
| 1.1.0 | Functional Requirement : | To transfer equipment's to maintenance area or outside the building. |
| 2.0.0 | **DESIGN & CONSTRUCTION REQUIREMENT** | |
| 2.1.0 | **Hoists** | |
| 2.1.1 | Drive | |
| | (i) More than 2.0 tonne or more than 10.0 m lift or hoists coming out-side the buildings | Motor driven for both travel & lift. |
| | (ii) Other hoists including the hoists for handling takeup pulley and takeup weight | Manual for both travel & lift. |
| 2.1.2 | Maximum trolley travel speed for electric hoists | 15m/min |
| 2.1.3 | Maximum Hoisting speed for electric hoists | 6 m/min |
| 2.1.4 | Drive Motors | SQIM, Separate for travel & lift |
| 2.1.5 | No. of starts for drive motor | 150 starts/hr at 40% CDF |
| 2.1.6 | Wire Rope | |
| | (i) Type/Construction | Pre-formed type, hemp cored, regular lay 6/36 construction |
| | (ii) Breaking Strength | 160-175 kgf/sq. mm |
| 2.1.7 | Bearing | |
| | (i) Type | Ball/Roller bearing |
| | (ii) Life | 20 years |
| 2.1.8 | Brake | Electro Mechanical type with asbestos lining. |
| 2.1.9 | Load Hook | Swiveling type forged circular shank section. |
| 2.1.10 | Duty | Class –2 |
| 2.2.0 | **Monorail location/layout** | |
| 2.2.1 | Cross section | I beam |
| 2.2.2 | Distance between C/L of monorail & C.G. of equipment to be lifted | Maximum 500 mm |
| 2.2.3 | Power Cables Support | Festoon type arrangement |
| 2.3.0 | **Manual Hoists** | |
| 2.3.1 | Maximum manual effort for operation. | 30 kg |

## DATA SHEET: CHUTES AND HOPPERS

| | | |
|---|---|---|
| 1.0.0 | **GENERAL** | |
| 1.0.1 | Limestone Parameters | As specified elsewhere |
| 2.0.0 | **DESIGN & CONSTRUCTION** | |
| 2.1.0 | **Chutes & Hoppers** | |
| 2.1.1 | Minimum Valley Angle | 60 deg.for limestone & 70 deg for gypsum |
| 2.1.2 | Material : | |
| | (a) Chute work | |
| | (b) Sliding zones & adjacent sides | 20 mm thk. TISCRAL / equivalent |
| | (c) No striking/ Non sliding zones | 10 mm thk MS |
| | (d) Chute with valley angle 80 degree and above | All four sides of 20 mm thk. TISCRAL/equivalent material |
| | (e) In the zone of magnetic field of ILMS (chute above floor over which ILMS is suspended) | SS-304 10 mm thk. |
| | (f) In the zone of flap gates | 20 thk TISCRAL/ equivalent material |
| | (g) Discharge Hoods over head pulleys | 4 mm thk M.S. with rubber curtain |
| 2.1.4 | Inspection Doors | Hinged & leak proof construction (min. size 350 x 450 mm) |
| 2.1.5 | Chute Construction | |
| | (a) Corners | One face of removable bolted flange connection |
| | (b) Joints Bolted | Flange joints of dust tight construction |
| | (c) Bolt size | Min. M-16 |
| | (d) Bolts spacing | Not more than 125 mm C/C |
| | (e) Fixing Arrangement | Bolts with plain spring washers |
| 2.2.0 | **Skirt Boards** | |
| 2.2.1 | Length | Entire feeding chute shall be extended minimum 3 m ahead of front edge of chute & 500 mm beyond rear edge of chute. |
| 2.2.2 | Height | Not less than 750 mm |
| 2.2.3 | Width | 2/3 of belt width |
| | Side plate | Min. 10 thk TISCRAL/equivalent |
| | Top cover | 6 mm thk M.S. |
| 2.3.0 | **Flap Gate** | |
| 2.3.1 | Type | Linear actuator operated, 2 position |
| 2.3.2 | Travel | 60 to 70 deg. (with limit switches on both sides). |
| 2.3.3 | Automatic operation | |
| | (i) Drive | Dust tight motor driven with suitable linkages |
| | (ii) Minimum Actuator Rating | 2500 kg with 1 m lever arm |
| | (iii) No. of Operation / Hr | 15 (with 10 consecutive switchings) |
| | (iv) Protection | Travel and Thrust dependent limit Switches. |
| 2.4.4 | Manual Operation | |
| | (a) Maximum effort | Convenient for single operator by declutchable hand wheel regardless of electrical power. |
| | (b) Minimum Hand wheel Diameter | 500 mm |
| 2.4.5 | Flap gate shaft | |
| | (i) Diameter minimum | 150 mm |
| | (ii) Material | EN-8 |

## DATA SHEET: DRIVE EQUIPMENT

| | | |
|---|---|---|
| 1.0.0 | **GENERAL** | |
| 1.1.0 | Continuous Motor Rating (Name Plate Rating) at 50 Degree Centigrade Ambient temp. for Electric Motors | |
| | a) For conveyors of belt conveyor systems | *120% of actual power at drive motor output shaft at specified design capacity |
| | b) Mobile trippers travel drive, mono-rail hoists (travel and hoisting), various pumps of DS–systems, service water systems, cooling water system, potable water system and Ventilation Fans | *110% of actual power requirement at drive motor output shaft at guaranteed (rated) capacity. |

*****The actual power at drive motor output shaft shall be calculated after considering all the losses of down the line equipment's of the drive train.

Single LT drive motors shall be used for conveyor drive ratings up to 160 KW. For conveyor drive rating beyond 160 KW, single HT drive shall be used for conveyors.

| | | |
|---|---|---|
| 2.0.0 | **DESIGN & CONSTRUCTION REQUIREMENT** | |
| 2.1.0 | Gear Box | TYPE |
| 2.1.1 | (a) Below 40 kW | Helical, worm, bevel as per requirement without cooling coil |
| | (b) Equal to and Above 40 kW | Helical / bevel helical without cooling coil |
| 2.1.2 | Service Factor | As per accepted engineering practice / manufacturer's recommendations . |
| 2.1.3 | Ambient temperature for Thermal rating | 50° C Minimum |
| 2.1.4 | Mounting | On Machined/Ground Surfaces |
| 2.1.5 | Output Rating | a) For belt conveyor systems @ Service factor X {1.2 times the actual power requirement at drive pulley shaft at design capacity}<br>b) For other equipment @ Service factor X {1.2 times the actual power requirement of the driven equipment } |

@ Service factor shall include all the components considered by the supplier and should be clearly indicated in manufacturer's gear box selection catalogues.

| | | |
|---|---|---|
| 2.1.6 | Duty | 24 Hrs. Continuous |
| 2.1.7 | Rating | Not less than motor name plate rating |
| 2.1.8 | Thermal Rating | Corresponding to 50 Deg ambient Temp and in any case shall not be less than motor rating. |
| 2.2.0 | Flexible Couplings | |
| 2.2.1 | Type | Geared coupling. |
| 2.2.2 | Rating | Not less than motor rating. |
| 2.3.0 | Fluid Couplings | For all motors having rating more than 40 kW. |

| | |
|---|---|
| 2.3.1 | Type<br>(a) L.T. Motors — Traction type<br>(b) H.T. motors — Scoop tube type. |
| 2.3.2 | Rating — Not less than motor nameplate rating |

In lieu of fluid coupling & gearbox bidder may also offer permanent magnet coupling/adjustable speed drive with permanent magnet coupling for motor upto 160kW rating.

## DATA SHEET: LHP BUILDING

| | | |
|---|---|---|
| 1.0.0 | **GENERAL** | |
| 1.1.0 | Under ground Junction tower (JT) | RCC |
| 1.2.0 | Over ground Junction tower | Steel Construction |
| 1.3.0 | Control/MCC rooms | RCC |
| 2.0.0 | **DESIGN & CONSTRUCTION REQUIREMENT** | |
| 2.1.0 | Junction tower & Crusher House | |
| 2.1.1 | Space requirement | To accommodate all equipments drive units, head/ tail ends of conveyors transfer chutes etc. and to provide adequate space for maintenance. |
| 2.1.2 | Floors | RCC construction with facility to wash the floors. Min. slope of 1:80 for floors in JTs shall be provided towards drain pipes. |
| 2.1.3 | Walls/Enclosure | Permanently colour coated cladding |
| 2.1.4 | Stairs | Steel construction with minimum 1000 mm width. |
| 2.1.5 | Doors & Windows | Steel construction |
| 2.1.6 | Monorails | Capacity as per equipment installed |
| 2.1.7 | Drainage | From each floor to drain pit suitable to handle limestone slurry. |
| 2.1.9 | Vertical bracing | Only along four sides. |
| 2.1.10 | Maintenance platform with handrails. | Chequered plate floors Min.1500 mm wide |
| 2.1.11 | Flooring | 50 mm thick metallic hardener like ironite floor finish. |
| 2.1.12 | Level of ground floor | 500 mm above ground level. |

## DATA SHEET: TRAVELLING TRIPPER

| | | |
|---|---|---|
| 1.0.0 | **GENERAL** | |
| 1.1.0 | Mobile Tripper | Motor driven type rail mounted. |
| 2.0.0 | **DESIGN & CONSTRUCTION** | |
| 2.1.0 | Mobile Tripper | |
| 2.1.1 | Mounting | Rail mounted on rails (90 lbs/yard) with double flanged wheels. |
| 2.1.2 | Drive | Motor driven with suitable gearbox. Suitable for minimum 60 starts/hours. |
| 2.1.3 | Pulleys | |
| | (a) Head & Bend Pulleys | As specified elsewhere |
| 2.1.4 | Brakes | AC operated electro hydraulic thruster type on either side of tripper. |
| 2.1.5 | Clamps | Manual Rail clamps on either side of tripper. |
| 2.1.6 | Walkways | Both sides of tripper, 800 mm wide each |

