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BHARAT HEAVY ELECTRICALS LIMITED

पारेषण व्यापार अभियांत्रिकी प्रबंधन

TRANSMISSION BUSINESS ENGINEERING MANAGEMENT

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परामर्शदाता/ CONSULTANT	NATIONAL THERMAL POWER CORPORATION LTD (NTPC LTD.)						
परियोजना/ PROJECT	3X800 MW PATRATU SUPER THERMAL POWER PROJECTS EXPANSION PHASE-I (3X800MW) - 400 KV GIS						

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Rev No.	Date	Altered	Checked	Approved	REVISION DETAILS

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PRE- QUALIFYING CRITERIA (PQR) FOR BIDDERS

Air Conditioning System:

The bidder should have designed, supplied, erected and commissioned atleast One (1) number of Air conditioning system having a total installed capacity of 300TR or more, which should have included atleast one chilling unit with a minimum capacity of 60TR. The systems should have been in #successful operation for atleast one (1) year prior to 07-09-18.

In addition, the chiller unit(s) proposed to be supplied for this package shall be sourced from the manufacturer(s) who have manufactured and supplied atleast one (1) no. of similar type of chiller units each having a capacity of not less than 150 TR, which should have been in #successful operation for atleast one (1) year prior to 07-09-18.

Ventilation System:

The bidder/ its sub-vendor should have designed, supplied, erected, and commissioned atleast One (1) number ventilation systems including air washer units having individual fan capacity of 80,000 Cum./Hr. or more at each ventilation system, in Industrial/ Commercial installations. The systems should have been in #successful operation for atleast One (1) year prior to 07-09-18.

In support of the above credentials, the bidder should submit copy of Purchase order along with performance certificate from customer.

(#) Successful operation means certificate issued by the Customer/ end user certifying the operation without any adverse remark.

Only Bidders qualifying PQR requirements will be made technically acceptable for further bid evaluation activity.

SECTION -1

INTENT, SYSTEM DESCRIPTION, DESIGN CRITERIA AND SCOPE

1.0 INTENT OF SPECIFICATION

1.1 This specification covers the design, manufacture, inspection and testing at bidder's and/ or his sub vendor's work(s), proper packing, transportation & delivery, storage and handling at site, erection, testing and commissioning, final painting and carrying out acceptance tests at site of **Air-Conditioning and Ventilation System** as detailed in this section and in various other sections of this specification for different rooms located inside the 400KV Gas Insulated switchyard (GIS) control Building and GIS Hall of **PATRATU SUPER THERMAL POWER PROJECTS EXPANSION PHASE-I (3X800MW) - 400 KV GIS**.

1.2 The requirement(s) specified under 'SECTION 2, SECTION 3, SECTION 4' and 'SECTION 5' of this specification shall be considered as part of this section. In case of variance between sections, the requirement of Section-1 shall prevail ***(except those points where specifically mentioned to follow customer specification strictly).*** Customer specification in annexure to section-2 shall be adhered to by the bidder.

1.3 It is not the intent to specify herein all the details of design and manufacture. However, the equipment shall conform in all respects to high standards of design, engineering and workmanship and shall be capable of performing the required duties in a manner acceptable to Purchaser/ Owner, who will interpret the meaning of drawings and specifications and shall be entitled to reject any work or material, which in his judgment is not in full accordance herewith.

1.4 The bidder shall be deemed to have understood completely all the tender drawings and documents and quoted accordingly.

1.5 The bidder has to note carefully the parameters, estimated capacities of equipment indicated and the tender drawing in the specification are only for guidance of the bidder. The system shall be designed as per relevant standards / codes and exact capacities and quantities are to be estimated by the bidder. All such estimations and design calculations shall be submitted for Purchaser's approval.

1.6 *Deviation:* In case of any deviation, the bidder shall indicate separately the deviations clause-wise with respect to the specification in the 'Schedule of Deviation' given in schedule 2 of section-5. Deviations in any other form including clarifications / assumptions / etc. will not be considered and it will be construed that the bid conforms strictly to the specification.

1.7 The contract shall be on lump sum basis for the package. Within the scope of the contract no variation shall be admissible to the contractor so far the inputs remain unchanged. The Contractor

shall be responsible for providing all material, equipment and services, specified or otherwise which are required to fulfill the intent of ensuring operability, maintainability and the reliability of the complete work covered under this specification. In case of change in the input after placement of order the additions / deletions to the scope shall be settled on the basis of mutually agreed rates.

1.8 The Purchaser, Consultant and Customer in this specification stand for BHEL, NTPC and PVUNL respectively. The successful bidder shall be referred to as Contractor.

AIR CONDITIONING AND VENTILATION SYSTEM

This system shall be designed with the objective of providing Air Conditioning and Ventilation in different rooms located inside the 400KV Gas Insulated switchyard (GIS) control Building and GIS Hall of **3X800MW PATRATU SUPER THERMAL POWER PROJECTS EXPANSION PHASE-I -400 KV GIS.**

CODES AND STANDARDS

The design, manufacture, inspection and testing of Air Conditioning and Ventilation system shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment is to be installed. The equipment shall also conform to the latest applicable Indian/ British/American standards.

The equipment shall conform to the latest edition to the following standards:

IS: 659 - Safety Code for Air-Conditioning
IS: 655 - Specification of metal Air-Ducts
IS: 4999 (Part-51) - Noise Level
IS: 3588 - Specifications of Electrical Axial Flow Fans
IS: 2312 - Propeller type Ventilation fans
BS: 6540 Part I - Air Filters used in Air-Conditioning & General Ventilation
IS: 4671 - Expanded polystyrene for Thermal Insulation purpose
IS: 8183 - Bonded Mineral wool

1.0 SCOPE & DESIGN CRITERIA FOR AIR CONDITIONING SYSTEM

As per technical specification Air conditiong system for various areas of 400KV GIS Switcyard control building shall be provided as below:

Sl. no.	Name of the Area	Dimensions of area (Sq. m)	AC Equipment
1.	GIS Relay/PLCC panel Room including SAS room	17.23 m X 7.273 m	Air cooled condensing units (D-X type) mainly comprising scroll / screw

	area at First Floor		compressor, drive unit, condenser, interconnected refrigerant piping, controls, instruments, base frame, etc. **Air cooled condensing unit (D-X type) Air conditioners: 2X100% (capacity) & AHU (with VVVFD): 2X100%. (capacity) Unit with ducting arrangement and accessories.**
2.	Battery Charger Room at First Floor	7.0 m X 7.7 m	
3.	AC Plant/AC Unit Room at Ground Floor	7.0 m X 6.0 m	
4.	Conference Room at First Floor	5.27 m X 6.0 m	
5.	Office at First Floor	5.04 m X 6.0 m	
6.	Lab Room at First Floor	16.27 m X 7.81 m & 12.5 m X 5.68 m	

Design Criteria for above areas covered with D-X type Air cooled AC units:

Ambient Conditions	**DB in ° C**	**WB in ° C**
Summer	41	25
Monsoon	32.5	27
Winter	9	7.1
Desired Inside Condition	24^0C±1^0C 50%±5% RH	
False Ceiling	All Air conditioned areas shall have false ceiling (under BHEL scope)	
Under Deck Insulation in all air conditioned area	50mm nominal thickness of glass wool 32kg per cum. or rock wool 48 kg per cum. (under BHEL scope)	
Floor Area	As per Gas Insulated switchyard control building layout	
Exposed glass area	As per Gas Insulated switchyard control building layout	
Exposed wall area	As per Gas Insulated switchyard control building layout	
Illumination Heat load	2 Watt per sq. ft. or actual whichever is higher.	
Occupancy	***The occupancy for general/ office area shall be minimum one person per 10 Sq.M and for conference room the same shall be one per 3.0 Sq.M. In the control rooms/control equipment room, the occupancy may be one person per 25 Sq.M (Minimum) or actual seating arrangement whichever is higher***	

Fresh Air Quantity	The fresh air quantity for air-conditioned areas of Switchyard shall be 0.45 M3/minutes/person or 1.0 air change per hour whichever is greater. Fresh air fan capacity shall be minimum 10% of the total CMH value of working indoor units.
Return Air	In Air conditioning system the return air shall be through ducts and use of plenum space for return air shall be avoided
Motorized Fire Dampers	The supply and return air ducts shall be provided with automatic (motorised) fire dampers (of 90 minutes fire rating) at locations where ducts pass through walls & floors. Operation of these dampers shall be interlocked with the fire alarm system and shall also be possible to operate manually from the remote control panel. Required electrical contacts shall be provided in control panel of A/C plant by the Contractor for further wiring upto fire alarm panels.
Refrigerant	Refrigerant should be CFC/HCFC free. The refrigerant shall be R-134a/ R-410A/R-407C or any other environment friendly refrigerant.
Insulation	Supply and return ducts shall be insulated. All types of Insulation used for HVAC application shall be CFC/HCFC free.

- Peak heat load shall be calculated cconsidering following safety margins:
  - **i. Safety factor has been considered under Room Sensible heat (RSH) – 10%**
  - **ii. Safety factor has been considered under Room Latent heat (RLH) – 10%**
- **A design margin of 10% over and above the peak heat load (Final TR) & supply air quantity as per heat load calculation) shall be considered while designing the AC plant capacity for the areas tabulated above**.
- **Notes (strictly to be followed by contractor):**

i) After finalization of plant capacity during detailed engineering, contractor shall ensure it's placement in the space specified as **AC Plant room/AC Unit Room of CRB**. The final configuration (quantity and capacity of each unit to meet final capacity as per calculation and space availability) of plant shall be decided during detailed engineering to accommodate the plant and it's ducting arrangement etc.

ii) Also it is to be noted that the capacity mentioned above as 2X 100% stands for 100% working and 100% standby units. Hence we can also choose configuration as 2x50% (100% capacity) working and 2x50% (100% capacity) standby depending on the space availability.

iii) ***Hence there shall not be any price implication to BHEL on account of finalization of the capacity and configuration during detailed engineering as explained above. Bidder should understand all above facts and quote accordingly.***

1.01 TYPE OF AIR CONDITIONING SYSTEM

Air Cooled D-X type Air Conditioner Unit

(Applicable for GIS Relay/PLCC panel Room including SAS room area at First Floor, Battery Charger Room at First Floor, AC Plant/AC Unit Room at Ground Floor conference room, Office Room & Lab Room at first floor of 400KV Gas insulated switchyard control building. Refer drawing: Arch drawings-ground & first floor plan control room building-TB-0-378-607-620-1)

a. Air-conditioning shall be provided on continuous basis to maintain the specified inside conditions. The system shall comprise of Air cooled D-X type ducted AC units on 2x100% basis.

b. 2 Sets (100% working+100% standby capacities)* AHU with VVVF control *& 2 Sets (100% working+100% standby capacities) D-X type air cooled condensing unit shall be provided to cater the AC requirement of above mentioned areas in GIS control Room building. However location of the outdoor unit shall be finalised during detailed engineering stage and accordingly drawing shall be submitted to customer separately for approval.

c. **The Indoor unit (AHU's including VFD panel and it's PDB/MCC panel) shall be kept in separate dedicated room (AC Plant/AC Unit Room) on the ground floor of switchyard control building whereas D-X type condensing unit comprising of compressor, condenser coil & condenser fan shall be provided outside. Indoor unit and outdoor unit shall be connected with pipe of adequate size (both suction and liquid line)**.

d. There shall be a proper arrangement/provisions for supply and accommodation of NRD/URD in the supply air circuit near AHU duct to avoid any cross/reverse flow of air and inturn AHU fan of standby unit. The purpose of providing these damper is to isolate standby unit when working unit is under operation.

e. Refrigerant should be CFC/HCFC free. The refrigerant shall be R-134a/ R-410A/R-407C or any other environment friendly for the AC plant unit.

f. **Outlet of all the AHU's shall be collected in a common supply plenum chamber through flexible canvass connection. The conditioned air is then distributed to various AC areas mentioned above through supply air duct along with diffuser running above false ceiling. The return air from all these areas shall be collected through return air ducts running in the space above false ceiling and shall brought back to AHU/AC Unit room at ground floor of switchyard building where it will be mixed with a fixed amount of fresh air before being circulated again**.

Capacity of the D-X type AC units will be inline with heat load estimates and technical specification and it shall be on 2X100% (100% working+100% standby capacities) basis as defined above.

This complete AC plant for air conditioned areas as mentioned shall operate continuous (24 hours a day, 7 days a week except during loss of normal power failure).

✓ **Notes:**

1. Heat Load calculation for each area mentioned above will be submitted for customer/ consultant approval during detailed engineering stage.
2. For AC plant (**D-X type condensing and AHU with VVVF control**), all monitoring and control shall be suitably done automatic through their microprocessor based control panel based on the load requirement and necessary feedbacks from their instruments and other sensing devices installed within the plant.
3. For controls and interlocks provisions in D-X type plant, please follow customer specification strictly attached to section-2 ***(Please refer clause 7.05.00, sub section-A-17, Air conditioning system, Page 24 of 31)***

1.02 SYSTEM DESCRIPTION

a. **(2x100%) air cooled DX type condensing AC unit complete with all accessories as described here in after.**
b. **(2x100%) Air Handling Unit (AHU's) with VVVF control complete with all accessories as described here in after.**
c. **One VFD panel in the AHU room/AC Plant room.**
d. **One Lot-Refrigerant Pipe-MS Heavy Class (Liquid and suction line of adequate size)**
e. **One Lot-Condensate Drain water piping out of MS pipes confirming to IS:1239, Part-I, heavy grade and galvanized as per IS:4736, from various equipments upto nearest drain point.**
f. **Fire Dampers-The supply and return air ducts shall be provided with motor operated fire damper at locations where duct passes through walls & floors for ease of isolation, maintenance and as well as for emergency operation. The operation of these automatic dampers shall be interlocked the fire alarm system.**
g. **One Lot-GSS ducting (class 275) of zinc coating sheet metal work air duct and acoustic insulation for initial length of 5m from the AHU outlet.**
h. **Temp. & humidity sensor with indicator/display shall be provided in AHU Room, Relay/PLCC & SAS room only for monitoring purpose. Details of sensor shall be as per below:**

HUMIDITY SENSOR
Sensor: Capacitance type
Accuracy: +/-3% R.H
Range: 0-100% R.H
Output: 4-20 ma
Time constant: 2 mins.

Output from the sensor is to be connected to respective control system. Contractor can also provide combined instrument for measurement of humidity and temperature subject to Employer's approval during detailed engineering. In all such cases, 4-20 ma outputs, each for temperature and humidity measurements are to be provided.

TEMPERATURE/ HUMIDITY INDICATOR

Sensor: RTD for (Pt 100) for temperature: Capacitance Type for Humidity (specs for humidity and temperature shall be as mentioned above)
Display: Combined enclosure with two three digit seven segments LED display with decimal point after two digits. LED height shall be 4 inches, clearly legible from a distance of at least 10 meters.
Range: 0-60 Deg. C for temperature.
: 0-95.0 % for Relative Humidity.
Accuracy: Better than +/_0.5 % for Temperature
: Better than +/_2.5 % for Relative Humidity
Mounting: Table Top/ wall mounting.
Power supply: 240 V AC, 50 Hz.
Output: 4-20 mA signal each for temperature.

i. 1x100% duty fresh air fan with pre filter & fine filter in AHU room shall be provided.

j. The supply all Carbon steel sheets under air conditioning system shall be hot dip galvanized or spray galvanized unless otherwise specified and minimum zinc deposition shall conform to Class 275 of IS: 277.**The air distribution system shall be sized to have a constant frictional drop.**

k. Duct sizing and fabrication shall comply with requirements of IS 655/ /ASHRAE/SMACNA. Duct sizing shall be done in a way to ensure air velocity in the main duct & branch ducts shall be restricted to 7.5 m/sec and 6 m/sec (max.) and 2m/s for the diffusers/grill.

l. For calculating friction loss in piping system: WILLIAM & HAZEN formula shall be used with C value as 100.

m. **Thermal insulation -** Supply air duct and part of the return air duct passing through non conditioned space, if any, with at least 13 mm thick aluminium foil faced Nitrile Rubber thermal insulation.

n. **Acoustic insulation -** Upto a length of 6 mtrs from outlet of the PAC units, supply air duct shall be acoustically insulated with 25 mm thick fiber glass crown 150 (density of 48 kg/cu.m) and shall be covered with 26G aluminium perforated sheet. Perforation area shall be 30% of free area.

o. Common strip heater of adequate capacity shall be provided in the plenum for winter heating.

p. Pan type humidifier of adequate capacity shall be connected through a duct piece to the common plenum.

q. Motorized fire damper shall be provided in supply air duct in order to block supply air to conditioned space and vice versa in case of fire.

r. The fresh air unit shall consist of:

- Wall cowl with bird screen, tube axial fan with motor.
- Pre-filter made up of HDPE and efficiency 90% down to 10 microns and maximum face velocity of 1.75 m/sec.

- Fine filter made up of HDPE and efficiency 99.5% down to 5 microns and maximum face velocity 1.25 m/sec.
- Volume control damper, ducting, fixing frame and necessary supports.
- Filter frame shall be of aluminium and shall be flanged.

1.03 EQUIPMENT SPECIFICATION

A. 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
Refrigerant	The refrigerant shall be R-134a/ R-410A/R-407C or any other environment friendly refrigerant
Accessories	High/Low pressure cut-outs, 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.
Capacity	Minimum capacity shall be suitable for the identified/selected at evaporating temperature and condensing temperature and shall be indicated

B. Air Handling Unit (AHU)

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) at the discharge of each individual AHU, and heater section in the common discharge of AHUs. NRD shall be provided at outlet of each AHU when multiple AHU used for a common plenum.

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.

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.

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.

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.

B.1 Centrifugal fan for AHU

Fan Type	Double Width Double Inlet (DWDI) Centrifugal Type
Fan impeller	Backward curved blades
Casing material	GI /Mild steel with minimum thickness of 3 mm.
Impeller material	Carbon steel
Shaft	EN 8 Steel
Fan bearings	Self-aligning type, permanently lubricated, heavy duty with a design life of 10,000 operating hours.
Critical speed	First critical speed of rotating assembly shall be at least 25% above the operating speed.
Drive	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.
Fans	**For AHUs of capacity 50,000 CMH and above, Bidder may offer two (2) Nos. centrifugal fans of equal capacity for each AHU provided all such AHUs are accommodated within the space identified by the Employer.**

C. 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.

D. Pan Humidifier:

Pan humidifier shall be made of 22 gauge SS 304 tank, duly insulated with 25 mm thick resin bonded fibre 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.

E. Bidder should strictly follow the customer specification of switchgear board attached to section-2 of this specification

2.0 SCOPE & DESIGN CRITERIA FOR VENTILATION SYSTEM

a) **All the areas served by means of dry mechanical ventilation shall be designed for a maximum inside temperature of 3 deg. Celsius above the design ambient (DBT) condition during summer or according to suitable air changes per hour. The criterion that gives the highest flow rate will be considered for design & selection of the equipment.**

b) All the ventilation fans shall operate on 100% fresh air considering **25 air changes** per hour (ACPH) for ACDB/DCDB MCC room, **15 ACPH** for cable vault room.

c) **Ventilation fans of suitable capacity for toilet & pantry rooms of 400KV GIS control building is excluded from bidder scope.**

d) All the equipments of ventilation system shall be designed for continuous duty for continuous operation of 24 hours a day.

e) ***Heat dissipation* (188kW) *from GIS bays shall be considered as one of the design criteria for sizing of ventilation system of GIS hall during detailed engineering stage.***

f) Selection of size, rating & number of ventilation fans shall be done through proper calculation and the same will be submitted for final approval during detailed engineering stage.

g) Wall mounted supply air fans of suitable capacity (CMH) & required static head (WC) each having pre filter & fine filter **(Efficiency of pre filter shall not be less than 90% down to 10 micron while fine filter 99.5% down to 5 micron)**, rain protection cowl, bird screen and mounting arrangement along with gravity operated back draft damper (to maintain pressurized condition) shall be provided for positive pressurization of the following rooms:

   i. Cable Vault (In Control building of GIS)

   ii. ACDB/DCDB MCC Room (In Control building of GIS)

h) Wall mounted Exhaust fans of suitable capacity (CMH) each having rain protection cowl, bird screen and mounting arrangement shall be envisaged for the Battery rooms of control building of GIS.

Supply of air to battery room shall be through intake louvers provided at suitable location in the room.

i) **Supply and exhaust fans of above mentioned areas shall be provided with their local starter/push button (3 phase DOL starter).**

j) **Supply and exhaust fans of above mentioned areas shall be in multiplicity minimum 2X50% to have suitable availability/redundancy.**

k) The axial/propeller fans shall have a single piece cast aluminium impeller with blades of aerofoil design. The fan casing shall be of heavy gauge sheet steel construction minimum thickness of 3 mm up to a fan diameter of 750 mm, 5 mm for fans with impeller diameter of 750 mm and above and the same shall be spray or hot dip galvanized. Necessary rain protection cowl, inlet and outlet cones, bird protection screen, adjustable damper, vibration isolators, back draft dampers etc. shall be provided. 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. The static pressure of supply air fans with pre & fine filters shall not be less than 32 mm WC while for exhaust fans 10 mm WC. All other accessories like supporting structure etc. as required shall be provided.

l) Gravity dampers (self-acting dampers) are provided to ensure pressurization of above areas. Dampers shall be of gravity type designed such as not to allow infiltration of air from outside. The louvers of the dampers shall be freely mounted on Spindles to allow the damper to open freely with the pressure developed in the premises. The damper shall be provided with flange at the inlet, the pressure inside the premises shall be 1-2mm WC.

m) **Ventilation system for 400 kV GIS Hall**

Ventilation system shall be provided to maintain positive pressure inside GIS building. The system shall comprise of supply air fan assemblies with Pre & Fine filters, Gravity louvers, exhaust air fans, gravity dampers or a suitable combination of these along with necessary filters, ducting, grilles etc. Fans and accessories & it's dedicated PDB/MCC as per spec for this ventilation system shall be **placed in separate ventilation room (AHU Room) provided in control room building of GIS**. This dry mechanical ventilation system shall be designed for a maximum inside temperature of 3 deg. Celsius above the design ambient (DBT) condition during summer or according to suitable air changes per hour (**minimum 20 ACPH**) to cater proper heat dissipation from GIS equipment load **(188kW).**

The criterion that gives the highest flow rate will be considered for design & selection of the equipment. Ventilation system for GIS hall shall operate on 100% fresh air and no recirculation is envisaged.