## DATA SHEET: DUST CONTROL & MISCELLANEOUS SYSTEM

| | | |
|---|---|---|
| 1.0.0 | **GENERAL** | |
| 1.1.0 | Dust Control | Dust extraction system |
| 1.2.0 | Miscellaneous systems | Service water system, Potable water system, Cooling water system, sump pump and DE system pumps |
| 2.0.0 | **DESIGN REQUIREMENT** | |
| 2.1.2 | Pumps | 2x100% for water |
| 2.6.0 | **Service Water System** | |
| 2.6.1 | Water connections | |
| | (a) Conveyor Galleries | every 50 m |
| | (b) Junction towers | Min. 1 no. at every floor |
| 2.6.2 | Connection details | 32 NB plug valve |
| 2.6.3 | Hose pipes with hose reel | One in each building of 25 mtr. Length with nozzle |
| 2.7.0 | **Potable Water System** | |
| 2.7.1 | Pumps | 2 X 100% electric motor driven |
| 2.7.2 | Water connections | |
| | a) Junction towers | Minimum one (1) no. at each floor |
| | (b) Tripper floor | Minimum one (1) no. at every tripper bay. |
| 3.0.0 | **CONSTRUCTION REQUIREMENTS** | |
| 3.1.0 | **Water Supply Pumps for SW/PW/CW/DE** | |
| 3.1.1 | Casing | Axial or radially split with drain & vent connection |
| 3.1.2 | Impeller | One piece, keyed to shaft along with locking device |
| 3.1.3 | Shaft | Critical speed atleast 20% away from operating speed |
| 3.1.4 | Shaft sleeves | At bearings & stuffing boxes. |
| 3.1.5 | Bearings | Antifriction type |
| 3.1.6 | Wearing rings | Renewable type (preferable) |
| 3.1.7 | Pump speed | Below 1500 rpm for capacity more than 10 $m^3$/hr. |
| 3.1.8 | Head flow characteristics | Suitable for parallel operation. |
| 3.1.9 | Materials | |
| | (a) Casing | Cast Iron to IS:210, FG 260 |
| | (b) Impeller | Bronze conforming to Gr.I of IS:318 |
| | (c) Impeller Wearing ring | Bronze conforming to Gr.I of IS:318 |
| | (d) Casing Wearing ring | Bronze conforming to Gr.I of IS:318 |
| | (e) Shaft | Medium carbon steel |
| | (f) Shaft sleeve | Stainless steel conforming to AISI-416 hardened. |
| | (g) Gland packing | Impregnated teflon |
| 3.2.0 | **Sump Pumps** | |
| 3.2.1 | Type | Wet pit type vertical shaft |
| 3.2.2 | Duty | Capacity to handle large solids or unscreened liquid. |
| 3.2.3 | Materials | |
| | (a) Casing and rotor housing | Ni-Cast Iron (350 BHN) |
| | (b) Rotor | Ni-Cast Iron (350 BHN) |
| | (c) Shaft | Medium carbon steel |
| | (d) Gland | Bronze |

| | | |
|---|---|---|
| | (e) Wearing rings | Stainless steel |
| | (f) Shaft enclosing tube | Carbon steel |
| 3.3.0 | **Pipings & Fittings** | |
| 3.3.1 | Joints | |
| | (i) Pipe to pipe | |
| | Pipe size ≤ 50 NB | Socket welding/screwed |
| | Pipe size ≥ 65 NB | Butt welding |
| | (ii) Pipe to valves | |
| | Pipe size ≤ 50 NB | Screwed |
| | Pipe size ≥ 65 NB | Flanged |
| 3.3.2 | Isolation of flow | Plug / Gate / Sluice valves |
| 3.3.3 | Regulation of flow | Globe Valve |
| 3.3.4 | Valves | |
| | (i) Size ≥ 65 NB | Bolted bonnet outside screw rising type. |
| | (iii) Size ≤ 50 NB | Union bonnet with screwed ends for Globe valve & screwed ends for plug valve |
| 3.3.5 | Materials for Pipework | |
| | (a) For sizes 200 NB and Larger | ERW carbon steel pipes to API-5L-Gr.B/IS:3589 with minimum thickness 6.35 mm |
| | (b) For sizes 150 NB to 65 NB | ERW carbon steel black pipes to IS:1239 (Part-Heavy class). |
| | (c) For sizes below 65 NB | ERW carbon steel galvanized pipes to IS:1239 (Part-I) Heavy class. |
| 3.3.6 | Materials for Valves & Specialities | |
| | (a) Cast Iron Valves | 65 NB and above |
| | (i) Body and bonnet | Cast Iron to IS:210, Gr.FG-200 |
| | (ii) Disc for non- return | Cast Iron to IS:210, Gr.FG-200 valves |
| | (iii) Seating surfaces and rings | 13% chromium steel |
| | (iv) Hinge pin for non return valves | Stainless steel type AISI-316 |
| | (v) Stem for gate and globe valves | 13% chromium steel |
| | (vi) Back seat bush | 13% chromium steel |
| | (a) **Gun metal valves (50 NB & below and upto a working pressure of 10 kg/cm2 (g))** | |
| | (i) Body | Gun metal to IS:318, Gr-2. |
| | (ii) Trim | Gun metal to IS:318, Gr-2. |
| | (b) **Duplex Strainer** | |
| | (i) Body | MS fabricated |
| | (ii) Strainer | Stainless steel type element AISI-316 |
| | (c) **Pressure Gauge/Switch (to be provided with isolating valves, gauge cock, snubber and syphon)** | |
| | (i) Dial size | 150 mm |
| | (ii) Accuracy | (+/-) 1% of range span |
| | (iii) Bourdon | AISI 316 SS |

| | | |
|---|---|---|
| (iv) | Block | AISI 316 SS |
| (v) | Movement | AISI 316 SS |
| (vi) | Case and Bezel | Die cast Alum. Weather proof case stove enameled block with screwed type inner bezel of ABS plastic and glycerin filled. |
| (vii) | No. of contacts | 2 NO + 2 NC |
| (viii) | Type of contact | Adjustable throughout the range. |
| (ix) | Degree of protection | IP. 65 |
| (d) | **Solenoid valve (to be provided with isolating valve)** | |
| (i) | Type | 2/2 way Diaphragm type pilot operated |
| (ii) | Diaphragm | molded synthetic rubber |
| (iii) | Body | Forged brass / SS |
| (iv) | Pressure | 0.5 to 10 kg/cm² (g) |
| (v) | Protection Class | IP 65 |
| (e) | **Flow Switch (to be provided with isolating valves)** | |
| (i) | Body | Forged steel |
| (ii) | Extension Rod/wire | SS-304 |
| (iii) | Sleeve and Sleeve pipe | SS-304 |
| (iv) | Cover | Die cast aluminum |
| (v) | Max. working pressure | 10 kg/cm² (g) |
| (vi) | Repeatability | ± 0.5% |
| (vii) | No. of contacts | 2 NO + 2 NC |
| (viii) | Type of contact | Adjustable throughout the range. |
| (ix) | Protection class | IP – 65 |
| (f) | **Level Switch** | |
| (i) | Type | Displacer operated magnetic type |
| (ii) | Displacer | SS – 316 |
| (iii) | Wire rope | SS – 316 |
| (iv) | Spring Housing Spring and sleeve pipe | SS – 316 |
| (iv) | Cover | Cast Aluminum |
| (v) | No. of Contacts | 2 NO + 2 NC |
| (vi) | Type of Contact | Adjustable throughout the range. |
| (viii) | Protection class | IP – 65 |
| (g) | **Level gauges** | |
| (i) | Type | Float type mechanical gauge with arrow scale |
| (ii) | Accuracy | (+/-)1% of full scale range |
| (iii) | Material of construction | |
| (aa) | Float & Guide wire | 316 SS |
| (bb) | Elbows | Suitable grade of SS |
| (cc) | Housing | Mild Steel |
| (dd) | Cable fastener | SS 304 |

## DATA SHEET: VENTILATION SYSTEM

| | | |
|---|---|---|
| 1.0.0 | **GENERAL** | |
| 1.1.0 | Mech. Ventilation System | To provide ventilation using fans for specified areas. |
| 1.1.1 | No. of air changes per hour | |
| | (a) For over ground building | Not less than 10 supply air changes |
| | (b) For under ground building | Not less than 15 supply air changes and 7 exhaust air changes |
| 1.1.2 | **Equipment** | |
| | (1) Underground tunnel | Centrifugal fans/Axial fans |
| | (2) All other places | Axial fans, roof ventilators |
| 1.3.0 | **Air-conditioning system** | |
| 1.3.1 | Temperature to be maintained | 24 ± 1 deg. C |
| 1.3.2 | Humidity to be maintained | 60 ± 5% relative humidity |
| 1.3.3 | Fresh Air intake | Minimum 1.5 air changes per hour. |
| 1.3.4 | Equipment | 2 x 100 % roof mounted package AC units along with ducting etc. and 2X100% window AC |
| 1.4.0 | **Outside Ambient Conditions** | As per weather data given in project synopsis |
| 2.0.0 | **DESIGN & CONSTRUCTION** | |
| 2.1.0 | **Axial Fans** | |
| 2.1.1 | Capacity | 10% more of actual requirement |
| 2.1.2 | Head | 20% more of actual requirement |
| 2.1.3 | Speed | |
| | (a) Impeller dia above 450 mm | Max. 960 rpm |
| | (b) Impeller dia less than or equal to 450 mm | Max. 1440 rpm |
| | (c) Critical speed | 25% above operating speed. |
| 2.2.0 | **Centrifugal Fans** | |
| 2.2.1 | Capacity | 10% more of actual requirement |
| 2.2.2 | Head | 20% more than actual requirement |
| 2.2.3 | Speed | Max. 1500 rpm |
| 2.2.4 | Outdoor temperature | 50 deg.C. |
| 2.2.5 | Rating | Continuous |
| 2.3.0 | **Packaged Air-Conditioning Unit** | |
| 2.3.1 | Type | Roof top mounting |
| 2.3.2 | Service/application | Continuous, round the clock |
| 2.3.3 | Capacity | |
| | (i) TR | Suitable |
| | (ii) CFM | Suitable |
| 2.3.4 | Type of compressor | Hermetically sealed scroll compressor |
| 2.3.5 | Condenser | Air cooled type |
| 2.3.6 | Fan | Forward curved centrifugal |