Plant shall mainly consists supply air fans of DIDW type with pre and fine filters, Supply air ducting and grills. DIDW supply air centrifugal fans on **2x100 % (100% working and 100% standby)** capacity basis shall be provided for the collective requirement of GIS Hall. It shall also have GSS intake louvers with wire mesh, frame and bird protection screen and HDPE filters of min. 99% arrestance down to 5 micron. The vibration level of fans shall be within limits and vibration isolation shall be achieved by providing suitable spring type or pad type (or combination) vibration isolators for ventilation system equipment (centrifugal fans).

Notes (strictly to be followed by contractor):

After finalization of ventilation plant capacity during detailed engineering, contractor shall ensure it's placement in the dedicated space provided as AHU Room in Control building. The final configuration (quantity and capacity of each AHU to meet final capacity as per calculation and space availability) of plant shall be decided during detailed engineering to accommodate the plant and it's ducting arrangement etc.

Also it is to be noted that the capacity mentioned above as 2X100% stands for 100% working and 100% standby units. Hence we can also choose configuration as 2x50% (100% capacity) working and 2x50% (100% capacity) standby depending on the space availability.

Hence there shall not be any price implication to BHEL on account of finalization of the capacity and configuration during detailed engineering as explained above. Bidder should understand all above facts and quote accordingly.

There shall be 18 gauge G.I. common plenum chamber after centrifugal fans outlet provided with necessary maintenance windows, water tube manometer across air filter, one pressure switch and pilot light on panel to indicate dirty condition of filter.

These filters shall be arranged in a panel formation with filter module mounting frame on the downstream side. Wall cut outs for mounting of intake louvers shall be made available in ventilation room. Two Supply air duct shall be taken from plenum chamber which shall run on the both walls along the length of the GIS Hall with necessary grilles/ diffusers to make proper ventilation arrangement inside the hall to facilitate proper mixing and avoid any hot spot. Motorized & CBRI certified Fire damper of fire rating 90 minutes shall be installed in supply air path. No exhaust or return air ducting is envisaged in this area.

Also bidder should study the civil drawing of the GIS building (pre-fabricated structured), wherein the members of support wall may hamper the entry of ducts to the GIS building from

the ventilation room. Hence contractor shall make all necessary arrangements with respect to ducts entry its support between two buildings etc.

Also all duct supporting structures inside GIS Hall shall be of good quality and it's specification should be strictly inline with customer specification attached to section-2. Bidder may kindly note this point while quoting. No deviation shall be acceptable with respect to structural support steel material and it's painting details provided in the customer specification.

Spring actuated counter weight operated Pressure relief dampers with frame & bird screen shall be provided of suitable size and quantities on both walls of GIS hall above supply air ducts to release hot air & excessive pressure inside the hall beyond design over pressure.

Ventilation duct running inside GIS Hall shall be suitably placed to avoid any fouling with GIS incoming/outgoing ducts and LCC panels, if any.

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 at least fifteen percent (15%) above the maximum load demand of drives at the design duty point.

For fans and blowers, 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.

There shall be requirement of approximately 3 mm WG positive pressure inside the GIS hall.

All ducts shall be made of galvanized steel sheets confirming to IS 277 with minimum grade of 275 GSM. Duct sizing and fabrication shall comply with requirements of IS 655.

Duct design criteria- Velocity shall be 12m/s (max.) for main duct, 9m/s (max.) for branch duct and 3.75m/s for the grills.

All the equipments of Ventilation system shall be designed for continuous duty for continuous operation of 24 hours a day.

n) ***Bidder should strictly follow the customer specification of motors attached to section-2 of this specification***

✓ **<u>Note</u>:**

Ventilation fan calculation sheet for different areas mentioned above of GIS control building & GIS Hall shall be submitted for customer/ consultant approval during detailed engineering stage.

3.0.0. POWER SUPPLY REQUIREMENT

a. One (1) no. Power distribution board (PDB) in ventilation/AHU room of 400 kV GIS Hall shall be provided. This PDB shall extend power supplies to centrifugal fans for GIS Hall and also wall mounted fuse boards for Fans of cable vault, ACDB/DCDB/MCC and Battery room areas. Two nos. incomers, each of 400A rating capacity shall be provided from the main ACDB and the same will be terminated in Ventilation system PDB with a mechanical changeover switch. Lamps shall be provided for indicating the status of each fan etc. in the panel. All annunciations related to failure of equipments, tripping of equipments, source of failure/reason due to which the equipment is stopped/tripped, low & high limits of parameters such as level, temp., pressure drop etc. as applicable shall be provided for each fan in the PDB panel. Fully wired, 20% spare annunciation windows and terminal blocks each type & rating (minimum 1 no.) with all necessary wirings shall be provided in the panel. Also 20% spare feeders of each type & rating (minimum 1 no.) with all necessary wirings shall be made available in the panel.

b. Three (3) nos. wall mounted fuse boards each for extending power supplies to 3 phase supply/exhaust fans in Cable vault, ACDB/DCDB MCC Room & Battery rooms, shall be located in their respective rooms. Also necessary cabling shall be done further from the fuse board to each fan's 3phase DOL local starter.

c. One (1) no. Power distribution board (PDB) in AC Plant room at ground floor of switchyard control building shall be provided. This PDB shall extend power supplies to AHU units/DX type condensing unit etc. All annunciations related to failure of equipments, tripping of equipments, source of failure/reason due to which the equipment is stopped/tripped, low & high limits of parameters such as level, temp., pressure drop etc. as applicable shall be provided for each fan in the PDB panel. Fully wired, 20% spare annunciation windows and terminal blocks each type & rating (minimum 1 no.) with all necessary wirings shall be provided in the panel for future use. Also 20% spare feeders of each type & rating (minimum 1 no.) with all necessary wirings shall be made available in the panel.

d. Bidder should strictly follow the customer specification of switchgear board attached to section-2 of this specification for preparing the scheme etc. of the PDB & push button etc. of Air conditioning and ventilation system covered in this specification. No deviation shall be acceptable with respect to customer's switchgear board specification attached to section-2.

e. Cable entry to the panel (top or bottom) shall be finalized during detailed engineering based on the provision of trench in those particular area or space availability.

4.0.0. <u>Inspection & Testing requirement</u>

Being standard equipment, no shop tests have been envisaged for air conditioning equipments and ventilation fans. Test certificates for all major equipments of air conditioning and ventilation system will be submitted to customer for verification and release of dispatch instruction.

After the installation is over, the system will be subjected to performance guaranteed test in the presence of customer.

"Performance Guarantee Test Procedure" will be submitted during detailed engineering for approval of customer/consultant.

List of Mandatory Spares

AIR CONDITINING AND VENTIALTION SYSTEM		
SL. NO.	**ITEM DESCRIPTION**	**QUANTITY**
A.	**Air handling unit (for each model)**	
1.	V-belts for AHU Blower	2 Sets
2.	AHU Blower bearing	1 SET
3.	Blower motor bearing	1 SET
4.	Filters at suction and discharge of all AHUs	25% of installed population
B.	**Electrical Actuators**	
1.	Actuators	10% or 1 No. of each type, model and rating, whichever is more.
C.	**Control & Instrumentation**	
1.	Relative Humidity Sensors	2 Nos
2.	Local Humidity/Temperature indicators	2 Nos. each
D.	**Process Connection Piping**	
1.	Valves*	10% or 1 No. of each type, class, size and model whichever is more.
2.	2 way, 3way, 5way valve manifolds*	10% or 1 No. of each type, class, size and model whichever is more.
3.	Fittings*	10% or 1 No. of each type, class, size and model whichever is more.

***Note**: Items under mandatory spares D.1, D.2 & D.3 shall be supplied only if applicable under the Air conditioning system for switchyard area and shall be finalized with customer during detailed engineering.*

References:

- **CONTROL BUILDING LAYOUT FOR OF 400 KV SWITCHYARD (Drg. No. 9585-001-572-PVC-F-0047)**
- **400kV GIS Hall Building (Drg. No. 9585-001-572-PVE-F-0283)**

Notes:

- Air Conditioning & Ventilation system for different areas of Gas insulated switchyard control building shall be designed as per the latest architecture drawings during detailed engineering stage.

- Customer/ consultant approval on all the technical data sheets of equipments /drawings/ documents for this package will be obtained during the detailed engineering stage.

4.0.1. SCOPE OF SUPPLY & SERVICES

Exact requirements shall be worked out during detailed engineering after award of contract. The scope of the work under the contract shall be deemed to include all such items, which although not specifically mentioned in the bid documents and/or in the bidder's proposal, but are required to make the equipment/system complete for its safe, efficient, reliable and trouble free operation, unless the same is specifically excluded from the Bidder's scope of work under clause 5.0 of this section.

4.0.2. Bidder shall also consider the following while quoting for the system:

i) Power & Control cables including instrumentation and FO cable for Air Conditioning and Ventilation System will be supplied on free issue basis to contractor. Contractor shall have to choose their cables from the available sizes only *as listed in Annexure – I to Section-1* and necessary modifications in their equipment for termination of these cables shall be made by contractor.

ii) Since laying & termination of all cables is in contractor's scope, supply of cable accessories such as lugs, glands, cable tags & markers etc. shall be included by the bidders in their offers

iii) Necessary cable trays will be supplied on free issue basis to the contractor, however necessary hardware for fixing the same on walls or elsewhere shall be included by the bidders in their offers.

iv) Earthing material viz. GS flat & wire will also be supplied on free issue basis to contractor; however requirement shall be given by the bidders in their respective bids.

v) Bidder shall ensure that sufficient quantities of commissioning spares are made available for timely completion of commissioning of the system. The bidder shall furnish a list of Commissioning spares that will be brought by him. The unused commissioning spares shall be returnable to the bidder.

vi) Conducting performance guarantee tests as per approved procedure to the satisfaction of Owner / Purchaser and handing over an operational system to the owner. Procedure for performance guarantee test shall be submitted by contractor for customer review and approval.

vii) Contractor shall submit valid Type test report for approval by owner. Fresh type test of equipment is not envisaged. It is presumed that equipment offered is duly type tested.

In case the type test reports are found un-satisfactory, tests shall be carried out afresh by contractor without any additional cost implication to BHEL.

viii) Bidder shall provide NTPC approved makes for all HVAC items for this system as per the NTPC makelist provided in Annexure –1A to section-5 of this specification. All such makes shall be subjected to acceptance of NTPC during detailed engineering stage. No additional price implication shall be made to BHEL on account of non-acceptance of proposed makes by NTPC.