| | | | |
|---|---|---|---|
| | | | fan |
| 2.3.7 | Filter | | High efficiency filter |
| 2.3.8 | Cooling Coil | | |
| | (a) | Type | Direct Expansion |
| | (b) | Material | Copper |
| | (c) | Fins | Aluminum mechanically bonded. |
| 2.3.9 | Refrigerant Piping | | Copper |
| 2.3.10 | Insulation for PAC parts | | Expanded polyethylene of density at least 15 kg/m³. |
| 2.4.0 | **Filters** | | |
| 2.4.1. | Metallic Filters | | |
| | (1) | Max. air velocity | 2 m/s. |
| 2.4.2 | HDPE filters | | |
| | (1) | Efficiency | 90% down to 5 microns |
| | (2) | Max. velocity | 2.5 m/s |
| | (3) | Testing | As per BS 2831 / Sqv. |
| 2.4.3 | High Efficiency Filter | | |
| | (1) | Efficiency | 99% down to 5 microns. |
| | (2) | Pr. drop across | 10 mm W.C. |
| | (3) | Testing | As per BS 2831 / Sqv. |
| **2.5.0** | Insulation for A/C Ducting Resin Bonded Mineral wool as per IS:8183 | | |
| 2.5.1 | Density | | 24 kg/m³ |
| 2.5.2 | Thermal conductivity | | 0.49 mw/cm deg.C |

## DATA SHEET : BELT SCALE

| | | | |
|---|---|---|---|
| 1.0.0 | **GENERAL** | | |
| 1.1.0 | Ambient Temperature | | 50°C |
| 1.2.0 | Relative Humidity | | 100% |
| 2.0.0 | **DESIGN & CONSTRUCTION** | | |
| 2.1.0 | Type | | Electronic load cell type |
| 2.2.0 | Operation | | Microprocessor based fully automatic |
| 2.3.0 | No. of floating idlers | | Minimum four (4) |
| 2.4.0 | Load Cells | | |
| 2.4.1 | Type | | Strain gauge type hermetically sealed |
| 2.4.2 | Minimum Nos. | | Four (4) |
| 2.4.3 | Overload protection | | 100 % of rated belt scale capacity |
| 2.4.4 | Structural capacity | | 250 % of rated belt scale capacity |
| 2.5.0 | Flow Rate Indicator | | Electronic Digital Display Minimum 4 digits |
| 2.6.0 | Flow totalizer | | 8 digit display with reset facility. |
| 2.7.0 | Accuracy | | For entire range of 20% to 120% of rated capacity<br>Minimum $\pm$ 0.25% |
| 2.8.0 | Calibration | | |
| 2.8.1 | Automatic | | Zero & span calibration |
| 2.8.2 | Manual | | With test load chain |
| | (a) | Test load chain length | Two idler spaces more than weighing lengths |
| | (b) | Chain reel equipment | Complete with weight adding facility. |

## DATA SHEET: ILMS/SM

| | | |
|---|---|---|
| 1.0.0 | **GENERAL** | |
| 1.1.0 | Type | In line or suspended magnet type as specified. |
| 2.0.0 | **DESIGN & CONSTRUCTION** | |
| 2.1.0 | In-line Magnetic Separator / Suspended Magnet | |
| 2.1.1 | (a) Location of ILMS | Over discharge pulley. |
| | (b) Location of SM | Over Conveyor (as per tender drawing) |
| 2.1.2 | Force index (As defined earlier) | Minimum 100,000 |
| 2.1.3 | Strength of magnet at the specified mounting height | 1000 gauss. |
| 2.1.4 | Mounting height | Mounting height of In Line Magnetic Separator and Suspended Magnet shall be 450mm in the conveyors carrying uncrushed limestone & 400 mm in the conveyors carrying crushed limestone (between top of conveyor belt & surface of magnetic separator) |
| 2.1.5 | Magnetic Separator Belt | |
| | (i) Drive Unit | Adequately sized with 20% margin. |
| | (ii) Belting | Suitable to withstand high temp. & impact of tramp iron. (FR Grade) |
| | (iii) Discharge | Into Tramp iron chute. |
| 2.2.0 | Tramp Iron Items | |
| | (i) MS cube of 20 mm size | |
| | (ii) Brake shoe of Railway Wagon (Cast Iron 15 kg.) | |
| | (iii) MS plate of 250 x 250 x 100 mm size. | |
| | (iv) Shovel Teeth and spikes. | |
| | Material | Carbon Steel |
| | Size | Typical |
| | (v) MS round bar of 50 kg with L/D ratio not exceeding 5. | |
| 2.3.0 | Control | |
| | Inline Magnetic Separator / Suspended Magnet | Local and remote |
| 2.4.0 | Electric Supply 415V, 3 phase, 50 Hz input | Silicon Rectifier units |
| 2.5.0 | Location of silicon rectifier unit | Nearby control/MCC room |
| 2.6.0 | Handling Arrangement for inline Magnetic separator/Suspended magnet | |
| | (a) Height adjustment | With turn buckle arrangement |
| | (b) Cross-travel | Electric Hoist operated cross travel facility. |

## DATA SHEET: METAL DETECTOR

| | | |
|---|---|---|
| 1.0.0 | **GENERAL** | |
| 1.1.0 | **Type** | Coil type |
| 2.0.0 | **DESIGN & CONSTRUCTION** | |
| 2.1.0 | Sensitivity | - 25 mm aluminum sphere below limestone for synthetic belting |
| 2.2.0 | Enclosure | Fiber glass |
| 2.3.0 | Control | Through local control panel. |
| 2.4.0 | Calibration | Provision for automatic static calibration with adjustable sensitivity. |

## DATA SHEET: LIMESTONE SAMPLING UNIT

| | | |
|---|---|---|
| 1.0.0 | **GENERAL** | |
| 1.1.0 | Type | Automatic |
| 2.0.0 | **DESIGN & CONSTRUCTION** | |
| 2.1.0 | Codes & Standard | ASTM C-50 |
| 2.2.0 | Uncrushed feed limestone size | (-) 250 mm |
| 2.3.0 | Crushed feed limestone size | (-) 20 mm |
| 3.0.0 | **CHUTES** | |
| 3.3.1 | Min. angle | 60 deg |
| 3.3.2 | Cross section | Square/rectangular with rounded corners. |
| 3.3.3 | Joints | Bolted flanges with 6 mm thick standard grade neoprene gasket. |
| 4.0.0 | **CRUSHER** | |
| 4.4.1 | Uncrushed (as received) feed limestone size | (-)250 mm |
| 4.4.2 | Crushed (as fired) feed limestone size | (-) 20 mm |
| 4.4.3 | Output size | ASTM C-50 |
| 4.4.3 | Stages of size reduction | Single stage crushing |
| 5.0.0 | **BELT FEEDER** | |
| 5.5.1 | Belt | Flanged type, FR grade |
| 5.5.2 | Pulleys | Rubber lagged head pulley |
| 5.5.3 | Drive | Electric Motor |

## DATA SHEET – LIMESTONE CRUSHER

| | | |
|---|---|---|
| 1.0.0 | **GENERAL** | |
| 1.1.0 | Type | Hammer Mill type crusher |
| 1.3.0 | Material to handle | Limestone |
| 1.4.0 | Feed Size | (-) 250 mm, occasionally 1-2% of 400mm size |
| 1.5.0 | Product size | To suit limestone pulverizer and system , minimum 90% |
| 1.6.0 | Input limestone parameters | As specified elsewhere |
| 1.7.0 | Limestone feeding arrangement | Through vibrating screen feeder (However the crusher hall be designed/sized considering zero passage of limestone through screen). |
| 2.0.0 | **DESIGN AND CONSTRUCTION** | |
| 2.1.0 | Drive arrangement | Electric motor with belt drive |
| 2.2.0 | Rotor Balancing | Static |
| 2.3.0 | Type of sealing | Labyrinth, dust tight arrangement |
| 2.4.0 | Type of bearings | Spherical roller |
| 2.5.0 | Lubrication | Manual through grease gun<br>OR<br>with recommended grade of oil in which case the Plummer block shall be designed with oil filling, oil draining and visual oil checking facilities |
| 2.6.0 | Tramp collection | Required |
| 2.7.0 | Output size adjustment facility | Required |
| 2.8.0 | Top cover of crushers | Hydraulically operated |
| 3.0.0 | **MATERIAL OF CONSTRUCTION** | |
| 3.1.0 | Rotor Shaft | Forged steel |
| 3.2.0 | Hammer heads | Wear resistant cast alloy steel/Mn Steel IS276 Gr.3 |
| 3.3.0 | Hammer arm | Carbon steel |
| 3.4.0 | Housing/frame | Steel as per IS:2062 |
| 3.5.0 | Bearing blocks | Cast steel/MS fabricated |
| 3.6.0 | Liners | |
| | (a) Material | Suitable for duty requirement |
| | (b) thickness | As required |

Vibration monitoring system should be offered for crushers as indicative below:

| Sl. No | Equipment | Type | No. | * No. of location per equip. | Equipment bearing type |
|---|---|---|---|---|---|
| 1. | Limestone Crusher | Radial ring | 4 | (2 Nos.)<br>1 at DE &<br>1 at NDE | As per manufacturer's design |

Vibration shall be measured at each location in Horizontal as well as vertical direction.

4.0.0 Specification of the Vibration Monitoring System

| | | |
|---|---|---|
| a) | Number & type of vibration | One (1), Microprocessor based, monitoring system able to distinguish between high frequency vibration caused by bearing trouble and low frequency vibration caused by imbalance. |
| b) | Number of channels | 16 (Rack mounted in cabinet) |
| c) | Transducer | a) Velocity pick-up or a peizo-electric accelerometer. Type shall be decided during detail engineering based on the details of equipment to be monitored.<br>b) Light weight stud mounting.<br>c) Frequency response 1 Hz -10 kHz. |
| d) | Connecting cable | Low noise fire proof coaxial cable to be laid in flexible conduit. |
| e) | Monitors (to be located in FGD control room) | Dual channel monitor for each location alongwith :<br>a) Buffered signal output and software for vibration analysis through FGD control desk HMI.<br>b) Recorder signal output |
| f) | Display | Analogue and digital |
| g) | Alarm | 0-100% full scale adjustable. |
| h) | Trip | 0-100% full scale adjustable. |
| i) | Test | Functional checking from front inhibiting alarm & trip |
| j) | Relays | 0.25 A at 220 Volts DC or 5 Amp at 240V AC. Independent potential free contacts for alarm & trip purpose. |
| k) | Signal Conditioner | Individuel 4-20 mA DC analogue output. |
| l) | Power Supply | 240 V ±10% AC, 50 Hz + 3%, -5% |

**6.0.00** **OPERATION AND CONTROLS**

This section is intended to cover control/instrumentation and operational philosophy as specified hereinafter complete in all respects, required for Lime stone & Gypsum handling facilities under subject package.

**6.1.00** **General Requirements**

The instruments and controls to be furnished and erected under this specification are as required for safe and satisfactory operation of the Lime Handling System, as outlined under mechanical section and as specified elsewhere in the specification. For the equipment and materials procured by the Contractor from his sub-vendors, the Contractor shall study the specification, safety requirements, interface drawings for such equipment and material in detail and shall coordinate his work with his sub vendors and FGD DDCMIS system and supply instrumentation and control to suit the actual Lime stone and Gypsum Handling equipment.

6.1.01 **Standards / Codes**

All construction, installation, workmanship, design & equipment shall conform to acts, rules & regulations of the jurisdiction within which the project is to be located, and to the current edition of the following or equivalent standards or codes, in so far as they apply :

American Iron & Steel Institute (AISI)
American Society for Mech. Engineers (ASME)
American Society for Testing & Materials (ASTM)
American Wire Gauge (AWG)
Institute of Electrical & Electronic Engrs. (IEEE)
Instrument society of America (ISA)
National Electrical Code (NEC)
National Electrical Manufacturers Association (NEMA)
United States of America standards (USAS)
Bureau of Indian Standards (BIS)
Conveyor Equipment Manufacturers Association (CEMA)

6.1.02 This Sub-section shall be read in conjunction with Electrical Sub-sections.

**6.2.00** **General Construction and Design**

6.2.01 **General Construction**

Control desks/panels and annunciation system shall be as per the requirement of electrical Section. Annunciations, indications, electrical meters and instrumentation shall be provided as specified.

6.2.02 **Design**

The complete lime handling plant & Gypsum shall be controlled from FGD DDCMIS system as detailed elsewhere. Also refer other clauses of this chapter.

The Contractor shall provide a comprehensive control indication and annunciation scheme. Contractor shall furnish block diagram and write-up on the scheme proposed. The final scheme will be approved by the Employer. In general, interlocking shall be achieved through feed-back signals from field equipment. Comprehensive Annunciation and Indication scheme shall be provided such that, it will be possible for the operator to locate and identify the fault from the face of DDCMIS/LVS/Control-Panel/ TFT itself. The scheme shall include the basic remote control instrumentation, indication and annunciation requirements as per various technical specification requirements.

However, the Contractor may offer any alternative proposal which he considers to be equal, superior to the scheme as described in subsequent clauses below for achieving reliable and trouble free operation of the plant, for consideration of the employer.

**6.3.00 OPERATION AND CONTROL PHILOSOPHY**

The lime handling system & Gypsum shall be controlled from the following control points.

6.3.01 **Limestone & Gypsum Handling Plant Main Control Room**

Overall, operation of the following equipment of Limestone & Gypsum Handling Plant shall be controlled from the main FGD control room through FGD DDCMIS being provided by the Contractor.

(a.) Conveyors, feeders, flap gates, R&P gates, crushers, hydraulic scoop couplings.
(b.) Complete Dust Suppression system, service water system, cooling water system & potable water system.
(c.) Ventilation system (group/individual control as required).
(d.) In line Magnetic separators and Suspended Magnet (ON/OFF control with indication).
(e.) Metal Detectors (ON/OFF control with indication).
(f.) Lime Sampling Units.
(g.) Belt weigher (ON/OFF control with indication)
(h.) Mobile trippers over bunkers/ storage shed (tripper position indications).
(i.) Gypsum Handling Plant-Mechanical handling equipment provided in the silos (if applicable)

6.03.02 **Local Control Panels**

**Local control stations for following equipment's shall be provided**

(a.) Mobile trippers over bunkers/ storage shed
(b.) Belt Weighers
(c.) Metal detectors
(d.) Electric hoist - wall mounted control box with pendent push button controls.
(e.) In line magnetic separators
(f.) Suspended Magnet
(g.) Sump Pump
(h.) Hydraulic scoop coupling.
(i.) Lime Sampling System:- Complete PLC along with interface with FGD DDCMIS
(j.) Gypsum Handling Plant-Mechanical handling equipment provided in the silos (if applicable)
(k.) Truck Tipplers alongwith surface feeder/box feeders/bulk reception units.

All the above local control panels shall be accessible and located near their respective equipment and shall be complete with all the required controls, interlocks, annunciation's etc. However, for items (j.), above, controls shall be through contractor's PLC. Further, necessary controls, indications and annunciations for all the above equipment shall also be provided at main FGD Control Room as described under relevant clause.

6.04.00 **System Operation**

6.04.01 The lime handling plant being provided by bidder envisages control of complete lime handling system including facilities under subject package by DDCMIS.

Envisaged Operation philosophy of the plant, in general, shall be as elaborated below:

Limestone flow path selection shall be done from CRT/Keyboard

The limestone handling system operator will select any one the stream from OWS located on the main control desk. The flow stream path is then selected by positioning different flap gates/ movable discharge pulley at desired positions by means of keyboard available at the central control desk. Once the system is in the operation, the gates/ movable discharge pulley can not be moved from their positions and path. Flap gates which do not come in the stream in which lime flow is taking place, can be operated at any time. However, for the flap gates in Limestone bunker area conveyors, it shall be possible to change flap gate position while the conveyor is in operation and feeding lime using interlock bypass facility, provided that sequential permissive are available.

The Control system will be designed for “Auto” & “Manual” operation of the conveyors in the selected path. Auto/Manual Selection shall be done from keyboard.

**Auto Mode** : In the “Auto” mode, the conveyors and related equipment will start sequentially when the “System Start” is activated. During stopping, when the “System Stop” is activated, all conveyors will also stop sequentially (in the reverse sequence) allowing time delays for clearing the belts.

**Manual Mode** : In Manual Mode, the operator will start the conveyor system, in the same sequence as in Auto mode from keyboard. The operator will also stop the conveyor system, by pressing "System stop" or individual “Stop” push buttons/command from keyboard in the reverse sequence.

During “Sequence Start” in both Auto and Manual modes, first the required number of hooters (3 phase induction motor type) will be energized simultaneously for a preset time of 1 minute or so (adjustable at site) as per the program. After the preset time, the hooters will stop and a preset time of two minutes (adjustable at site) as per program will be allowed for the movement of the personnel and for the permissive of the conveyor system operation. This condition will be indicated on the panel by glowing of lamp “Lime Handling Sequence Start”. The starting permissive will be available for a period of 5 minutes (Pre-programmed and adjustable in the field). In the event the last conveyor / equipment is not started within this preset time of 5 minutes, the start command for equipment not started will be withdrawn. The system cannot be started again unless the “Sequence Start” push button is again pressed and the hooters sound again, as described before. Those conveyors and equipment, which have already started, will continue to run.

The status indication in the graphic display against all conveyors and equipment in the selected path/stream will start slow flickering. However, all status indications against all flap gates / movable discharge pulley in the selected path will glow steadily. Therefore, from the selected flow stream path of the flap gates, the operator will come to know the conveyors and equipment to be started for the selected path/stream. After a conveyor/equipment is started, the status indications against that conveyor / equipment will change to steady glow indicating that it is running.

Graphic display status indicators associated with a particular motor/equipment shall flicker fast in case of fault / trip.

In addition, emergency stop push button on the control desk for immediate shut down of complete plant shall be provided.

For changeover of feed from one Bunkers to another Bunkers without stopping of the LHP, provision shall be made for interlock bypass on the control desk for flap gates of all conveyors in FGD area for a preset period. If the changeover, in above specified time, is not completed then the entire LHP shall stop.

(i) Lamp test facility will be provided for the annunciation and mimic lamps.

6.05.00 **Conveyor System**.

(a) Each conveyor shall be protected against damage to the edge of the belt due to excessive sideways movement by providing an adequate number of belt sway switches. In addition, each conveyor shall be provided with one (1) No. speed detection device (zero speed switch). The zero speed switches shall be designed to sense belt speed. In case of speed of belt goes below 85% of rated speed, it shall trip the conveyor.

(b) All the conveyors shall be protected from reverse running due to power failure by providing mechanical or electrical locking system.