4.1. Scope of services

A. Erection, Testing & Commissioning (ETC) requirements

i) The scope of ETC shall include receipt of material at site, unloading, safe storage of material, handling of equipment/ material at site, erection of equipment /material at site including fabrication, equipment and system testing, commissioning of the entire system, conducting performance guarantee tests to the satisfaction of Owner / Purchaser and final handing over to the owner of the entire system.

ii) Furnishing technical calculations in support of equipment selection or sizing as and when required.

B. Electrical System

i) Preparations of cable interconnection diagram for equipment supplied under this contract and accordingly offer guidance to the purchaser for laying necessary cables. Termination details shall also be furnished in the said interconnection table.

ii) Cables laying for incomers to the PDB panel shall be done by the purchaser while termination of the same to the MCC panel end supplied under this contract is in bidder's scope of works. The contractor has to lay and terminate all the other power and control cables supplied under the present scope.

iii) Laying & Termination of Power/ Control cables/FO Cables for the equipment under the scope of this specification. Bidders shall include all cable accessories like lugs, glands, cable tags, markers etc in their respective bids. All cable laying and termination shall be done as per NTPC standard.

iv) Earthing of all installations (to the nearest earth mat/ earthing pad) supplied under the scope of this specification.

C. All machinery tools & tackles and consumables required for erection/testing / commissioning of the system shall be arranged by the Bidder.

D. Piping from water tap-off to inlet of pan humidifier. Water tap-off shall be provided by the purchaser at one point inside the AHU room.

E. One water tap shall be provided nearby AC outdoor unit for make-up water arrangement. Contractor shall further extend this pipe for their use.

F. Piping from overflow of pan humidifier & packaged unit (disposal of condensate) to the nearest drain point.

G. Minor modifications, alterations in system installation as per customer's specific requirements shall be done without any extra cost to purchaser.

H. Painting of all the equipments shall be as per customer specification. Final touch up/proper painting shall be done at site (if painting on the equipment get damage during ETC) in case of any remark given by customer.

I. After completion of erection and commissioning of the system, the bidder shall train site engineers of

Purchaser/Owner so that they are fully conversant with both electrical and mechanical part of this package.

J. Bidders to ensure that sufficient quantity of spares are made available for timely completion of commissioning of the system. The bidder shall furnish a list of commissioning spares that will be brought by him. The unused commissioning spares shall be returnable to the bidder.

K. **Obtaining approval on documents & installations.**

i) Obtaining, "As Built" certification from purchaser or owner on applicable drawings. Completing documentation as per specification requirement.

ii) Obtaining customer's written acceptance of satisfactory completion of job. (Acceptance of PG + handing over of system and mandatory spares (if any)).

iii) Any other service not explicitly illustrated herein but which may be required to complete the system with its desired functionality or in the spirit of contract shall also deemed to be under the scope of bidder.

L. Civil Works

Major civil works such as room & foundations for various Air Conditioning and Ventilation System equipments shall be in purchaser's scope. However following shall be in contractor scope of services:

a. Wall openings at suitable locations for duct, refrigerant/drain piping, Fresh Air unit & ventilation fans shall be made by the contractor. Associated civil works such as grouting, filling up crevices/cut outs etc during installations of equipments shall also be in contractor's scope. Any other damage caused to civil works during ETC work of the equipment/system shall be made good to the original finish by the contractor at no extra cost to the purchaser. All wall opening shall be sealed completed after erection of equipments/facilities.

b. All erection material including supporting structure for ducts or any other associated air conditioning and ventilation equipments for proper strengthen and stability shall be supplied by contractor.

c. All duct supporting structures inside GIS Hall shall be of good quality and it's specification should be strictly inline with customer specification attached to section-2. Bidder may kindly note this point while quoting. No deviation shall be acceptable with respect to structural support steel material and it's painting details provided in the customer specification.

d. Furnishing of details for construction of outdoor unit's mounting arrangement.

e. Providing necessary guidance to / coordination with civil contractor so that appropriate sized / correctly located cut outs are made (by civil contractor) in false ceiling for installation of grilles / diffusers / return air.
However in case wall openings / cut outs have not been provided for either duct laying, louver fixing, ventilation fan(s) or fresh air fan, the same shall have to be made by the Contractor.

Minor modifications, alterations in system installation as per customer's specific requirements shall be done without any extra cost to purchaser. The Bidder shall however supply foundation bolts & hardware and undertake minor civil works such as grouting, filling up of crevices/ cut outs etc. Any damage caused to civil works during ETC work of the equipment/system shall have to be made good to the original finish by the Contractor at no extra cost to the Purchaser.

5.0 Exclusions

a) **Supply of power & control cables including instrumentation or Fiber Optical cable (if applicable) are excluded. However laying and termination of these cables shall be in contractor's scope.** The bidder shall furnish quantity and type of cables required complete system in their respective bids. Laying & termination is in contractor scope.

b) **Supply of necessary cable trays for laying cables, however hardware for fixing the same on wall trenches or elsewhere shall be included by the bidder in his bid.**

c) **Supply of GI flat for earthing of equipments.**

d) Supply & installation of false ceiling and openings in false ceiling for diffusers as required.

e) Underdeck insulation of the air conditioned areas.

f) **Major civil works such as room & foundations for various Air-Conditioning & Ventilation system equipments.**

6.0 Utilities Available

Construction water and electricity shall be available at one point each. Contractor shall be required to make own arrangement for taking supplies from there.

7.0 Engineering Drawings/ Documents

Engineering shall start immediately after the award of the contract.

Submission & approval of all drg. / data sheet – as per tender requirement.

7.1 OPERATION & MAINTENANCE (O&M) MANUAL

Operation and Maintenance manuals shall be specifically compiled for the project by the bidders. The draft O&M manual shall be submitted along with the supply of the items. The O&M manual shall contain the following information:

a. Description of the system and equipment with design particulars.
b. Instruction for erection.

c. Instruction for operation, maintenance and repair.
d. Recommended inspection practices and inspection schedule.
e. Ordering information for all replaceable parts.
f. Recommendation for type of lubricants and frequency of lubrication.

8.0 Handing & Taking Over

It is the responsibility of the contractor to maintain the Air conditioning and Ventilation system for switchyard till PG test conducted successfully and it is handed over to customer. Any defect noted during the period shall be rectified by the contractor without any price implication to BHEL. Also suitable PG tests shall be conducted by the contractor to show the achievement of guaranteed parameters in line with the requirements of specification/ standards/ codes and to the satisfaction of Purchaser/ Owner.

9.0 Various Heads to be quoted for

9.1.1 Based on the above input it is recommended that the bidders shall submit their LUMPSUM offers in the prescribed format only

Sl. No.	Item Description	Unit	Qty.	Ex-works Rate	Total Ex-works	ETC rate	Total ETC price
1.0	Air Conditioning and Ventilation System for switchyard area as per technical specification	Lot	1				
2.0	Supply of Mandatory Spares as per technical specification	Lot	1			NA	

9.1.2 <u>It may be noted that BOQ furnished by the bidder against main heads as per Table-I in Cl. 9.1.1 shall not be considered as limits to scope of supply and ETC. Being a lumpsum offer, any other item, which is not specifically mentioned in this specification 'OR' any item not considered by the bidder in his BOQ 'OR' additional quantity of any given item in Bidder's BOQ, which is required for satisfactory operation of the system shall be supplied and erected without any additional cost implication to BHEL</u>. Miscellaneous items like hardware, fixtures etc. shall be deemed to be included and bidders shall consider the same while quoting under above heads.

10.0 *Inspection & Testing*

All the equipments shall be inspected prior to dispatch in line with relevant IS, approved GTP/ drawing and technical specification, BHEL/ customer approved QAP.

11.0 ACCEPTANCE TEST

Room condition test shall consist of taking the reading of dry bulb and wet bulb temp at different locations points to be mutually decided at site in the areas which are air-conditioned by the respective system/plant. Room condition test shall be done after stabilization of the system. The dry and wet bulb temp shall be measured by measured by sling psychomotor which will have accuracy of +/-0.5% with atleast count of 0.5 Deg.C. This will be carried out for 24 hrs continuously and readings will be taken every two hours. Standby equipment should be changed over during these 24 hours. This test shall be carried out during summer during month May to August when the dry bulb temp is generally high and during. The Relative humidity shall be determined from psychometric chart.

The following measurements are also to be done prior to the acceptance of the plant by the client:

a. Air Quantity measurement to be taken at the Inlet Louver to establish the Equipment capacity in line with the specification requirement.
b. Power consumption to be measured for each equipment.
c. Measurement of Noise and Vibration for different Equipment.

- Painting of all equipment and structures shall be provided and the colour & quality shall be subject to approval by the Client / Engineer.

ANNEXURE-I

Cable Sizes being procured by BHEL for Sub-Station

Sl. No.	Item Description	Length (Mtrs)	Remark
A	**XLPE Auxiliary Power Cables**		**Bidder to furnish the quantity required against the applicable cable size.**
1	1C X 630 sq mm XLPE/Aluminium, FRLS, Armoured Auxiliary Power Cable		
2	3.5C X 300 sq mm XLPE/Aluminium, FRLS, Armoured Auxiliary Power Cable		
3	3.5C X 150 sq mm XLPE/Aluminium, FRLS, Armoured Auxiliary Power Cable		
4	1C X 150 sq mm XLPE/Aluminium, FRLS, Armoured Auxiliary Power Cable		
B	**PVC Auxiliary Power Cables**		

5	3.5 C X 70 sq mm PVC/Aluminium, FRLS, Armoured Auxiliary Power Cable		
6	3.5 C X 35 sq mm PVC/Aluminium, FRLS, Armoured Auxiliary Power Cable		
7	4 C X 16 sq mm PVC/Aluminium, FRLS, Armoured Auxiliary Power Cable		
8	4 C X 6 sq mm PVC/Aluminium, FRLS, Armoured Auxiliary Power Cable		
9	2 C X 6 sq mm PVC/Aluminium, FRLS, Armoured Auxiliary Power Cable		
C	**PVC Control Cables**		
10	19 C X 2.5 sq mm PVC/Copper, FRLS, Armoured Control Cables		
11	14 C X 2.5 sq mm PVC/Copper, FRLS, Armoured Control Cables		
12	10 C X 2.5 sq mm PVC/Copper, FRLS, Armoured Control Cables		
13	5 C X 2.5 sq mm PVC/Copper, FRLS, Armoured Control Cables		
14	2 C X 2.5 sq mm PVC/Copper, FRLS, Armoured Control Cables		
15	4 C X 10 sq mm PVC/Copper, FRLS, Armoured Control Cables		

SECTION -2

EQUIPMENT SPECIFICATION

- Customer contract document is enclosed as part of this specification, and all details specification of applicable equipments covered under section-1 shall be adhered to customer's requirement given in section-2. Regarding quantities and type of Air conditioning & Ventilation System, section-1 shall be referred. In case of variance between section-1 and section-2, the requirement of Section-1 shall prevail ***(except those points where specifically mentioned to follow customer specification strictly in this specification)***. Customer specification as annexure to section-2 shall strictly to be followed by contractor.