(c) The starting sequence of the conveyors shall follow a direction opposite to that of flow of material i.e. :

(1.) In case of conveying of lime to limestone bunkers, start from lime bunker conveyor and end up with reclaim conveyors in limestone storage shed/silos

(2.) In case of stacking of lime in shed/silos, start from conveyor feeding to the shed/silos and end up with conveyors below receiving feed from the box feeder/surface feeders etc.,.

(3) The starting of mobile trippers shall be interlocked with operation of the associated conveyors.

(d) Any individual equipment (belt conveyor etc.) should not be allowed to start unless the equipment immediately following the same in the direction of flow of material is already in operation.

(e) Stop/tripping of any equipment from running condition shall trip all preceding equipment in the system, except crushers but shall not effect succeeding ones which shall continue to operate.

(f) Adequate number of pull-cord switches shall be provided at suitable intervals along the length of each belt conveyor, which shall enable the respective conveyor to be stopped immediately. Each pull chord switch shall be identified by a specific number on HMI in the main control room. Each belt sway switch shall also be identified by a specific number on HMI in control room.

(g) Means shall be provided to pre-warn personnel working nearby when starting any conveyor and mobile tripper.

(h) Interlocking of various conveyors shall be achieved with Flap Gate, discharge pulleys, limit switches and zero speed switches.

(i) Motors shall start only when the brake/rail clamp if-provided, is in "not applied' 'condition. This signal shall be obtained from limit switch provided for that purpose.

(j) Lime stone crusher shall be provided with speed and vibration monitoring instruments. Crusher shall trip in case speed/ vibration is going beyond tolerable limits of design. Temperature sensing devices shall be installed on all bearings of each of the ring granulator to trip the ring granulator in case of temperature goes beyond limit. Audio-visual annunciation shall be provided in main control room and locally also.

(k) Once a conveyor trips, flap gate directing lime from this conveyor shall change over its position with a time delay and shall come back to the original position again. This is to prevent jamming of gate.

(l) Tripping of the respective conveyor shall be provided in case any of mobile trippers starts running along with conveyor belt at speed higher than their rated speed by providing an over speed sensing device on the equipment.

(m) It shall be possible to trip bunker conveyor from mobile tripper wherever scoop type coupling provided for HT motors, the coasting time of respective conveyor, thruster brake, actuator selection and the chute size shall be so selected such that there is no spillage of lime from any down stream conveyors during next start.

(n) Wherever the conveyor is provided with the movable discharge pulleys in place of flap gates, the starting of the conveyor will be interlocked with the position of the movable discharge pulley.

6.06.00 **Interlocking**

(a.) The following conveyors / equipment will come under interlock scheme :-

(1) All conveyors
(2) All flap gates
(3) Mobile Trippers
(4) Rack & Pinion Gates
(5) Metal detectors
(6) Magnetic Separators and suspended Magnet
(7) Crushers
(9) Belt scale
(10) Surface feeders/box feeders/ bulk reception units etc.,

(b.) The following equipment will not come under interlock of the conveyor scheme.

(1.) All dust extraction systems & service water system.
(2.) Ventilation systems

(c.) All conveyors and equipment will have local push button stations each consisting of :

(1.) Pos - I, Pos - II & stop button for flap gate.
(2.) Emergency stop push button (Red) for other equipment

(d.) Belt scale shall be started when relevant conveyors are started

(e.) The dust extraction systems will be energized as soon as the conveyors are energized.

(f.) Lime & Gypsum handling plant shall be tripped in case of detection of fire.

(g.) Interlock for H.T. Motor :

H.T. motors used will continue to run on no load by disengaging the fluid coupling in case of failure of any process interlock. The H.T. motors will however be tripped in case of any motor fault like O/L, high motor winding temperature etc. In addition, in case of normal stop command, after running of the system, motors will stop.

(h.) The following are the various safety interlocks for the conveyors and other equipment. This list is indicative only and the Contractor shall develop a comprehensive interlocking scheme.

**Conveyors**

a) Pull - Chord switch - not operated
b) Belt sway switch - not operated
c) Under speed switch - closed at 90% speed of the conveyor within designed accelerating time.
d) Motor protection - not tripped
e) Local stop PB – reset
f) Chute Block switch - not operated.
g) Brakes for conveyor – not operated.
h) Trip circuits healthy.
i) Temp. of fluid coupling oil - not high

**Travelling Tripper :**

a) Stop PB in Local control station - reset
b) Motor O/L not tripped.
c) Over Travel Limit switches - not tripped.

**Magnetic Separators / Metal Detectors / Suspended Magnets**

a) O/L / fault relay - not tripped.
b) Stop PB (Local & Remote) reset.
c) Metal detector reset
d) Oil temperature - not high

**Flap Gates/ R & P Gates**

a) End of travel limit switches - reset.
b) Torque limit switches - reset.
c) Local stop - reset.

**Crusher**

a) Zero speed - not operated
b) Temp. of fluid coupling oil - not high.
c) Local stop push button reset.
d) Temperature of bearings – not high.
e) Cooling water flow switch – reset
Motor O/L – not tripped
Local E-Stop PB-reset
Stop PB in main FGD Control Room reset.
All limit switches - reset
All limit Switches – not tripped.
Apron feeder
Motor O/L – not tripped.
Local stop PB – reset

6.06.01 The lists of indications and audio-visual annunciation given in subsequent clauses are indicative only and the same shall be finalized during detail engineering.

6.06.02 Status indications in Large Video Screen
Following individual status indications shall be provided in LVS with individual ON/OFF/TRIP indications on CRT.

a) Conveyor 'ON'
b) Flap Gate Rack and Pinion.
c) Belt scale flow rate indication and totalizer.
d) Belt sway switch operated for each conveyor (individual switch indication on CRT).
e) Pull cord switch operated for each conveyor (Individual switches indication on CRT).
f) Zero speed switch operated for each conveyor
g) Travelling tripper position."
h) Crusher ON
i) MD/ ILMS/ SM/ LSU ON
j) DE/ SW/PW/CW/Vent ON (System wise)
k) Unit wise MW indication, total lime flow & Bunker level.
l) Further Mimic lamps for HT and LT SLDs shall be provided on the control desk.

6.07.00 **Annunciation System:**
DDCMIS/Control desk shall be provided with adequate number of facia type annunciation windows operating through DDCMIS for the following audio-visual fault annunciation purposes. Wherever group annunciation is provided, alarm status of individual equipment shall be provided on OWS.

a) 3.3 kV Breaker Trip (Group wise for each board)
b) 415 V MCC Breaker Trip (MCC wise)
c) Bus under voltage for each LT MCC & HT switchgear buses.
d) Following group wise annunciation shall be provided for transformers :
- Buchholz alarm
- Winding/oil temperature high alarm
- Oil level low alarm
- Buchholz trip
- Winding/oil temperature high trip

e) A.C Control Supply failure.
f) D.C. Control Supply failure.
g) Annunciation supply failure.
h) Both CPU fail
i) Stand by CPU in service
j) H.T. motor overload alarm (individual)
k) HT motor bearing/ winding temp. high alarm (for each) and trip (for each)
l) HT motor trip on electrical fault (for each)
m) LT motor overload tripped (for each).
n) Belt sway switch operated (for each)
o) Pull cord switch operated (for each)
p) Zero speed switch operated. (for each)
q) Chute plugged (for each)
r) Tripper over speed tripped (for each)
s) Magnetic separator fault and cleaning belt trip.
- Metal Detector fault (for each)
- Metal detected / MD not reset (for each)

t) Belt Scale fault (for each)
u) Sampling system faults and trips (for each)
v) Crusher low speed & crusher bearing temperature – high.
w) Water level low in tanks (for each)
x) Oil temperature of fluid coupling high
y) Dust Extraction/service water system faults and trips (system wise)
z) Surface feeder/box feeder/bulk reception units - trip
aa) 20% spare window

For identification of the fault for a particular conveyor or equipment, status indication against that conveyor / equipment in the mimic will start fast flickering and the annunciation window will be blinking against that particular fault. In addition, a buzzer (alarm) will start sounding. After acknowledgement of the fault, the buzzer will stop, but the fast flickering on the mimic and the steady glow on the annunciation window will continue until the fault is cleared and the Reset push button is pressed. When the fault is cleared and the Reset push button is pressed, the status indication of that conveyor / equipment on the mimic will start slow blinking if it is on selected path otherwise it will go off and the steady glow in the annunciation window will go off. However, pressing of the Reset push button before clearance of the fault, will have no effect on the lamps.

At the time of a fault, the faulty conveyor / equipment, as well as the preceding conveyors / equipment in the interlock sequence, will stop except H.T. motors for which only scoop coupling will be disengaged and motor will continue to run for process fault. In case of motor fault, H.T. motor will trip but the succeeding conveyors / equipment will continue to run. The status indication against the preceding conveyors / equipment will start slow blinking while the faulty conveyor / equipment will be fast blinking.

Start command shall not be initiated unless reset button in pressed after clearance of fault.

The sequence of operation of the annunciation system shall be as follows:-

| CONDITION | | | STATUS |
|---|---|---|---|
| Normal : | Ann. Window | : | Off. |
| | Status indication | : | Steady glow |
| | Buzzer | : | Off. |
| Fault : | Ann. Window | : | Blinking. |
| | Status indication | : | Fast blinking |
| | Buzzer | : | Sounding. |
| Press Accept. PB. | Ann. Window | : | Steady glow. |
| | Status indication | : | Fast blinking |
| | Buzzer | : | Off. |
| Press Reset PB (When fault is cleared): | Ann. Window | : | Off. |
| | Status indication | : | **i)** Steady blinking (if on selected path)<br>**ii)** Off (if not on selected path) |
| | Buzzer. | : | Off. |

6.08.00 **Dust Extraction System**

Complete interlock, protection, annunciation for Dust Extraction System to be provided by the contractor and the same shall be approved by Employer during detail engineering.

6.09.00 **Metal detectors**

(a) It shall be possible to start the conveyors only after energizing the metal detector and 'Metal detector reset' condition. Once the metal is detected, the corresponding conveyor shall trip.
It shall be possible to restart the conveyors, after local resetting of metal detector and putting back the marker bag in position. Metal detector ON/OFF push buttons shall be provided in main control room also.

(b) In case of tripping of conveyor system, metal-detector shall get de-energized after a time lag.

(c) Following individual indications shall be provided on local control panel.
- Metal detector 'ON'
- Metal detected
- Metal detector 'reset'.
- Metal detector faulty.

6.10.00 **Sump Pumps**

(a) Sump Pumps shall start and stop by the level switches in the sump automatically. Further manual override start / stop push button shall be provided locally on ground level.

(b) Any of the pumps can be selected as auto-standby.

(c) If the sump level continues to be high even after the first pump is under operation second pump shall start automatically.

(d) The following indications for sump pumps shall be provided on local Control Panel.
- Water level high
- Motor ON/OFF/TRIP.

6.11.00 **Lime Sampling system**

(a) Lime Sampling Unit shall be controlled through PLC as per standard and proven practices of LSU equipment / LHP supplier, which will be located nearest MCC. Controls and interlocks for proper material flow shall be provided similar to conveyor system. Suitable Mimic shall be provided in the PLC.

(b) Lime Sampling Unit shall be controlled through main FGD DDCMIS. Controls and interlocks for proper material flow shall be provided similar to conveyor system. Mimic shall be provided in the Operator Work Station (OWS) at main FGD control room.

(c) Only one start/stop push button along with selector switches for various modes of operation of Lime sampling system shall be provided for automatic operation of complete lime sampling system. This control facility shall be provided at main FGD control desk as well as locally. In any case, local push button stations shall be provided for all individual equipment of lime sampling system near the equipment.

(d) All necessary automatic controls shall be provided for meeting the requirements of ASTM-D-2234 or ASTM-C-50.

(e) Following indications shall be provided on local control panel

- System ON/OFF/TRIP
- Primary cutter stuck up between parking positions.

(f) In case of primary cutter getting stuck between parking positions, preceding conveyor shall trip and annunciation shall appear at Main FGD Control room.

(g) There shall be protection in the primary lime sampler to trip the conveyor belt in case primary sampler falls on running conveyor due to coupling failure etc.

(h) Necessary interface signals e.g. LSU system status, cutter stuck etc shall be provided at main FGD control room.

6.13.00 **Travelling Trippers**

(a) Mobile tripper unit shall be locally controlled from the operating platform suitably located with the unit as per instructions given from main FGD control room.

(b) End travel limit switches shall also be provided.

(c) Travel drive motor shall start only when brake and rail clamps are in disengaged condition.

(d) It shall be possible to trip the bunker Conveyors from tripper.

(e) When the last bunker is full, it shall not be possible to change over the tripper flap gate from bunker feeding position to last bunker feeding position.

(f) As soon as the bunker conveyor trips, tripper flap gate shall change over its position after a time lag.

(g) Two nos. emergency stop button one on each side shall be provided on tripper to stop the machine at any position. The control unit on tripper shall be provided with start / stop push button and indication lamp for travel / gate. The tripper brakes and rail clamps shall be energised (and released) when the tripper motors are ON and the brakes will be applied when the travel motors are OFF. Two travel limit switches shall be provided at either end of tripper carriage for limiting the travel drive between two ends of the track. The first one shall be normal limit and the second one for over travel limit. In addition to above, position indication for bunker position of tripper will be provided in Main control room. Necessary position encoders/limit switches shall be provided.

(h) Following individual indications shall be provided on local control panel

- Motor ON/OFF/TRIP
- Brakes applied
- Rail clamps applied
- Flap gate position

(i) Indication of tripper flap gate positions shall be given in the main FGD control room.
(j) Chute blockage switch shall be provided at each leg of chute and shall trip the tripper conveyor in case of blockage.

6.14.00 **Flap Gates/ R&P Gates**

All Flap Gates/ R&P Gates shall be motorised with remote controlled from the main control desk. Their position shall be indicated on the mimic of main control room.

6.15.00 **Belt Weighers**

Each belt scale shall give output to DDCMIS for display of flow rate indicator and totalizer on TFT and print out at main FGD control room. Each belt scale shall also have rate flow indicator and totaliser mounted near the unit.

6.16.00 **Magnetic separator / Suspended Magnet**

It shall be possible to start the conveyor only after energising the magnet of ILMS or SM. Further, if conveyor system trips magnetic separators shall get de-energised after a time lag and suspended magnet will remain energised and can be de-energised locally. Also if drive motor of cleated belt of ILMS trips, magnetic separator shall not get de-energised, but conveyor system shall trip and audio-visual annunciation shall appear at main FGD control room.

Following individual indications shall be provided on local control panel

(a.) Magnetic separator ON.
(b.) Incoming supply ON
(c.) 'Under current relay' operated
(d.) Cleated belt motor ON/OFF/TRIP
(e.) Oil temperature high

6.17.00 **Service water, Cooling Water and potable water pumps**

(a.) These pumps shall be started from main FGD control room
(b.) Pump shall trip in case of low water level in tank.
(c.) Following individual inputs shall also be provided to DDCMIS system for alarms/indications :
- Motor ON/OFF/TRIP
- Discharge water pressure low
- Water level low in tank
- Water level high in tank

Contractor shall provide a comprehensive interlock and protection scheme and include a block logic diagram and write up on the scheme proposed. The final scheme shall be subject to approval of Employer. Sequential interlocking as applicable shall be provided. This shall be a part of main interlock scheme /writeup for the entire Limestone & Gypsum Handling Plant.

6.18.00 **Summary of control philosophy**

Contractor shall furnish summary of control philosophy indicating permissive, trip and interlock conditions for each drive/equipment. It shall clearly list all permissive conditions (conditions required to start the drive), all the trip/protection conditions and each auto start/open and auto stop/close condition for each drive/equipment.
The sequential start-up and shut-down steps for a group of drive/equipments shall also be described clearly.

The above summary conditions shall be comprehensive to include all process conditions and shall be elaborated in clear and unambiguous way, and shall include tag numbers of devices and equipments.
A centralized main FGD control room (DDCIMS based) shall be provided to control and monitor the operations of the Lime handling system and Gypsum handling plant.

6.19.00 **Logic Diagram**

The contractor shall furnish comprehensive logic diagram showing all interlock, protection, sequence and alarm requirements of complete system to the employer during detail engineering stage. In this logic diagram, tag number corresponding to I/O list and drive list shall be clearly indicated. The format of this logic diagram shall be informed by employer during detail engineering. The recommended logic and write-up shall match fully.

# SUB-SECTION-I-M7

# PIPING

## LOW PRESSURE PIPING

### 1.00.00 EQUIPMENT SIZING CRITERIA

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

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

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

a) **Water Application**

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

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

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

| | | |
|---|---|---|
| (i) | Carbon steel pipe | 100 |
| (ii) | Ductile Iron. | 140 |
| (iii) | Rubber lined steel pipe | 120 |
| (iv) | Stainless steel pipe | 100 |

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

(b) **Compressed Air Application**

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

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

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

1.06.00 Corrosion allowance of 1.6 mm will be added to the calculated thickness being considered (except stainless steel piping).

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

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

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

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

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

1.12.00 Threaded joints shall be provided with Teflon sealant tapes.

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

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

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

| | |
|---|---|
| 2.00.00 | **TECHNICAL SPECIFICATION** |
| 2.01.00 | **GENERAL** |
| | Specific technical requirements of low-pressure piping, fittings, supports, valves, specialties and tanks etc. have been covered under this Sub-section. It includes details pertaining to design and material of construction for piping, fittings, valves, equipment, etc. cleaning/surface preparation application of primer and painting on over ground piping. It also includes detailed technical requirement of laying underground/buried piping including water proofing/anti corrosive protection. It also covers design, engineering, manufacturing, fabrication, technical details of piping, valves, specialties, piping hangers / supports, tanks etc. |
| 2.02.00 | **Pipes and fittings** |
| 2.02.01 | All low pressure piping systems shall be capable of withstanding the maximum pressure in the corresponding lines at the relevant temperatures. However, the minimum thickness as specified in the following clauses and or respective codes for pipes and fittings shall be adhered to. The bidder shall furnish the pipe sizing/ thickness calculation as per the criteria mentioned above under LP piping equipment sizing criteria of this Technical Specification. |
| 2.02.02 | Piping and fittings coming under the purview of IBR shall be designed satisfying the requirements of IBR as a minimum. |
| 2.02.03 | Supporting arrangement of piping systems shall be properly designed for systems where hydraulic shocks and pressure surges may arise in the system during operation. Bidder should provide necessary protective arrangement like anchor blocks/anchor bolt etc. for the safeguard of the piping systems under above mentioned conditions. The requirement will be, however, worked out by the contractor and he will submit the detailed drawings for thrust/anchor block to the Employer. External, and internal, attachments to piping shall be designed so as not to cause flattening of pipes and excessive localized bending stresses. |
| 2.02.04 | Bends, loops, off sets, expansion or flexible joints shall be used as required in order to prevent overstressing the piping system and to provide adequate flexibility. Flexibility analysis (using software packages such as Caesar-II etc.) shall be carried out for sufficiently long piping (straight run more than 300M). |
| 2.02.05 | Wherever Bidder's piping coming under this specification, terminates at an equipments or terminal point not included in this specification, the reaction and the thermal movement imposed by bidder's piping on equipment terminal point shall be within limits to be approved by the Employer. |
| 2.02.06 | The hot lines shall be supported with flexible connections to permit axial and lateral movements. Flexibility analysis shall be carried out for pipelines which have considerable straight run as indicated above and necessary loops/ expansion joint etc. shall be provided as may be necessary depending on layout. |
| 2.02.07 | Piping and fittings shall be manufactured by an approved manufacturer of repute. They should be truly cylindrical of clear internal diameter, of uniform thickness, smooth and strong, free from dents, cracks and holes and other defects. |
| 2.02.08 | For rubber lined ERW pipes, beads shall be removed for pipe size 80 NB and above. |
| 2.02.09 | Inspection holes shall be provided at suitable locations for pipes 800 Nb and above as required for periodic observations and inspection purposes. |