SUB – SECTION – A-17

AIR CONDITIONING

AIR CONDITIONING 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 supply, delivery and erection of the entire equipment listed here shall be in bidder's scope of work.

2.00.00 AREAS TO BE COVERED UNDER AIR CONDITIONING SYSTEM

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

a) Control rooms/Central Control Rooms, Control Equipment Rooms, UPS & battery charger room, SWAS room, static excitation control room (if applicable) etc.

b) Centralized Air conditioning system for Ash handling control room, Ash handling VFD room, FGD control room, ESP control room, etc. of Unit # 1, # 2 and # 3.

c) Switchyard (GIS Control building).

d) Service building: Various office areas, entrance lobbies, visitor & VIP lounge, reception area, etc.

e) Administrative building: Various office areas, entrance lobbies, visitor & VIP lounge, reception area, Satcom area, etc.

f) Auditorium building, Canteen, IT Building, Permanent stores etc.,

g) Fire water pump house control room.

h) Fire water booster pump house control room.

i) Ash Water recirculation control room (if applicable)

j) CHP control room and its RIO rooms

k) Auxiliary Boiler Control Room

l) Water system control room and remote I/O associated with PT plant, AWRS and DM and CPU service vessels / Regeneration area/control room

m) Fuel oil Pump house (pressurizing & unloading) control room.

n) CT SWGR control room.

o) Satcom building (if applicable).

p) Township & other miscellaneous building, etc.

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

r) Apart from the above, any area/building which are in the scope of the bidder and require air conditioning.

3.00.00 REDUNDANCY OF EQUIPMENTS

3.01.00 Redundancy of various A/C system equipments shall be as follows:

a) For Main Plant Areas (control room, control equipment room, UPS room and SWAS room, static excitation control room (if applicable)):

i) Vapour compression type water chilling units: 5x33.33%

ii) Chilled water pumps: 5x33.33%

iii) Condenser water pumps: 5x33.33%

iv) Cooling Towers (with VVVFD): 5x33.33%

v) AHUs: Minimum 50% standby of total AHU capacity shall be provided to each AHU room/unit. AHUs shall be Variable voltage variable frequency driven (VVVFD).

b) For Ash handling control room, Ash handling VFD room, FGD control room, ESP control room, etc. of Unit # 1, 2 and 3:

i) Vapour compression type Air cooled chiller units: 3X50%

ii) Chilled water pumps: 3X50%

iii) AHUs: Minimum 50% standby of total AHU capacity shall be provided to each AHU room/unit. AHUs shall be Variable voltage variable frequency driven (VVVFD).

c) Service Building:

i) Screw type water chilling units: 2X100%

ii) Primary Chilled water pumps: 2X100%

iii) Secondary chilled water pumps (with VVVFD): 2X100%

iv) Condenser water pumps: 2X100%

v) Cooling Towers (with VVVFD Fan) : 2X100%

vi) All AHU's working & no standby AHU. AHUs shall be Variable frequency driven (VVVFD)

d) Administrative Building:

i) Screw type water chilling units: 2X100%

ii) Primary Chilled water pumps: 2X100%

iii) Secondary chilled water pumps (with VVVFD): 2X100%

iv) Condenser water pumps: 2X100%

v) Cooling Towers (with VVVFD Fan): 2X100%

vi) All AHUs working & no standby AHU. AHUs shall be Variable frequency driven (VVVFD)

e) Water system control Room Building:-

i) Air cooled condensing unit (D-X type) Air conditioners: 2X100%

ii) AHU (with VVVFD): 2X100%.

f) Switchyard (GIS)control Room Building:-

i) Air cooled condensing unit (D-X type) Air conditioners: 2X100%

ii) AHU (with VVVFD): 2X100%.

g) Auditorium Building:-

i) Air cooled condensing unit (D-X type) Air conditioners: 2X50%

ii) AHU (with VVVFD): 2X50%.

h) IT Building:-

i) Air cooled condensing unit (D-X type) Air conditioners: 3X50%

ii) AHU (with VVVFD): 3X50%.

i) Canteen building:-

i) Air Cooled condensing units (D-X type): - 2X50%

ii) AHU (with VVVFD): 2 X 50%

j) 100% standby shall be provided for area served by Cassette / Hi-wall Split type Air conditioners for all other offsite control rooms.

k) Fresh air fans shall be 1 x 100 % Capacity for each AHU room.

4.00.00 EQUIPMENT DESCRIPTION – AIR CONDITIONING SYSTEM

4.01.00 **Vapour compression type machines**

4.01.01 Each chilling unit shall comprise of compressor with drive motor, Air cooled Condenser, Water Chiller/evaporator, Chilled water pumps, Condenser Cooling Water pumps (if applicable) other accessories such as supporting structure, vibration isolators, insulation, piping, valves, instrumentation, microprocessor / PLC based Control panel, etc. Chilling unit shall have **stepless** capacity control. The screw/centrifugal compressor based chilling unit to be supplied shall be ARI /Eurovent/Equivalent standard certified (if applicable).

4.02.00 **Chilling Unit**

(A) Water-cooled type

Type		Water-cooled type. (Chillers for main plant shall be with multiple compressors)
Vibration isolators	:	Steel spring/ Neoprene rubber cushy foot/ neoprene serrated rubber pad type with isolation efficiency not less than 85%.
Compressor Type	:	Compressor shall be Screw type (open/semi-hermetic/multiple hermetic)
Type of drive	:	Motor driven, along with Star delta/Double delta Starter.
Capacity	:	Minimum capacity shall be suitable for the identified/selected evaporating temperature and

		condensing temperature.
Condenser		
Type	:	Water cooled shell and tube type.
Fluid	:	Shell side – Refrigerant
	:	Tube side - Water
Capacity	:	To match with respective compressor and to provide atleast 2 deg. C sub-cooling. To store full charge of refrigerant.
Design fouling Factor	:	Not less than 0.0002 (in MKS units)
Shell material	:	Mild steel (IS: 2062) / SA 106 Gr. B
Tube material	:	Replaceable seamless copper
Fin material		Copper
Accessories	:	As required such as Purge and drain connections, relief valves, liquid line shut-off valves, refrigerant filling charging, flow switches, Isolating valves, pressure & temperature indicators at inlet and outlet etc.
Refrigerant	:	The refrigerant shall be R-134a/R-410A/R-407C or any other environment friendly refrigerant.
Steel structure	:	The complete condensing/ chilling unit shall be mounted on steel structure and shall be provided with necessary vibration isolators
Inlet temperature		33-36 ^{o}C.
Leaving temperature differential	:	Maximum 5 ^{o}C.
Evaporator		
Type	:	Shell and tube type
Superheating of	:	At least 2 deg.C
Design Fouling Factor	:	Minimum 0.0001 (MKS units)
Fluid	:	Shell side - Refrigerant
	:	Tube side - Water
Capacity	:	To match with respective plant capacity.
Shell material	:	Mild steel (IS : 2062) / SA 106 Gr. B

Tube material		Plain tube internally /externally finned copper as per the manufacturer's standard practice.
Fin material	:	Integral
Accessories	:	Purge and drain connections, Isolating valves, flow switches, Pressure & temperature indicators at inlet and outlet, Anti-freeze thermostats, electronic expansion valve or float assembly as applicable, pilot solenoid valve, Relief valves, Operating thermostats for capacity control, supporting frame, etc.
Steel Structure	:	The complete condensing/ chilling unit shall be mounted on steel structure and shall be provided with necessary vibration isolators.

(B) Air-cooled type

Type		Air-cooled type chilling unit.
Vibration isolators	:	Steel spring/ Neoprene rubber cushy foot/ neoprene serrated rubber pad type with isolation efficiency not less than 85%.
Casing /frame material	:	GI sheet (3.15 mm thickness minimum)
Design ambient	:	Air cooled chiller shall be designed for minimum 50deg.C ambient temperature.
Noise level	:	Max 85 dba under free field condition at horizontal 1m distance and 1.5m height
Compressor Type	:	Compressor shall be Screw type (open/semi-hermetic/multiple hermetic)
Type of drive	:	Motor driven, through direct/V-belt along with Star delta/Double delta Starter.
Capacity	:	Minimum capacity shall be suitable for the identified/selected evaporating temperature and condensing temperature.
Refrigerant	:	The refrigerant shall be R-134a/R-410A/R-407C or any other environment friendly refrigerant.
Capacity control	:	Automatic (stepless).

Air Cooled Condenser		
Type	:	Shall be as per manufacturer standard and proven practice. However design ambient temperature for air cooled condenser shall be minimum 50 deg.C
Evaporator		
Type	:	Shell and tube type
Superheating of	:	At least 2 deg.C
Design Fouling Factor	:	Minimum 0.0001 (MKS units)
Fluid	:	Shell side - Refrigerant
	:	Tube side - Water
Leaving/entering water temperature	:	6.7 dec.C / 12.2 deg.C
Capacity	:	To match with respective plant capacity.
Shell material	:	Mild steel (IS : 2062) / SA 106 Gr. B
Tube material		Plain tube internally /externally finned copper as per the manufacturer's standard practice.
Fin material	:	Integral
Accessories	:	Purge and drain connections, Isolating valves, flow switches, Pressure & temperature indicators at inlet and outlet, Anti-freeze thermostats, electronic expansion valve or float assembly as applicable, pilot solenoid valve, Relief valves, Operating thermostats for capacity control, supporting frame, etc.
Steel Structure	:	The complete condensing/ chilling unit shall be mounted on steel structure and shall be provided with necessary vibration isolators.

4.03.00 **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.
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.
Capacity	:	Minimum capacity shall be suitable for the identified/selected at evaporating temperature and condensing temperature and shall be indicated.

4.04.00 **Air Handling Unit (AHU)**

4.04.01 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. NRD shall be provided at outlet of each AHU when multiple AHU used for a common plenum.

4.04.02 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.

4.04.03 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.

4.04.04 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.

4.04.05 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.

4.04.06 **Centrifugal fan for AHU**

a)	Fan Type	:	Double Width Double Inlet (DWDI) Centrifugal Type
b)	Fan impeller	:	Backward curved blades
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 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	:	For AHUs of capacity 50,000 CMH and above, Bidder may offer two (2) Nos. centrifugal fans of equal capacity for each AHU provided all such AHUs are accommodated within the space identified by the Employer.

4.04.07 **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.

4.04.08 **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.

4.05.00 HI-WALL SPLIT/CASSETTE/PRECISION AIR-CONDITIONERS

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

i) Casing

ii) Hermetically sealed rotary/scroll Compressor

iii) Condenser

iv) Evaporator and condenser cooling 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.

4.05.02 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.

4.06.00 **COOLING TOWERS (for chilling units)**

4.06.01	Type	:	Induced draft, cross or counter flow.
4.06.02	Casing & Sump tank	:	F.R.P/G.R.P
4.06.03	Fan	:	Cast Aluminum / FRP Propeller type and multi-blade aerofoil construction with adjustable pitch.
4.06.04	Fill	:	Non combustible PVC or equivalent
4.06.05	Louvers:	F.R.P. /PVC/ Aluminum.	
4.06.06	Nozzles:	Brass with chrome plating / Polypropylene.	
4.06.07	Eliminators	:	In removable sections to reduce the drift loss to 0.2% of water flow.
4.06.08	Supporting structure	:	Mild steel with spray galvanization or epoxy painting.
4.06.09	Strainer at water outlet	:	Plate strainer made of GI/SS wire mesh of 16 gauge.