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

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

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

2.03.00 **Material**

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

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

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

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

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

| Sl No | Type of Fluid | Material |
|---|---|---|
| 1. | i) Ordinary Water (Raw Water, Clarified Water, etc.)<br>ii) Equipment cooling water including Both primary & secondary circuit (DMCW pH-corrected & ACW drain water) | IS-2062 Gr.-E-250B/ASTM A-36/ASTM A-53 type 'E' Gr.B/IS-3589 Gr. 410 /IS-1239 Heavy. |
| 2. | i) Demineralized water,<br>ii)Alkaline solution (ECW system chemical dosing) | Stainless Steel to ASTM A312, Gr. 304 welded for sizes 65 mm NB and above.<br>Stainless steel to ASTM A312, Gr. 304 sch.40s seamless for sizes 50mm and below |
| 3. | i) Drinking (potable) water<br>ii)Compressed air (Instrument & service air) | ASTM A-53 type E Gr. B galvanized/ IS 1239 Gr heavy galvanized/IS 3589 Gr 410 galvanized. Galvanized shall be to IS- 4736 or equivalent. |

2.03.06 In water lines, pipes upto 150mm Nb shall conform to ANSI B36.10/ASTM-A-53, Type-E Gr.B /IS:1239 Gr. Heavy and minimum selected thickness shall not be less than IS:1239 Grade Heavy except for demineralized water, drinking water .

| | |
|---|---|
| 2.03.07 | Pipes of above 150mm Nb shall be to AWWA-C200/ANSI B 36.10/ASTM A-53/IS 3589 Gr.410. Pipe to be fabricated by the bidder shall be rolled and butt welded from plates conforming to ASTM A-53 type 'E' Gr. B/IS 2062 Gr.E-250B/ASTM-A-36. However, larger pipes, i.e. 1000mm Nb and above shall be made from plates conforming to ASTM A 36/IS 2062 Gr.E-250B and shall meet the requirements of AWWA-M-11 (for deflection & buckling criteria considering water filled pipe as well as vacuum condition that may prevail during transient/surge conditions, truck-load, rail-load and weight density for compacted soil or any other load as the case may be). |
| 2.03.08 | In demineralized water service, the pipes up to 50 NB shall be of stainless steel ASTM A 312, Gr. 304 sch. 40 Seamless. The size for these pipes shall be to ANSI B 36.19. These shall be socket welded. The material for pipe from 65mm NB up to and including 400 NB shall be to ASTM A 312, Gr. 304 (welded). In no case the thickness of fittings shall be less than parent pipe thickness.<br><br>Bidder/Contractor shall note that pipes offered as per a particular code shall conform to that code in all respects i.e. Dimension, tolerances, manufacturing methods, material, heat treatment, testing requirements, etc. unless otherwise mentioned elsewhere in the specification. |
| 2.03.09 | Instrument air, Plant (service) air lines and Drinking water lines shall be to ASTM A 53 type E grade B/ANSI B 36. 10/IS 3589, Gr. 410 / IS: 1239 Heavy (in case thickness calculated is more than gr. Heavy, ANSI B 36.10 Schedule numbers shall be followed) and galvanized to IS 4736 or any equivalent internationally reputed standard. The material of the pipes shall be to ASTM A 53 type 'E' Gr. B / IS: 3589, Gr. 410 / IS: 1239 Gr. Heavy. The fittings shall be of either same as parent material or malleable iron to IS-1879 (galvanized). |
| 2.03.10 | Spiral welded pipes as per API-5L/IS-3589 are also acceptable for pipe of size above 150 NB. However minimum thickness of the pipes shall be as elaborated in above clauses. |
| 2.03.11 | Condensate lines shall be to ASTM A 106 Gr. B and dimension to ANSI B 36.10 schedule "standard" as minimum to be maintained. |
| 2.03.12 | If carbon steel plates of thickness more than 12 mm are used for manufacture of pipes, fittings and other appurtenances, then the same shall be control-cooled or normalized as the case may be following the guidelines of the governing code. |
| 2.04.00 | **Field routed pipes:** |
| 2.04.01 | Pipe lines of NB 50 size and below are regarded as field run piping. It is Bidder's responsibility to plan suitable layouts for these system insitu. Bidder shall prepare drawings indicating the layout of field run pipe work. These drawings shall be approved by Project Manager to the installation of the field run pipe work. Based on these approved layouts the Bidder shall prepare the BOQ of field run-pipes and submit to Employer for approval. |
| 2.05.00 | **Slope/Drains and Vents** |
| 2.05.01 | Suitable slope shall be provided for all pipelines towards drain points. It is Bidder responsibility to identify the requirements of drains and vents, and supply the necessary pipe work, valves, fittings, hangers and supports etc. As per the system requirement low points in the pipelines shall be provided with suitable draining arrangement and high points shall be provided with vent connections where air or gas pockets may occur. Vent for use during hydrostatic test shall be plugged after the completion of the test. Vent shall not be less than 15mm size. Drains shall be provided at low points and at pockets in piping such that complete drainage of all systems is possible. Drain shall not be less than 15mm for line size up to 150mm, not less than 20mm up to 300mm and not less than 25mm for 350mm to 600mm pipes and not less than 50mm for 600mm and above pipes. |

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

2.06.00 **Pipe Joints**

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

2.06.01 **Screwed Joints**

(a) Threading of pipes shall be carried out after bending, heat treatment etc. If not possible, threading may be done prior to these operations but proper care should be taken to protect them from damage. Threads shall be to ANSI B 2.1 (taper) NPT/ ANSI B1.20.1 (taper) NPT / IS: 554 unless specified otherwise.

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

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

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

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

2.06.02 **Welded Joints**

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

2.06.03 **Flanged Joints**

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

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

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

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

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

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

2.07.02 For pipe size 350Nb and above mitre bends may be used for all pipes except rubber lined pipes. However, mitre bends are also acceptable for rubber lined pipes above 1200 NB. The bend radius shall be 1½ times the nominal pipe diameter. 90 deg. bends (mitre) shall be in 4 pieces (3 cuts) and 45 deg. mitre bends shall be in 3 pieces 22½ deg. Fabrication of mitre bends shall be as detailed in BS 2633/BS534.

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

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

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

2.08.00 **Flanges**

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

2.08.02 All flanges and-flanged drilling shall be to ANSI B 16.5 / BS EN-1092 / AWWA C - 207 of relevant pressure/temperature class. Flanges shall be fabricated from steel plates conforming to ASTM A 105/IS 2062 Gr. E-250B. However stainless steel flanges shall be fabricated from SS plates to ASTM-A-240, Gr. 304 or equivalent.

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

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

2.09.01 **Trenching**

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

2.09.02 **Preparation and cleaning of piping**

(a) The pipeline shall be thoroughly cleaned of all rust, grease, dirt, weld scales and weld burrs etc. moisture or other foreign matter by power cleaning method such as sand or grit blasting, power tool cleaning, etc. Grease or heavy oil shall be removed by washing with a volatile solvent such as gasoline. Certain inaccessible portions of the pipeline (which otherwise not possible to be cleaned by power cleaning methods) may be scrubbed manually with a stiff wire brush and scrapped where necessary with specific permission of the Project Manager.

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

2.09.03 **Coating and wrapping/ Anti corrosive Protection Coal tar tape**

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

(1) Coating primer (coal tar primer)

(2) Coating enamel (coal tar enamel)

(3) Wrapping materials.

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

Protective coating shall consist of coal tar primer, coal tar enamel coating, glass fiber, tissue inner wrap followed by glass fiber or coal tar impregnated Kraft outer wrap or finish coat.
Number of coats and wraps, minimum thickness for each layer of application shall be as per IS-10221. Number of. Coats and wraps shall be decided based on soil corrosivity/resistivity as indicated in IS-10221. Soil data-for this purpose shall be made available.

Total thickness of completed coating and wrapping shall not be less than 4.0 mm.

| | |
|---|---|
| | b. Alternatively, the anti-corrosive protection for buried pipes can consist of anti-corrosive protection Coal-tar tapes. Material and application of tapes shall conform to IS 15337 or equivalent. These-tapes shall be applied hot over the cold coal tar primer in steps of 2mm thickness so as to cover the spiral edges of the first tape by the application of second tape. The total thickness of the finished protective coating shall be 4.0 mm minimum. |
| 2.09.04 | **Trench bed preparation and back filling**<br><br>Prior to lowering and laying pipe in any excavated trench, the bottom of the trench may require to be back filled and compacted (or as the case may be) to provide an acceptable bed for placing the pipe. Bed preparation in general shall be as per IS: 5822. |
| 2.09.05 | **Laying of galvanized steel (GI) pipes**<br><br>All the joints shall be screwed with socket or flanged. Screwed ends of GI pipes shall be thoroughly cleaned and painted with a mixture of red and white lead before jointing Threaded portion on either side of the socket joint shall be applied with Zinc silicate paste.<br><br>All the provisions for trenching' bed preparation' laying the pipe application of primer' coating' wrapping with tapes and back filling etc. as indicated for "laying of buried piping" and " anti-corrosive protection for buried piping" are applicable for buried galvanized steel (GI) pipes also. |
| 2.10.00 | **Cleaning and flushing** |
| 2.10.01 | All piping shall be cleaned by the Bidder before and after erection to remove grease, dirt, dust, scale and welding slag. |
| 2.10.02 | Before erection all pipe work, assemblies, sub-assemblies, fittings, and components, etc. shall be thoroughly cleaned internally and externally by blast cleaning or by power driven wire brushes and followed by air-blowing. However for pipe sizes below 100nb the pipes may be cleaned internally by compressed air blowing as an alternative to internal blast cleaning. The brushes shall be of the same or similar material as the metal being cleaned. Cleaning of Galvanized pipes shall be done by air blowing only. |
| 2.10.03 | After erection, all water lines shall be mass flushed with water. The cleaning velocities in water lines shall be 1.2-1.5 times the operating velocities in the pipelines. |
| 2.10.04 | All compressed air pipe work shall be cleaned by blowing compressed air. |
| 2.11.00 | **Specification for hangers and supports** |
| 2.11.01 | All supports and parts shall conform to the requirement of power piping code ANSI B 31.1 or approved equivalent. |
| 2.11.02 | The maximum spans of the supports of straight length shall not exceed the recommended values indicated in ANSI B 31.1. |
| 2.11.03 | At all sliding surfaces of supports suitable arrangement is to be provided to minimize sliding friction. |
| 2.12.00 | **Design/Construction/Material Particulars of Gate/ Globe /Check /Butterfly / Ball / Air release /Float valves / Moisture Traps.** |

2.12.01 **GENERAL**

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

(b) Special attention shall be given to operating mechanism for large size valves with a view to obtaining quick and easy operation ensuring that a minimum of maintenance is required.

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

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

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

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

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

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

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

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

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

2.12.02 **VALVE BODY MATERIAL**

Valve body material for various services shall be as follows:

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

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

DM water: SS body and disc along with SS internals. However for butterfly valves, Cast Iron /Ductile Iron/SG iron/carbon steel body and disc with elastomer lining are also acceptable.

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

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

**Standards and Codes**

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

2.12.04 **End Connections**

The end connections, shall comply with the following:

Socket welding (SW) - ANSI B 16.11

Butt Welding (BW) - ANSI B 16.25.

Threaded (SC) - ANSI B 2.1

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

2.13.00 **Gate/Globe/Check Valves**

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

(b) All steel and stainless steel body valves of sizes 65 mm and above shall have flanged or butt welding ends. Valves of sizes below 65mm shall have flanged or socket welded ends. Compatibility of welding between valve body material and connecting pipe material is a pre-requisite in case of butt-welded joints.

(c) All gun metal body valves shall have screwed ends.

(d) All flanged end valves/specialties. shall be furnished along with matching counter flanges, fasteners, gaskets etc. as required to complete the joints.

(e) Gate/sluice valves shall be used for isolation of flow. All gate valves shall be of the full-way type, and when in the full open position the bore of the valve shall not be constricted by any part of the gate.

Gate valves shall be of the solid/elastic or articulated wedge disc. Gate valves shall be provided with the following accessories in addition to other standard items:

(1) Hand wheel

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

(3) Draining arrangement wherever required.

(f) Globe valves shall be used for regulation purposes. They shall be provided with hand wheel, position indicator, draining arrangement (wherever required) and arrow indicating flow direction. Preferably, the valves shall be of the vertical stem type. Globe valves shall preferably have radius or spherical seating and discs shall be free to revolve on the spindle.

The pressure shall preferably be under the disc of the valve. However, globe valves, with pressure over the disc shall also be accepted provided (i) no possibility exists that flow from above the disc can remove either the disc from stem or component from disc (ii) manual globe valves can easily be operated by hand. If the fluid load on the top of the disc is higher than 40-60 KN, bypass valve shall be provided which permits the downstream system to be pressurized before the globe valve is opened.

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

(h) For bore greater than 2" the valves must be swing check type or dual plate check type suitable for installation in all positions (vertical and horizontal);

(i) For bore smaller than or equal to 2" the valves must be of the piston type to be installed, in horizontal position.

(j) All gate and globe valves shall be provided with back seating arrangement to enable on line changing of gland packing. The valves shall be preferably outside screw & yoke type.

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

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

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

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

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

(1) **Cast Steel Valves**

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

(2) **Stainless steel valves**

| | |
|---|---|
| Body & Bonnet | SS 304 |
| Disc | -do- |
| Trim. | SS 316 |

(3) **Cast iron valves**

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

(4) **Gun Metal valves**

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

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

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

(d) Forged carbon steel valves are also acceptable in place of Gun metal valves.

2.14.00 **Air Release Valve**

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

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

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

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

2.15.00 **Butterfly valves**

2.15.01 **Design/Construction**

(a) The valves shall be designed for the design pressure/temperature of the system on which it is installed and in accordance with AWWA-C-504, EN-593 or any other approved equivalent standard latest edition. Fabricated steel (IS: 2062 GR. E-250B) butterfly valves instead of cast iron body valves are also acceptable for size above 300 mm nb diameter.

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

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

(d) Valves-200Nb and above shall also be provided with gear operator arrangement as a standard practice suitable for manual operation. Manual operation of valve shall be through gear arrangement having totally enclosed gearing with hand wheel diameter and gear ratio designed to meet the required operating torque It shall be designed to hold the valve disc in intermediate position between full open and full closed position without creeping or fluttering. Adjustable stops shall be provided to prevent over travel in either direction.

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

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

Materials and other design details shall be as indicated below:

(a) **Cast Iron Butterfly Valves**

| | |
|---|---|
| Body & Disc | ASTM A48, Gr. 40 with 2% Ni / IS: 210. Gr. FG-260, with 2% Ni / SG iron BSEN 1563, Gr EN GJS-400-15 with 2%Ni and epoxy coated |

| | |
|---|---|
| Shaft | BS 970 431 S: 291 / EN 57, or AISI-410 or AWWA-permitted shaft material equivalent to EN-57/AISI-410 or better. |
| Seat ring | 18-8 Stainless steel |
| Seal | Nitrile Rubber |

(b) **Stainless Steel Butterfly Valves**

| | |
|---|---|
| Body & Disc | SS 304 |
| Shaft | SS 316 |
| Seat Rings | EPT/BUNA-N/Neoprene |

(c) **Carbon steel Butterfly Valves**

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

(d) **Elastomer lined Butterfly Valves**

| | |
|---|---|
| Body & Disc | ASTM A48, Gr. 40 / IS: 210. Gr. FG-260 / SG Iron (ductile iron) IS 1865 Gr 400-15 or BSEN 1563, Gr EN GJS-400-15 / ASTM A 216, Gr. WCB with elastomer lining. |
| Shaft | SS 316 |

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

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

All valves that are designed and manufactured as per AWWA-C-504 / AWWA-C-516 shall be governed by the relevant clauses of P.O.D test in AWWA-C-504/AWWA-C-516. For Butterfly valves, designed and manufactured to EN-593 or equivalent, the P.O.D. test methods and procedures shall generally follow the guidelines of AWWA-C-504 in all respect except that Body & seat hydro test and disc-strength test shall be conducted at the pressures specified in EN-593 or the applicable code. Actuators shall also meet requirements of P.O.D. test of AWWA-C-504/AWWA-C-516.

2.16.00 **Float operated valves**

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

(b) DESIGN AND CONSTRUCTION FEATURES

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

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

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

(e) Leather liner shall not be provided.

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

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

(h) The valves shall have flanged connections.

2.17.00 **Surface preparation and Painting for external piping surfaces (non-coastal projects)**

a) Surface preparation - Power tool cleaning / Shot blasting/ abrasive blasting
b) Type of Primer - Red Oxide Zinc Phosphate primer (Alkyd base) to IS 12744 (2 X 25 microns)
c) Intermediate Coat – Synthetic Enamel (long oil alkyd) to IS2932 (1 X 30 microns)
d) Final Coat - Synthetic Enamel (long oil alkyd) to IS2932 (2 X 35 microns)

Min. Total DFT (Microns) to be maintained – 150 (Min) and Color shall be as per NTPC Color Coding Scheme

Note: No painting is required on Galvanized, Stainless Steel, Gun Metal surfaces

2.18.00 **Surface preparation and Painting for external piping surfaces (coastal projects)**

a) Surface preparation - Near white metal blast cleaning with surface profile 35-50 microns as per surface preparation specification SSPC.SP10 of Society of Protective coatings , USA
b) Type of Primer –
Inorganic zinc (ethyl) silicate primer coat(1 X 70 microns): Self-curing Inorganic Zinc (ethyl) Silicate Primer Coat (having minimum 80% of metallic Zinc content in dry film , Solid by Volume Minimum 60% ±2%) to be applied over blast cleaned surface.
c) Intermediate Coat (2 X 90 microns)– Polyamide Cured pigmented Micaceous Iron Oxide Epoxy based Paint (containing lamellar MIO minimum 30% on pigment, Solid by Volume Minimum 80% ±2%) Polyamide Cured pigmented Micaceous Iron Oxide Epoxy based Paint (containing lamellar MIO minimum 30% on pigment, Solid by Volume Minimum 80% ±2%).
d) Final Coat (1 X 70 microns) - Acrylic Aliphatic Polyurethane, two pack, iso-cyanate based color pigmented Paint (Solid by Volume Minimum 55% ±2%)

Min. Total DFT (Microns) to be maintained – 320 (Min) and Color shall be as per NTPC Color Coding Scheme

Note:
1.) For external surfaces (galvanized steel), proper surface preparation with power tool cleaning up to grade ST2, ISO:8501-01 followed by zinc phosphate primer with 50 microns DFT, again followed by Acrylic Aliphatic Polyurethane coat of 40 microns DFT.

2.) If final shade of 9002 (off white) is required then Micaceous Iron Oxide (MIO) color shall be grey.

3.) No painting is required on Stainless Steel, Gun Metal surfaces.