4.06.10	Bird screen on top of tower	:	25 mm square made of GI/SS wire mesh of 16 gauge.
4.06.11	Distribution Pipe (if any)	:	Galvanised MS pipe.
4.06.12	Accessories	a)	Drain connection with isolation valve.
		b)	Make up connection with ball – float valve, back up gate valve and a bypass with a gate valve for manual operation.
		c)	Overflow connection.
		d)	Equalizing connection to connect sump of all the towers wherever applicable.
		e)	Access door in louvers/fan deck.
5.00.00	**BALANCE EQUIPMENT SPECIFICATION**		
5.01.00	**Centrifugal Pumps**		
	a) Type	:	Horizontal Centrifugal, Axially split type casing 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.

5.02.00 **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.

2) For sizes 50 NB and below, the material shall conform to ASTM A-105.

3) All steel flanges shall be of slip on type and shall conform to ANSI B 16.5

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.

5) Fittings, flanges and pipe joints of refrigerant piping shall conform to ANSI B31.5

5.03.00 **VALVES**

5.03.01 Valves shall have full sizes port and suitable for horizontal and as well as vertical installation.

5.03.02 Valves for regulating duty shall be of globe type suitable for controlling throughout its lift.

5.03.03 All safety /relief valves shall be so constructed that the failure of any part does not obstruct the free discharge.

5.03.04 Valves shall be furnished with back seating arrangement for repacking while working under full working pressure.

5.03.05 Manual gear operators be provided for valves of size 200 NB and above.

5.03.06 All valves shall be supplied with companion flanges, nut, bolts & washers, etc.

5.03.07 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.

5.03.08 ~~All water line valves shall be of Cast Iron body for sizes 65 NB and above conforming to IS :14846 and Gun Metal construction for sizes less than 65NB conforming to IS:778. Cast Iron parts shall conform to IS:210 Gr FG 220. Butterfly valves shall confirm to latest revision of BS:5155 or equivalent standard of required class/rating.~~

5.03.09 **Balancing / Controller Valves:**

~~The valves of sizes 32 mm to 65 mm dia shall be of gun metal / cast iron construction with screwed ends. Whereas valves of sizes 75 mm and above shall be of cast iron construction with internal parts of SS 410 and EPDM / nitrile seat with flanged ends.~~

5.04.00 **AIR FILTERS**

5.04.01 **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

   : c) At the suction of each Supply air fan

5.04.02 **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.
   iii) At the discharge of each supply air fan having static pressure 30mm wc or more.

5.04.03 **Absolute Filter / Hepa Filter**

1) Media : 100% sub-microscopic glass fibers.

2) Frame : Aluminium alloy of (minimum 16 gauge conforming to IS: 737) with handles.

3) Other requirements : A neoprene sponge rubber sealing shall be provided on either face of the filter frame.

4) Efficiency : 99.97 % down to 0.3 micron when tested in accordance with BS: 3928 (Sodium flame test)/FED–209B.

5) Minimum thickness : 300 mm

6) Face Velocity : Not more than 1.2 m/sec.

7) Pressure drop : Initial pressure drop - Not to exceed 25 mm WC at

rated flow;

Final pressure drop - Up to 75 mm WC.

8) Location : At the discharge of each individual AHUs for Control Equipment room / Control room areas.

6.05.00 **LOW PRESSURE AIR DISTRIBUTION SYSTEM**

6.05.01 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)

6.05.02 **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

6.05.03 **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

6.05.04 **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 and installed at site. However, in case of partly used factory fabricated ducts, vendor shall take back the unused ducts.

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 as provided by the Employer with provision of necessary auxiliary or special steel members or by hooks or can be provided by contractor 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.

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.

i) Where ever horizontal ducts are running outside the building and or at locations where it is not possible to support the ducts from Employers ceiling/floor due to non-availability of the same, the base steel frame/truss work for supporting the ducts between two columns shall be provided by Employer. However, all other auxiliary steel members, hooks, rods, etc. for supporting the duct work with the base frame/truss work shall be provided by the bidder. For vertical ducts running outside the building, bidder to take support from building columns and beams which is in Employer scope. However, all other auxiliary steel members, hooks, rods, etc. for supporting the duct work with the employers beam & columns shall be provided by the bidder.

6.05.05 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.

6.06.00 **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

6.07.00 **Diffusers, Grills & Dampers :**

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

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

6.07.03 The diffusers/grills shall be of extruded Aluminum of minimum 2 mm thick with powder coating. The colour of power coating shall be as per the interior Décor.

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

6.07.05 The nozzle type diffusers shall be fabricated from minimum 1.5mm aluminium sheet. The base shall be fixed type. The nozzle shall be of volute design with the

Spout diameter being half the base dia. and designed for low noise and long throw. The nozzle shall be able to rotate to any angle within the base. The whole assembly shall be powder coated as per interior decor.

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

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

6.07.08 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.

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

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

6.07.11 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.

6.08.00 **Thermal and Acoustic Insulation**

6.08.01 **A)** Application with Glass Wool

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

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

(c.) Insulation mass to be covered with 500 gauge polythene sheet with 50 mm overlaps and sealing all joints on hot side.

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

B) Application with Nitrile Rubber:

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

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

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

(d) 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

(a) All surfaces to be insulated shall be cleaned.

(b) 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.

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

(d) 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.

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

6.08.02

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
		or Rigid Polyurethane Foam	Pipe Section	50	F-3

Sl. No.	Surface	Insulation Material	Insulation Form	Thick (mm)	Finish (mm)
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 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 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 Polyisocyanurate Foam	Slab	50	F-4(a)

6.08.03 **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°C	i) 24 (For Glass wool) ii) 48 (For Rockwool)

		0.043 at 50°C	iii) 48(For acoustic insulation)
Mineral wool pipe section. Min.Gr.2	IS:9842	0.043 at 50°C	144
Closed Cell Elastomeric Nitrile Rubber		0.036 at 20°C	40 – 60
Polyurethane Foam Polyisocyanurate Foam	IS12436	0.03 at 50 ^{o}C 0.03 at 50 ^{o}C	34 $\pm$ 2 34 $\pm$ 2
Note : Insulation used for HVAC application shall be CFC/HCFC free			

6.08.04 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)**	
		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**	
	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** 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** Step-1 Same as Step-1 of Finish F-1 above. Step-2 Same as Step-2 of Finish F-1 above. Step-3 Same as Step-3 of Finish F-1 above. 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. 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)** 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. All sheet joints to be done in a manner to shed water.

6.08.05 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.

6.08.06 **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.

6.09.00 FRESH AIR FANS (Axial Fans)

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

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

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

d) The speed of the fan shall not exceed 1000 rpm for fan with impeller diameter above 450 mm and 1500 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 1500 rpm for fan with impeller diameter of above 450 mm and 3000 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.

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

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 All the functional requirements specified below and general control logic specified under this section shall be implemented in the respective control system.

7.02.02 The basic function of the system shall be to closely control and monitor temperature and humidity conditions inside the air-conditioned spaces, to optimize / minimize energy consumption by automated operation, to provide remote centralized monitoring & control for various mechanical facilities including sequential start/stop of the whole Air conditioning System, automatically calculate record and cooling load for each hour /day/season, to generate maintenance data & alarms, to maintain records of plant operation & energy consumption for varying loads, duty cycling to operate all the equipment including standby equipment for equal duration, automatic startup of standby equipment in case of failure of operating unit and displaying fault alarm status of the tripped unit, activating /deactivating water valves to startup/stop water flow through chiller/condenser circuit. For sequential operation /duty cycling, Programmed startup/stop of individual AHU as per operating requirements and inside room temperature and humidity of CR, CER, SWAS control room, UPS and Battery Charger room, static excitation room (as applicable) shall be maintained by controlling the chilled water flow by means of motor operated three way modulating valve at chilled water line, humidified system and duct heater.

7.02.03 Bidder shall provide Microprocessor/PLC based Control System along with Human Machine Interface System with two nos. Operator work station and one(1) no A-4 size color laser printer located at service building control room. For Service building, inside room temperature and humidity shall be maintained by varying the chilled water flow of secondary chilled water pumps through VFD driven motor and by varying the air flow of AHU through VFD driven motor, humidified system and duct heater. For sequential operation/duty cycling, programmed startup/stop of individual AHU's, pumps and cooling towers as per operating requirements and inside room temperature and humidity. Adequate no's of VAV box shall be provided for optimum use of VFD driven AH. Adequate no's of occupancy sensor and day light sensor shall be provided. CO2 sensor shall be provided in each AHU room to regulate the fresh air fan damper.

7.02.04 The operation of each Air Conditioning system shall be possible through Microprocessor based dedicated controllers to be provided by Contractor for each Screw /centrifugal Chiller

	units with local start / stop & indication for main plant A/C system in addition to Main DDCMIS based Control system of A/C plant (provided by contractor) for Main plant area, ESP control room and water system control room. Further these microprocessor based control panels of Chiller units shall be suitably interfaced with DDCMIS based Control panels.
7.03.00	**Water Chilling Plant Control**
7.03.01	Microprocessor based controls shall be provided as per manufacturer's standard practice along with facilities to interface with control system and to meet the requirement of all system operations and controls. Water chilling unit control system shall be designed to have a constant chilled water outlet temperature from evaporator at all load condition by means of controlling ON-OFF thermostat (one for each compressor). The closure of liquid line solenoid valve and tripping of compressor at lower water temperature and opening of solenoid valve and starting of compressor at high water temperature set point shall be automatic through the thermostat. Between the above set points the compressor capacity shall be controlled automatically through cylinder "load-unload" mechanism activated through the suction pressure or return chilled water temperature.
7.03.02	Water chilling unit shall be equipped with superheat control of water chilling unit through thermostatic expansion valve which gets its impulse from temperature element connected with suction line after chiller outlet.
7.03.03	High discharge pressure cut-out and oil pressure (OP) differential cut-out shall be of manual reset type and low pressure cut-out shall be automatic reset type. The OP cut-out shall trip the compressor in case of low oil pressure.
7.03.04	Facility toggle switch to close the liquid refrigerant line solenoid valve shall be provided to shut the compressor by the operation of low pressure cut-out (after the refrigerant has been pumped to the condenser).
7.03.05	Switching of Crank case heaters shall be interlocked with starting and stopping/tripping of compressor motor. Further, the safety thermostat shall switch off the crank-case heater in the event temperature rises above safe limit.
7.03.06	Provision shall also be made for the manual restarting of the compressor.
7.03.07	On-off type anti-freeze thermostats, one for each chiller shall be provided in addition to the controlling on-off thermostat for safety purpose and shall act in the event of failure of on-off thermostat to close the liquid line solenoid valve and also to simultaneously trip the compressor.
7.03.08	Compressor starting/running shall be interlocked with the low / adequate flow at the outlet of each chiller and each condenser and as well as with pressure in the inlet of the condensers. In addition, closure or open status of various valves shall be used for interlock, alarm and control of Air Conditioning System.
7.03.09	Condenser water pumps shall be interlocked with the low - level switch in each cooling tower sump and operation of cooling tower fans. High level in the cooling tower shall be annunciated in the panel by means of a separate level switch.
7.03.10	The standby condenser water pumps, standby chilled water pumps, standby fresh air fan & standby AHU shall be started automatically when the working equipments are stopped/

tripped. Auto/ Manual selecting and working/ standby selecting facility for the pumps/ AHU/ fresh air fan shall be provided.

7.03.11 Closure of fire dampers shall raise an alarm in the system.

7.03.12 There shall be provision for temperature and flow measurement in chilled water inlet and outlet line across AHUs to monitor the air conditioning load of each area.

7.03.13 Operation of air conditioning system shall be interlocked with the required minimum pressure and temperature of cooling tower at inlet to the condenser. Status indication of condenser water pumps and associated cooling towers shall be provided in the control panel of air conditioning plant.

7.04.00 **Air Handling Unit**

a) Inside room temperature and humidity shall be maintained by controlling the chilled water flow by means of motor operated three way modulating valve and by varying the flow by means of VFD driven AHU's which shall get its signal from the Control system for main plant A/C system. For Service building & Administrative building inside room temperature and humidity shall be controlled by varying the chilled water flow of secondary chilled water pumps through VFD driven motor and by varying the air flow of AHU through VFD driven motor.

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

c) 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.

d) 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)

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

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

g) Each AHU shall be provided with temperature indicators and pressure transmitter in the chilled water piping inlet and outlet to monitor the air-conditioning load of each area.

7.05.00 **D-X Air-Conditioning System** BIDDER SHALL FOLLOW THIS CLAUSE STRICTLY

a) The control and interlocks described above for water chilling plants are applicable for this system also.

b) Further the compressor starting/running shall be interlocked with the flow switches in condenser water circuit and as well as with AHU motors.

c) The standby condenser water pumps, fresh air fan & standby AHU shall be started automatically when the working equipments are stopped / tripped. Auto/ Manual selector Switches and working / standby selector switches for the pumps, fresh air fans and AHU shall be provided in the panel.

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

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

7.07.00 **Miscellaneous Control Requirements**

a) Separate emergency local stop push button shall be provided for each pump, compressor, fans etc. of A/C system.

b) Status shall be provided of each pump, compressor, fans etc. of AC system and Ventilation system on HMI system at control room.

c) All the annunciations related to failure of equipments, tripping of equipments,

source of failure / reason due to which the equipment is stopped / tripped, low & high limits of parameters such as level, temperature, pressure drop, pressure etc shall be provided for each pump, fan, compressor, AHU, PAC, AWU etc..

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

e) Relative humidity and temperature measurement of all control rooms and CERs, ESP control room, FGD control room and all major air-conditioned areas shall be available in DDCMIS. Relative humidity and temp. measurement for main plant control room and CERs to be available in multiple numbers.

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. 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.

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. 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.

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

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.

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.

Annexure –I

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.

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.

Annexure –I

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.

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 minimise 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 final thickness shall not be less then that specified as per IS: 3589 as indicated below.

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 – A-30

VENTILATION SYSTEM

VENTILATION SYSTEM

1.00.00 GENERAL

1.01.00 This section of specification covers details of system specifications, detailing the areas to be ventilated, basis of design, brief description of the system, equipment and services to be furnished by bidder. The supply, delivery and erection of the entire equipment listed here shall be in bidder's scope of work.

2.00.00 AREAS TO BE VENTILATED

2.01.00 The areas to be ventilated by Evaporative Cooling system are as follows:-

i) All floors and areas of turbine hall (TG Building) other than the areas which are air conditioned.

ii) Switch gear rooms and cable gallery areas of turbine (TG) building.

iii) Any other area where equipment heat load is high and requires ventilation by evaporative cooling process.

2.02.00 The areas to be ventilated by Unitary Air Filtration (UAF) unit are:

Non A/C areas of ESP Building, FGD building, Switch gear rooms, cable galleries, etc.

2.03.00 The areas to be ventilated by Mechanical Ventilation process (using Roof extractors/ Supply and/or Exhaust fans) shall consist of but not limited to the following:-

i) All the pump Houses like, Fuel oil pressurizing pump house, fuel oil unloading pump house, fire water pump house, hydrant & spray booster pump house, Ash water pump house, Ash slurry pump house, etc.

ii) Main Plant building (TG building)

iii) Battery rooms, Lube oil purification room, non-A/C areas of SWAS room.

iv) Switchgear rooms/MCC/Battery rooms in various auxiliary buildings.

v) Ash handling VFD room (non-A/C areas)

vi) Air Compressor house.

vii) Complete Water treatment Plant building facilities such as PT, DM, Chlorination, etc.

viii) Air Conditioning Plant Equipment areas

ix) A/C plant room, MCC room, Battery room, etc in Service & Administrative building, Auditorium, canteen, IT building etc.

x) Central workshop, Permanent stores, CHP workshop, etc.

xi) All Toilets & Pantries (to be provided with propeller exhaust fans)

xii) Battery rooms of various remote I/O rooms.

xiii) Other auxiliary areas not listed above but covered in the scope of Bidder

xiv) Any other areas which are not covered either by Air–Conditioning system or by Evaporative cooling system

3.00.00 **EQUIPMENT DESCRIPTION - VENTILATION SYSTEM**

3.01.0 **Air Washer Unit**

3.01.01 Each double skin Air Washer Units (- Modular Type ,Evaporative System) shall consist of the various Sections such as Air washer chamber / Casing, Tank, Distribution plates, set of metallic/fabric filters at suction, suction louvers, bird screens, water headers, Spray nozzle, piping, pumps, valves, Drift eliminators, Fans, and all other required accessories.

Housing/Casing of Air Washer Unit

The housing/casing of the Air Washer Unit shall be double skin construction.

(25±2)mm thick Double Skin Panels shall be made of 0.80 mm pre-painted sheet on outer side and 0.8 mm Galvanized sheet (275 GSM) inside with 40kgs/cub mtr density, fire retardant P.U. insulation injected in between. This panel shall be screwed on to the aluminum frame work with soft rubber Gasket in between to make the joints air tight.

Frame work for each section shall be jointed together with soft rubber gasket in between to make the joints air tight with suitable size air tight access door at various sections for maintenance. The entire fan section housing shall be mounted on rolled formed GSS Channel frame work.

3.01.02 The air washer 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.

3.01.03 The distribution plate shall be fabricated out of 18G galvanized steel sheets & galvanized steel angle supports with minimum 50% free area.

3.01.04 Air washer shall be two-bank construction (one uni-flow and the other cross flow). All header and stand pipes shall be galvanised. Cat Walks of suitable width shall be provided for maintenance of nozzles.

3.01.05 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

3.01.06 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.

3.01.07 An airtight inspection door of 600mm X 700mm size and a water marine light be provided for each air washer unit.

3.01.08	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
3.01.09	The specification for centrifugal fans shall generally be as indicated below. However, the fan shall be of DIDW type for TG building and ESP building & FGD building.
3.01.10	Saturation efficiency of Air Washer units shall be minimum 90%.
3.02.00	**Unitary Air Filtration**
3.02.01	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.
3.02.02	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. Thickness of galvanization shall be minimum 60 microns DFT. 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.
3.02.03	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.
3.02.04	The distribution plate shall be fabricated out of 18G galvanised steel sheets & galvanised steel angle supports with minimum 50% free area.
3.02.05	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.
3.02.06	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.
3.02.07	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.
3.02.08	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.

3.02.09 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.

3.02.10 The specification for centrifugal fans shall generally be as indicated below. However, the fan shall be of DIDW type for UAF unit.

3.02.11 All equipments, components used in unitary air filtration system shall be in line with the specification requirements stipulated in air washer units .

3.02.12 Saturation efficiency of Unitary Air Filtration units shall be minimum 60%.

3.03.00 Centrifugal Fan

3.03.01 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.

3.03.02 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.

3.03.03 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.

3.03.04 Inlet guard shall be spun to have a smooth contour. Inlet screen, if provided, shall be of galvanised wire mesh of 25 mm square.

3.03.05 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.

3.03.06 The first critical speed of the rotating assembly shall be at least 25% above the opening speed.

3.03.07 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.

3.04.00 Centrifugal Pumps

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.

3.05.00 **Axial Fans**

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

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

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

3.05.04 The speed of the fan shall not exceed 1000 rpm for fan with impeller diameter above 450 mm and 1500 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 1500 rpm for fan with impeller diameter of above 450 mm and 3000 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.

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

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

3.06.00 **Roof Ventilators (if applicable)**

3.06.01 The roof extractors shall be "COWL" type.

3.06.02 Impeller shall be of axial flow type, cast Aluminum 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.

3.06.03 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.

3.06.04 The speed of the fan be limited as per limitation given above for axial fans.

3.06.05 All accessories rain protection exhaust hood, transformation piece, vibration isolators, steel supports vibration isolators, bird screen, etc. as required shall be provided.

3.06.06 The vibration level for fans shall be as per ISO: 14694.

3.07.00 BALANCE EQUIPMENT SPECIFICATION

3.07.01 Centrifugal Pumps

a)	Type	:	Horizontal Centrifugal, Axially split type casing 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
	viii) Base Plate	:	Carbon steel as per IS:2062
	ix) Speed	:	Maximum 1500 rpm
	Other requirements	:	To refer to **Annexure-I** titled "Horizontal Pumps" of this sub section.

3.07.02 Piping and Fittings (Material & Standard)

a)	Circulating water piping of Ventilation System	:	Heavy grade-IS: 1239 or Equivalent upto150 NB and IS: 3589 or Equivalent for pipes beyond 200 NB with thickness as detailed at **Annexure-II.** The piping upto 100 mm diameter shall be of galvanized steel **(galvanization shall be as per IS: 4736)** and those above 100 mm dia. shall be black steel. The piping shall be adequately supported.
b)	Drain piping	:	Same as (a) above & galvanised as per IS: 4736.
c)	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. 2) For sizes 50 NB and below, the material shall conform to ASTM A-105.

3) All steel flanges shall be of slip on type and shall conform to ANSI B 16.5

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.

5) Fittings, flanges and pipe joints of refrigerant piping shall conform to ANSI B31.5

3.08.00 VALVES

3.08.01 Technical data sheet of the various types of valves (Gate, Globe, Butterfly and check valve) shall be as per Annexure – III.

3.08.02 Valves shall have full sizes port and suitable for horizontal and as well as vertical installation.

3.08.03 Valves for regulating duty shall be of globe type suitable for controlling throughout its lift.

3.08.04 All safety /relief valves shall be so constructed that the failure of any part does not obstruct the free discharge.

3.08.05 Valves shall be furnished with back seating arrangement for replacing while working under full working pressure.

3.08.06 Manual gear operators be provided for valves of size 250 NB and above in case of Gate valve & Globe valve.

3.08.07 All valves shall be supplied with companion flanges, nut bolts & washers etc.

3.09.00 AIR FILTERS

3.09.01 Pre Filter

1) Type : Flange / Cassette

2) Pre-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 : (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 : At the Suction of each Air washer and UAF (water repellent nylon type)

3.09.02 **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 Fresh air fan.

ii) At the discharge of each supply air fan having static pressure 30mm wc or more.

3.10.00 **Low Pressure Air Distribution System.**

3.10.01 Material of air distribution system shall be through galvanised steel sheet (Conforming to Grade 275 of IS: 277) or Aluminium alloy (grade 19000 / SIC or 3100 / NS3 of IS:737)

3.10.02 Thickness of rectangular ducts shall be as follows:

Larger Dimension of duct (mm)	Thickness of G I 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

3.10.03 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

3.11.00 **Duct Fabrication and Supports:**

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

b) 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 2000mm for ventilation ducts. The MS rods for these ducts routed inside the building shall be hung from the existing floor beams/wall beams/roof beams/columns as provided by the Employer with provision of necessary auxiliary or special steel members or by hooks or can be provided by contractor 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.

c) 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 fiber glass.

d) 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.

e) 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.

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

g) 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.

h) Where ever horizontal ducts are running outside the building and or at locations where it is not possible to support the ducts from Employers ceiling/floor due to non-availability of the same, the base steel frame/truss work for supporting the ducts between two columns shall be provided by Employer. However, all other auxiliary steel members, hooks, rods, etc. for supporting the duct work with the base frame/truss work shall be provided by the bidder. For vertical ducts running outside the building, bidder to take support from building columns and beams which is in Employer scope. However, all other auxiliary steel members, hooks, rods, etc. for supporting the duct work with the employers beam & columns shall be provided by the bidder.

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

3.13.00 Gravity operated back draft dampers shall be installed in association with supply air system in order to maintain positive pressure inside MCC/switchgear and cable gallery areas.

3.14.00 Diffusers, Grills & Dampers:

3.14.01 Supply air diffusers/grills with volume control dampers be provided for all areas provided with evaporative cooling system.

3.14.02 Inlet/Exhaust air grills/louvers are required for all negatively pressure ventilated areas. Back draft dampers shall be provided for all areas pressurised under ventilation system.

3.14.03 The diffusers/grills shall be of powder coated mild steel construction for Ventilation system.

3.14.04 Supply air grills shall be of double deflection type.

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

3.14.06 The thickness of frames of Diffusers, grills & VC dampers shall be of minimum 20 gauge and thickness of louvers shall be of minimum 26 gauge.

3.14.07 Suitable vanes shall be provided in the duct collar to have uniform and proper air distribution.

3.14.08 Bank of Baffles wherever required shall also be provided.

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

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

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

4.00.00 **Thermal and Acoustic Insulation**

4.01.00 **A)** Application with Glass Wool

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

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

4.01.03 Insulation mass to be covered with 500 gauge polythene sheet with 50 mm overlaps and sealing all joints on hot side.

4.01.04 Insulation Finish of types specified under shall be provided thereafter.

B) Application with Nitrile Rubber:

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

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

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

(d) 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 FR Closed Cell Chemically Cross Linked Polyethylene Material (XLPE)

(a) All surfaces to be insulated shall be properly cleaned of any dust, grease and moisture.

(b) A suitable adhesive, normally, a pressure sensitive acrylic base, such as SR 998/STAR Glue R242 or Neosole AA 900 or equivalent shall be used to paste the insulating material over the cleaned surface.

(c) XLPE cut to size for each surface, with overlaps provided for two faces shall be stuck to the surfaces in a manner to avoid air entrapment. The extent of over-lap shall be

equivalent to the thickness of the material to be applied. The adhesive is applied on both the surfaces to be insulated and the insulation foam material.

(d) Application of the insulating material to surfaces should preferably be carried out at ground level, in a clean dust free area.

(e) All joints- lateral & longitudinal, shall be taped with self adhesive aluminium foil tape 75 mm wide. The insulation over the surface shall be then held in position with 12mm wide PVC straps at every 600mm, to provide a neat & clean finish.

4.02.00 **Type of Insulation & Finish**

Sl. No.	Surface	Insulation Material	Insulation Form	Thick (mm)	Finish (mm)
1.	Acoustic insulation of duct	Resin bonded Glass wool	Slab	25	As per specifications
2.	Exposed air duct	Resin bonded Glass wool/Rock wool Or Polyisocyanurate Foam	Roll/Slab Slab	50 50	F-4 F-4(a)

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

Insulation Material	Code	Thermal conductivity (w/m/^{o}C)	Density Kg/m^3
Resin bonded glass wool / Rock wool	IS:8183	0.049 at 50°C	i) 24 (For Glass wool) ii) 48 (For Rockwool) iii) 48(For acoustic insulation)
Polyurethane Foam Polyisocyanurate Foam	IS12436	0.03 at 50 ^{o}C 0.03 at 50 ^{o}C	34 $\pm$ 2 34 $\pm$ 2
Note : Insulation used for shall be CFC/HCFC free			

4.04.00 The specification for various finishes shall be as follows

a)	**Finish F-1** 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.
b)	**Finish F-4** Step-1 Same as Step-1 of Finish F-1 above. Step-2 Same as Step-2 of Finish F-1 above. Step-3 Same as Step-3 of Finish F-1 above. 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. Step-5 After the above treatment, 22G Aluminium sheet cladding, properly stitched at all joints shall be provided over the external surface.
c)	**Finish F-4(a) (With FR Closed Cell Chemically Cross Linked Polyethylene Material)**
	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 tounge-in-groove joints applied with afelt for sealing joint against water ingress. Al sheet joints to be done in a manner to shed water.

4.05.00 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

4.06.00 Acoustic Insulation

All ducts up to a distance of 5 meters from Air washer unit fan, UAF fan and other centrifugal fan outlet 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.

Fiber 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.

5.00.00 PLANT CONTROL

5.01.00 GENERAL

5.01.01 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.

5.01.02 **Control Scheme of Ventilation System**

The Ventilation system for main Plant area (excluding roof extraction fans, standalone Air supply and Air Exhaust fans) shall be controlled through microprocessor based Distributed Digital Control Monitoring and Information System (DDCMIS). This DDCMIS system shall perform all functions such as auto/manual operation of valves, pumps, drives, local/remote selection of operation, status indication, annunciation, interlock and protection of pumps/drives, etc.

5.02.00 Air Washer Units (AWU) & Unitary Air Filtration Units (UAF)

5.02.01 Air washer units shall be started/stopped by initiation from Main DDCMIS based control system of A/C plant (provided by contractor) for Main plant area, ESP control room and water system control room. Starting/stopping of pumps shall be automatic upon such initiation.

5.02.02 The operation of the pumps shall be interlocked with the low level of water in the sump. High level of the sump shall be alarmed.

5.03.00 Miscellaneous control requirements

5.03.01 Separate emergency local stop push button shall be provided for each pump, fans, etc. of Ventilation system.

5.03.02 The status of each pump, fans, etc. of Ventilation system is available on OWS in control room locally.

5.03.03 All the alarms related to failure of equipments, tripping of equipments, source of failure / reason due to which the equipment is stopped / tripped, low & high limits of parameters such as level, temperature, pressure drop, pressure etc shall be provided for each pump, fan, AWU etc. in the control system.

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

6.00.00 CODES & STANDARDS

6.01.00 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.

6.01.02 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.

7.00.00 PAINTING

7.01.00 Painting Details for Vendor's Equipments/Other Items

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

b) The surfaces of stainless steel, Galvanised 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.

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

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

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

f) 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.

7.02.00 Employer's Painting Scheme of Steel Surfaces (To be followed by the Vendor for affected areas as described in Subsequent clauses)

(a) All steel surfaces shall be provided with self curing Inorganic Zinc Silicate Primer Coat (Solid by Volume Minimum 60%) of Minimum 75 Micron Dry Film Thickness (DFT) applied over blast cleaned surface to near white metal conforming to Sa 2 ½ finish of Swedish standard SIS-05-5900. The Primer shall be applied in Shop immediately after blast cleaning by Airless spray technique.

(b) Primer Coat shall be followed with the application of Intermediate Coat of Polyamide Cured pigmented Titanium Dioxide (TiO_2) or Micaceous Iron Oxide (MIO) Epoxy based Paint (Solid by Volume Minimum 60%) of Minimum 75 Micron DFT. This Coat shall be applied in Shop after an interval of Minimum overnight (from the application of Primer Coat) by Airless spray technique.

(c) Intermediate Coat shall be followed with the application of Finish Coat of Polyamide Cured colour pigmented Epoxy based Paint (Solid by Volume Minimum 60%) of Minimum 75 Micron DFT. This Coat shall be applied after an interval of Minimum overnight and maximum indefinite (from the application of Intermediate Coat) either before Erection by Airless spray technique or after Erection by brush and / or spray. Colour and shade of the Coat shall be as approved by the Employer. The finish Coat thickness of 75 Micron can be built up either in Single application at Shop or in two applications one at Shop and the other at Site.

(d) Finish Coat shall be followed with the application of Final Finish Coat of Polyurethane based colour pigmented Paint (Solid by Volume Minimum 40%) of Minimum 25 Micron DFT. This Coat shall be applied within Seven (7) days (from the completion of Finish Coat), after Erection by brush and / or spray. Colour and shade of the Coat shall be as approved by the Employer.

7.03.00 **Touch-up Painting on damaged areas**

(a) For Coatings damaged up to metal surface

Surface preparation shall be carried out by Manual Cleaning. Minimum 6 inches adjoining area with existing Coating shall be roughened by Wire brushing, emery paper rubbing etc., for best adhesion of patch Primer.

Primer Coat of self-priming Epoxy Touch-up Primer applied by brush immediately after the surface preparation. (Minimum DFT 100 Microns). Over this Primer Coat, Intermediate Coat, Finish Coat and Final Finish Coat shall be applied as covered above by brush with Intermediate Coat applied within seven (7) days of application of touch up Primer.

(b) For Coatings damaged upto Intermediate Coatings (i.e. where Primer is intact).
Damaged area including Minimum 6 inches adjoining area with existing Coating should be roughened by wire brushing, emery paper rubbing etc., for best adhesion of patch Primer without damaging the Primer Coat.

Touch-up Primer, Intermediate, Finish and Final Finish Coats shall be applied as specified above for Coatings damaged up to metal surface.

7.04.00 Painting to be provided by Vendor over Welded areas / areas exposed after removal of temporary supports / Touch-up Painting on damaged areas of Employer's Structures, where interconnection, Welding / modification etc. has been carried out by the Bidder.

(a) Clean the surface to remove flux spatters and loose rust, loose Coatings in the adjoining areas of Weld seams by wire brush and emery paper.

(b) Painting procedure to be followed as mentioned above for Touch-up Painting on damaged areas.

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 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 and with a minimum shut-off head of about 15% more than the design head.

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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.

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.

Annexure –I

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 minimise 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